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# The bilingual continuum:
# Mutual effects of language and cognition

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## Abstract

One of the main findings of research on bilingualism in the last twenty years is the fact that both languages are always active, to some extent, and interact with each other. This interaction gives rise to a computationally complex feature of the bilingual mind, namely that the two languages compete with each other. Many studies have addressed the linguistic consequences of this competition (e.g. differences in linguistic attainment), while others have instead addressed the cognitive consequences (e.g. training effects on cognitive control). These two strands of research, when brought together, can shed light on the dynamics of language processing and of its relationship with other cognitive abilities; however, they do not often converge. The first aim of this thesis is to seam them together.

The second aim of this thesis is to understand the effects of specific aspects of language experience on linguistic and non linguistic abilities. A critical assumption I make is that bilingualism is not a dichotomous variable, but rather a continuum, characterised by several aspects such as linguistic proficiency, age of acquisition, and daily exposure. All of these factors interact with each other to give rise to potentially infinite types of bilingual experiences, and arguably modulate how bilinguals deal with competing languages. However, the effects of these factors on linguistic and non linguistic abilities are poorly understood.

Hence, in this thesis I examine if the bilingual experience affects other cognitive abilities (study 1), how the ability to handle this competition is modulated by experience (study 2), and how it affects language processing (study 3). To examine how specific dimensions of the bilingual continuum affect these abilities, I compare four populations of bilinguals, whose linguistic experience ranges from late bilinguals who are immersed in their native language and are passive users of their second language, to early highly proficient bilinguals who use both languages actively.

My first study examines cognitive control performance and shows that high active proficiency and early age of acquisition, together, represent beneficial circumstances for the ability to modulate cognitive control; however, their effects are not strong enough to override individual variability. The second study investigates how the bilingual experience modulates the ability to access the two languages separately, overcoming the competition between them at different levels. This could be at a local level, i.e. the level of the individual linguistic representation (e.g. naming time of a specific word), or at a global or whole language level (e.g. overall naming latencies across languages). The results show that proficiency affects local competition, and age of acquisition affects global competition, whereas daily language exposure regulates competition at both the local and the global levels. My third study examines the processing of pronouns, which are particularly demanding linguistic structures. It shows that active proficiency and age of acquisition, together, define circumstances in which pronoun processing may vary between individuals, independently of structural differences between their languages. This suggests that bilinguals with long-term exposure to more than one language and high active proficiency may use some linguistic structures in the same way as individuals with different linguistic backgrounds, i.e. explicitly interpret them in similar ways, but process them in marginally different ways.

Through these studies, this thesis brings together research on linguistic and cognitive aspects of bilingualism by identifying three dimensions of the bilingual experience – proficiency, exposure and age of acquisition – and their effects on language processing, language control and cognitive control.

## Lay summary

One main finding of research on bilingualism in recent years is that the two languages of a bilingual never sleep: as a bilingual, when you use are choosing a word or a sentence in one language, you always browse the other language too. So the two languages that a bilingual speak are always active and compete, to some extent, when they speak and listen language. The interaction between the two languages represents an extra challenge for research on language. A number of studies have addressed how this interaction affects grammar in bilinguals. Another part of research has studied how using two languages impacts other mental abilities. However, these two branches of research do not often meet: the first aim of this thesis is to bring them together, to understand both the linguistic and the mental aspects of bilingualism.

The second aim of this thesis is to understand the specific role of different aspects of being a bilingual on linguistic and mental abilities. In my research, I challenge the assumption that the world is divided into bilinguals vs. monolinguals. I show how linguistic experience can be described on a range: from speaking one single language and only occasionally using another one, to knowing and using two or more languages proficiently. How well you know each language (proficiency), how much you use them (exposure), at what age you learnt them (age of acquisition) are all aspects that can be used to measure people's linguistic experience, and that may affect how people understand language and how they think. However, previous research does not tell us enough about the specific effects of these factors on linguistic and mental abilities.

Therefore, in this thesis I study the effects of being bilingual on mental abilities like attention (study 1), how different ways of being bilingual shape the ability to handle two languages at the same time (study 2), and how being bilingual affects the way language is understood and used (study 3). In order to understand how different dimensions of the bilingual experience affect these abilities, I compare four populations of bilinguals, that range from bilinguals who acquired their languages late in life and who mainly use one of them, to bilinguals who learnt both languages during childhood and who know and speak both languages fluently.

My first study addresses the relationship between bilingualism and attention, and shows that proficient bilinguals who acquired their languages early in life tend to have better attention abilities than those who are less proficient and learnt their languages later. However, the effects of bilingualism are weaker than individual differences in attention abilities, which play a very strong role. In my second study I look into how different dimensions of the bilingual experience affect how well bilinguals deal with the ability to switch from one language to the other. Specifically, I focus on language proficiency, age of acquisition and exposure. My results show that knowing your second language well makes it easier to go from one language to the other, when this happens between individual words. Age of acquisition instead affects how long you take to select each language – the earlier you learnt them, the longer it takes to mix them. Finally, how much you use each language every day affects both the local and the global level: the more you are exposed to your languages, the easier it is for you to access them. My third study addresses how bilinguals understand and use pronouns, such as words like "I" and "she". Pronouns are difficult parts of the grammar that people use in different ways. My study shows that the bilingual experience plays a role in how people understand pronouns, in particular, proficient bilinguals who learnt their languages as children

seem to use a different strategy to understand pronouns, even if they use them like any other speaker.

Through these studies, this thesis brings together research on the linguistic and cognitive sides of bilingualism, by identifying three dimensions of the bilingual experience – proficiency, exposure and age of acquisition – and their effects on attention, on how the ability to select the two languages, and on how language is understood.

## Riassunto

Una delle scoperte principali negli ultimi vent'anni di ricerca sul bilinguismo è che le due lingue di un bilingue sono sempre attive: per scegliere una parola o una frase in una lingua, un bilingue automaticamente passa in rassegna entrambe le lingue. Le due lingue, quindi competono tra di loro costantemente. Questo fatto rappresenta una sfida per la ricerca sul linguaggio. Una parte della ricerca esistente sul bilinguismo è dedicata a comprendere l'effetto di questa interazione sulla grammatica, un'altra parte è invece dedicata a capire gli effetti dell'essere bilingue su capacità non linguistiche quali l'attenzione. Tuttavia, queste due tradizioni di ricerca raramente s'incontrano. Il primo obiettivo di questa tesi è di riunirle, al fine di capire sia gli effetti del bilinguismo sia sul linguaggio, sia sulle capacità mentali non linguistiche.

Il secondo obiettivo di questa ricerca è capire il ruolo di aspetti specifici dell'esperienza bilingue su capacità linguistiche e non. Nella mia ricerca metto in discussione una divisione dicotomica tra bilingui e monolingui, per mostrare come l'esperienza linguistica possa essere descritta come un continuum: dal conoscere ed usare una sola lingua, e solo occasionalmente usare parole di un'altra, al conoscere approfondidatemente e fluentemente più di una lingua. Aspetti caratterizzanti dell'esperienza bilingue sono quanto bene si conosce una lingua (la competenza), quanto la si usa nella vita di ogni giorno (l'esposizione) e a che età le si apprende (età di acquisizione): questi aspetti sembrano avere effetti importanti sul modo in cui capiamo ed utilizziamo il linguaggio. Tuttavia, gli studi esistenti non ci dicono abbastanza sul ruolo di questi aspetti sulle capacità linguistiche e mentali.

Oggetto di questa tesi, perciò, sono gli effetti dell'esperienza bilingue su capacità mentali quali l'attenzione (1° esperimento), gli effetti di aspetti specifici dell'esperienza bilingue sulla capacità di gestire la competizione tra le due lingue (2° esperimento), e gli effetti dell'esperienza bilingue sul modo in cui capiamo e usiamo il linguaggio (3° esperimento). Per studiare gli effetti di competenza, esposizione ed età di acquisizione, in questa tesi confronto quattro popolazioni bilingui, la cui esperienza varia su un continuum, da bilingui che hanno imparato una delle loro lingue da adulti e che usano principalmente una lingua sola nella vita quotidiana, a bilingui che parlano fluentemente due lingue sin dall'infanzia.

Il primo studio indaga la relazione tra bilinguismo e attenzione, e mostra che i bilingui con un'alta competenza e un'età di acquisizione precoce tendono ad avere capacità attentive migliore di bilingui con una minore competenza che hanno acquisito la loro seconda lingua più tardi. Tuttavia, gli effetti dell'esperienza bilingue non sono abbastanza forti da superare le forti differenze individuali nelle capacità attentive. Il secondo studio è dedicato a capire in che modo i diversi aspetti dell'esperienza bilingue forgiano la capacità di gestire la competizione tra le due lingue: in particolare, in questo studio, analizzo l'effetto della competenza linguistica, dell'età di acquisizione e dell'esposizione. I risultati dimostrano che conoscere bene una seconda lingua rende più facile il passare da una lingua all'altra, quando questo accade tra singole parole. L'età di acqusizione invece ha un effetto più globale sui tempi di reazione necessari a scegliere una lingua o l'altra – prima una lingua e' acquisita, più difficile e lungo è l'accesso linguistico in un contesto in cui entrambe le lingue sono presenti. Infine, la quantità di esposizione alla seconda lingua nella vita quotidiana agisce sulla capacità di scegliere la lingua da usare sia ad un livello locale – tra una parola e l'altra – sia ad un livello globale – l'intero sistema linguistico: maggiore l'esposizione, più facile è passare da una lingua ad un'altra. Il terzo studio indaga come i bilingui interpretano i pronomi – parole quali "io" e "lei". I pronomi sono struttre grammaticali complesse, che possono essere usate in modo

diverso da parlanti diversi. Questo studio dimostra che l'esperienza bilingue influenza il modo in cui le persone comprendono e usano i pronomi: in particolare, i bilingui con un'alta competenza, che hanno appreso la loro seconda lingua da piccoli, sembrano usare strategie interpretative diverse dagli altri parlanti, anche se utilizzano i pronomi nello stesso modo.

Attraverso questi tre studi, questa tesi riunisce la ricerca sugli effetti linguistici del bilinguismo alla ricerca dedicata ai relativi aspetti mentali; in particolare, questa tesi identifica tre dimensioni cruciali dell'esperienza bilingue – la competenza, l'esposizione e l'età di acquisizione – e i loro effetti sull'attenzione, sulla capacità di selezionare la lingua in cui parlare, e sull'interpretazione di strutture linguistiche complesse..

## Declaration

I hereby declare that this thesis is my own composition, that the work reported here has been carried out by myself, except where due acknowledgement is made in the text, that this work has not been submitted for any other degree or professional qualification except as specified in the text, and that the included publications are my own composition.

The following chapters of this thesis are formatted manuscripts that have been submitted to peer-reviewed journals:

- Chapter 5: Bonfieni, Branigan, Pickering & Sorace, *Cognitive control in bilinguals: language experience and individual variability.*
  Submitted to *Bilingualism, Language and Cognition* in September 2017, currently under revision. Authorship details: Bonfieni designed the study, ran the participants, analysed the data and wrote the original manuscript. Branigan, Pickering and Sorace acted as supervisors, gave feedback on each of these steps and contributed to the revision of the manuscript.

- Chapter 6: Bonfieni, Branigan, Pickering & Sorace, *Language experience modulates bilingual language control: the effect of proficiency, age of acquisition, and exposure on language switching.*
  Submitted to *Acta Psychologica* in January 2018, currently under review. Bonfieni designed and programmed the experiment, ran the participants, analysed the data and wrote the original manuscript. Branigan, Pickering and Sorace acted as supervisors, gave feedback on each of these steps and contributed to the revision of the manuscript.

Michela Bonfieni

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*Le doute n'est pas une condition agréable, mais la certitude est absurde.*

Voltaire

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# Introduction

Bilingualism is a common circumstance for human cognition, as bilinguals and multilinguals represent more than half of the world population. Research in the last twenty years suggests that the difference between bilinguals and monolinguals in not quantitative – i.e. a bilingual is not the sum of two monolinguals – but rather qualitative. Being bilingual is not only knowing two grammars: it is also being able to learn them and process them in a flexible way. From this point of view, bilingualism challenges a static view of language as a system of rules and highlights the dynamics of language processing.

One of the main findings of research on bilingualism in the last twenty years is the fact that the two languages are always active, to some extent, and interact with each other. The simultaneous activation of the two languages represents a computational complexity that, on the one hand, impacts aspects of linguistic access and processing – such as word retrieval or syntactic resolution. On the other hand, the constant monitoring and suppression of the irrelevant language (the one not in use in the current context) seem to relate to cognitive abilities not specific to language, such as sustained attention and inhibitory abilities. The linguistic and cognitive sides of the bilingual experience constitute the object of two main strands of research on bilingualism. Together, they can shed light on the mutual influence of bilingual language abilities and bilingual cognition; however, these two strands of research do not often meet. The first aim of this thesis is to bring them together.

The second aim of this thesis is to identify the effects of specific aspects of the bilingual experience on linguistic and non linguistic abilities, that is, to ask what circumstances modulate the mutual influence of language and cognition. To answer this question, it is crucial to explore the different dimensions of the bilingual linguistic experience. A great deal of current research is based on an assumption that appears questionable: a dichotomous

distinction between monolinguals and bilinguals. To illustrate this point, let us consider Europe, for example: according to a survey (Special Eurobarometer 386, European Commission, 2012), only a quarter of Europeans have never learnt a second language, whereas over half can engage in a conversation in at least one additional language, a quarter are able to speak two additional languages, and one out of ten can use three languages fluently. Additional languages are predominantly used on an occasional basis by the majority of respondents, whereas one person out of ten uses their second language every day. In addition to native languages, slightly less than half of the European population also have a passive knowledge of at least one foreign language and use it regularly. These figures suggest that knowing and using more than one language is a pervasive experience in Europe, although it ranges from fluent and continuous usage, to passive and restricted understanding: quantity and quality of language use, proficiency, daily exposure, and native vs. formal learning are only some of the crucial dimensions that define the European linguistic experience, and that interact in multiple ways to create a diversified range of ways to be 'bilingual'.

Therefore, in this thesis, I use the term 'bilingual' to refer to individuals who know and use more than one language in their life. In line with recent approaches (Luk & Bialystok, 2013; Bak, 2016), I assume that this term refers to a continuum of experience, encompassing bi- and multilingualism, including people immersed in their native language, with little knowledge of another language, to individuals who use two or more languages daily throughout their whole life.

In order to investigate the linguistic and cognitive effects of the bilingual experience, in chapter 1 I discuss the development of the two languages through bilingual language acquisition and learning: how the degree of separation between the two languages during acquisition is affected by specific aspects of individual experience such as exposure and age, as well as by cross-linguistic differences and similarities. I then discuss accounts of bilingual language development that highlight the similarity between first and second language acquisition, and explain the variability in linguistic performance in bilinguals focusing on the cognitive aspects of bilingual processing. In chapter 2, I then discuss how the two languages

interact in language processing. Specifically, in line with chapter 1, I consider how the mutual influence of one language on the other during on-line processing is modulated by aspects of the bilingual experience, cross-linguistic differences and cognitive aspects. These latter are involved in selective language access and appear to be related to domain-general abilities such as executive functions. Therefore, in chapter 3, I discuss research that examines the relationship between language control and cognitive control: while these two do not completely overlap, their relationship is a key to understand the mutual effects of language and cognition in bilinguals. Since research addressing the cognitive effects of bilingualism provides inconclusive results, I review some theoretical and methodological aspects that limit its potential.

These chapters introduce unresolved issues in research on bilingualism, related to the specific role of aspects of the bilingual experience on language processing and on language control, as well as to the mutual effects of language processing and cognitive abilities in bilinguals. Given this context, in chapter 4 I formulate the following research questions, which I address in three experimental studies:

1. What are the effects of the bilingual experience on executive control, and what are the crucial factors to consider in the study of this relationship (study 1)?
2. How is the ability to handle competition between the two languages modulated by linguistic experience (study 2)?
3. Does the bilingual experience affect language processing independently of cross-linguistic interference (study 3)?

To examine how different dimensions of the bilingual experience affect these abilities, in these studies I compare four populations of Italian bilinguals, whose linguistic experience ranges on a continuum from late, passive bilinguals immersed in their native language, to early highly proficient bilinguals.

The first study (chapter 5) investigates the cognitive effects of bilingualism addressing theoretical and methodological concerns discussed in chapter 3. I adopt a model of executive

control based on the dynamic interplay of two control mechanisms (proactive and reactive control). The analysis of accuracy based on aggregated measures suggests an advantage in early highly proficient bilinguals over late passive bilinguals. However, once individual variability is factored into the analysis, there is no evidence for such an advantage.

The second study (chapter 6) examines the ability to selectively access two languages with a cued language switching task, addressing the role of specific aspects of the language experience that are known to affect language acquisition and processing (as I discuss in chapter 1 and 2), but that are relatively understudied with respect to language control: I show that language control is modulated, beyond proficiency, also by daily exposure to the second language and age of acquisition. Language control is discussed in reference to models of bilingual language control and its relationship with models of executive control.

After presenting these findings on the effects of the bilingual experience on cognitive and linguistic control, I look into its effects on language processing. In the third study (chapter 7), I investigate the processing of null and overt pronouns in Italian speakers in four experiments. Combining on-line and off-line measures, this study shows a processing asymmetry between null and overt pronouns in native Italian speakers (experiment 1), thereby extending previous knowledge on the processing of pronouns in Italian. In experiments 2, 3, and 4, I then report similarities and differences between bilingual groups. Specifically, participants in experiment 2 were Italian-English bilinguals, whose interpretational preferences for null and overt pronouns did not differ from those of Italian-dominant speakers. In experiment 3, Italian-Sardinian bilinguals showed different interpretational preferences from Italian-dominant bilinguals, even though Italian and Sardinian do not differ from the point of view of subject pronoun properties. Participants in experiment 4 (Italian-Sardinian Passive bilinguals), however, did not differ from Italian-dominant speakers. I discuss these findings in reference to the bilingual experience of the participants and their place on the bilingual continuum.

This thesis identifies three specific dimensions of the bilingual experience that affect the mutual influence of linguistic and cognitive abilities: active proficiency, age of acquisition

and daily language exposure play a role in language control and affect language processing independently of cross-linguistic differences. This work also shows that bilinguals at the high end of the continuum defined by these variables efficiently combine mechanisms of cognitive control, but this ability is primarily mediated by individual differences in executive functions.

# 1. The acquisition of two separate languages

This chapter discusses the differentiation between the two languages in bilingual language acquisition examining available theoretical accounts and empirical findings: how the two languages develop as distinct linguistic systems, similarities and differences in their developmental trajectories, and phenomena of cross-linguistic interference. Important factors that affect the degree of separation of the two languages are language exposure, in terms of quantity and quality of input (1.1), age of acquisition and relative proficiency, as well as linguistic properties (1.2). For late bilingualism, i.e. when the second language (L2) is acquired after childhood, accounts that posit a fundamental difference between first and second language acquisition are contrasted with continuity accounts, which focus on processing aspects and highlight the role of cognitive factors – besides linguistic ones – in the study of bilingualism, as well as the mutual influence of one language over the other (1.3).

## 1.1 Language differentiation in early bilingualism: exposure and dominance

Early accounts of bilingual language acquisition suggested that the two languages are acquired as one single linguistic system: according to Volterra and Taeschner (1978), initially the child has only one lexical system that includes words from both languages. Subsequently, the child displays two separate lexicons but applies the same syntactic rules to the two languages. Finally, the two languages are differentiated from both the lexical and the syntactic point of view. However, this study has received both methodological and theoretical criticism, as it ultimately does not explain how the two languages are separated (de Houwer, 2005). In contrast, later studies showing the independent acquisition of morpho-syntactic systems in bilingual children support early language differentiation. For instance, in a seminal case study by de Houwer (1990), an English-Dutch bilingual child shows a clear distinction in the

syntactic development of the two languages, reflected for example by the acquisition of distinct properties of word order, finiteness and auxiliary support; likewise, the acquisition of distinct syntactic features (such as finiteness, negation and subject pronouns) shows no delay nor interference in a study of French-English bilingual children, although these linguistic properties differ in the two languages (Paradis & Genesee, 1996). Further studies attest the ability to identify and map differences in the input onto distinct linguistic systems: for example, bilingual-to-be infants can discriminate between their languages around 3.5 months of age, even if these are rhythmically similar, showing no sign of delay with respect to their monolingual peers (Molnar, Gervain & Carreiras, 2014; Bosch & Sebastián-Gallés, 2001). Bilingual infants also distinguish and develop two separate phonemic inventories at a comparable rate to monolingual infants (Albareda-Castellot, Pons & Sebastián-Gallés, 2011; Burns, Yoshida, Hill & Werker, 2007).

The ability to separate the two languages has been related to the children's ability to pay attention to their linguistic environment (de Houwer, 1990, 2005), as exemplified by the correlation between exposure in terms of frequency of the input and vocabulary development: if the two languages are considered together, the rate of vocabulary growth of bilingual children is comparable to the rate of monolingual children; in contrast, if the two languages are examined separately, bilinguals lag behind monolinguals (Pearson, Fernandez & Oller, 1993). This finding, initially related to the idea that bilingual children confuse their two lexicons, reflects the fact that bilinguals receive less input in each of their languages than monolinguals (Paradis & Genesee, 1996); however, the differentiation between the two lexicons is confirmed by studies that show that during the second year of life bilingual children deliberately use translation equivalents (Genesee, Nicoladis & Paradis, 1995; Nicoladis & Genesee, 1996; Nicoladis, 1998).

Linguistic development is faster in the language the child is more exposed to: thus, exposure is linked to the development of an early language dominance. Consider the case of phonotactic development (i.e., what sequences of phonetic segments are plausible words in a language and what are not): Catalan-Spanish 10 month-olds showed a comparable preference

for sequences phonotactically legal in Catalan over illegal sequences, like Catalan age-matched monolinguals, whereas Spanish-dominant Catalan-Spanish infants did not show a significant preference over illegal sequences, thereby being comparable to Spanish monolingual infants (Sebastián-Gallés & Bosch, 2002). Bilingual language development relies on properties of the input in the same way as for monolinguals: frequent phonetic patterns are acquired earlier than less frequent ones (Jusczyk, Luce & Charles-Luce, 1994), and at a comparable rate. Relative language exposure also predicts vocabulary growth (Place & Hoff, 2011, Pearson, Fernandez, Lewedeg & Oller, 1997; Gathercole & Thomas, 2009), length and complexity of utterances (Hoff et al., 2012), and general grammatical abilities (Chondrogianni & Marinis, 2011), as well as the acquisition of specific syntactic features, such as gender, word order and anaphoric forms (Gathercole & Thomas, 2009; Yip & Matthews, 2006).

However, language dominance also correlates with cross-linguistic interference of one language (e.g. the more dominant language) on the other (the weaker one): for instance, Cantonese-English bilingual children, dominant in Cantonese, frequently produce null object pronouns in English, a structure common in Cantonese but infrequent in English (Yip & Matthews, 2006, 2007). Thus, dominance seems to represent a limit to the separation between the two languages, at least superficially, as it is related to cross-linguistic transfer, that is, the "incorporation of a grammatical property into one language from the other" (Paradis & Genesee, 1996).

Dominance is a concept "often taken for granted" (Hulstijn, 2012) but not straightforward. There are two main ways to operationalise dominance. The most common one is in terms of proficiency, for instance using measures of performance such as mean length of utterance (MLU), upper bound (i.e. length of the longest utterance in the sample) or percentage of multimorphemic utterances; on the basis of these measures, a balance score is produced by subtracting the score in one language from the score in the other language (Unsworth, 2013; Yip & Matthews, 2006). Several other measures of dominance have been produced (for the study of both bilingual children and adults), considering further aspects of language proficiency. These include: grammaticality judgements (Lemmon & Goggin, 1989),

vocabulary richness (Treffers-Daller, 2010; Bialystok, Craik & Luk, 2008), general measures of language processing such as fluency, speed, directionality of code-mixing and ability to translate (Segalowitz, 2010; Favreau & Segalowitz, 1983; Flege, Mackey & Piske, 2002), as well as judgements of experts (Talamas, Kroll & Dufour, 1999) and accent ratings (Favreau & Segalowitz, 1983). As the abundance of these measures indicates, the operationalisation of dominance in terms of proficiency is problematic.

First, proficiency measures vary across different linguistic domains: for example, dominance scores based on lexical and phonological accuracy do not correlate (Kupisch & van de Weijer, 2015), reflecting the fact that different linguistic domains develop at different rates (Yip & Matthews, 2007; Tsimpli, 2014), but also that these scores depend on the type of task (Bahrick et al., 1994). Second, it is difficult to compare specific dominance measures across languages, as tasks may not be equivalent in the two languages (e.g. different word frequency, morphological typology, Treffers-Daller, 2015). Third, some of these measures may give rise to a circularity problem, such as predicting dominance effects in a sample of utterances on the basis of a measure of lexical richness elaborated on the same sample (see Treffers-Daller, 2010). While this last aspect may be more relevant from a methodological point of view, it reflects the challenge of operationalising language dominance as language performance in the attempt to measure the speaker's linguistic competence (Yip & Matthews, 2006).

An alternative way of operationalising dominance is in terms of language exposure. As seen in studies mentioned above (e.g. Place & Hoff, 2011; Hoff et al., 2012; Gathercole & Thomas, 2009; Chondrogianni & Marinis, 2011), the amount of input in the two languages is related to the rate of linguistic development of bilingual children in a variety of domains, from vocabulary to morphosyntax. However, the effect of exposure on linguistic development also appears to be mediated by other environmental aspects, which affect linguistic development in general, such as socio-economic status (see Hoff, 2006), or that are specific to bilingual environments, such as parental language strategy, literacy, status of the languages, number of siblings and birth order (Paradis, 2011; Unsworth, 2015). These latter aspects affect how much linguistic input in each language the child receives, in absolute and relative measures, as well

as the quality of linguistic input, such as variety of sources, of contexts and of interlocutors, and whether the interlocutors are native or non-native speakers (Place & Hoff, 2011; Unsworth, 2013). A recent study examined the relationship between these aspects of exposure and standard measures of proficiency: there was a correlation between proficiency in the minority language (i.e., the one with less exposure) and the proportion of exposure to the two languages, the relative proportion of each language spoken by the child at home, as well as a more qualitative aspect such as the number of interlocutors who exclusively spoke this language with the child (Unsworth, 2015).

To summarise, the operationalisation of dominance in terms of proficiency appears to be problematic, whereas the use of exposure seems to be a better predictor of performance in the two languages (although it also has detractors, see Carroll, 2017). Specifically, although the two languages develop in parallel, relative language exposure correlates to language dominance, and predicts the amount and directionality of the influence of one language over the other.

## 1.2 Beyond exposure: age and linguistic domains

Exposure, however, does not always predict linguistic performance and patterns of cross-linguistic interference, nor is it the only factor at play. For instance, Chondrogianni and Marinis (2011) did not find any effect of exposure (nor of any other environmental factor) on the development of tense morphology in Turkish dominant Turkish-English bilingual children. In a study by Unsworth and colleagues (2014), the effects of exposure differ across bilingual populations (as defined by language combinations and chronological age): exposure predicts the development of grammatical gender in English-Dutch bilingual children, but its effect on the acquisition of the same property in English-Greek bilingual children is not straightforward. Specifically, in Dutch, simultaneous bilingual children, early bilingual children (i.e. who acquired both languages before the age of 4) and late bilingual children (i.e. who acquired their second language after the age of 4) performed differently than monolinguals, while in Greek,

simultaneous and early bilinguals, but not late bilinguals, were comparable to monolinguals (Unsworth, Argyri, Cornips, Hulk, Sorace & Tsimpli, 2014).

These results can be understood in reference to two main factors other than exposure that affect linguistic development: age and type of linguistic properties. The effect of age on language acquisition has been widely discussed in research on language. Since the proposal of a critical period for first language acquisition (Lenneberg, 1967), abundant research has extended its main tenet to second language acquisition, albeit to varying degrees. Johnson and Newport (1989) proposed that age of acquisition is linearly correlated with grammatical performance until puberty (17 years of age); after this point, performance drops and is unrelated to age – thereby describing an S-shaped curve indicating a non-linear decline in language acquisition abilities. The critical period hypothesis in second language acquisition has been related to a loss of brain plasticity (Birdsong, 1999), from a neurocognitive and developmental point of view, as well as to the loss of access to the faculty of language, from the point of view of theories of language acquisition (Fundamental Difference Hypothesis, Bley-Vroman, 1990).

However, more recent proposals have toned down the hypothesis of a critical period in terms of sensitive period (see DeKeyser & Larson-Hall, 2005) or multiple sensitive periods (Meisel, 2009). According to Meisel, there are multiple time-windows in which different components of language can be acquired successfully: broadly speaking, these windows correspond to the 4$^{th}$ year of age (within which we can speak of early bilingualism) and the 10$^{th}$ (which separates child bilingualism from adult bilingualism). In support of this last proposal, data on the acquisition of syntax and morphology show that child L2 syntactic acquisition is more similar to adult L2 acquisition (so the sensitive period for the acquisition of syntax seems to close around 4 years of age), while child L2 acquisition of morphology is more like L1 acquisition (so the relative sensitive period extends to 10 years of age, Schwartz, 2004, in Meisel, 2009). However, some studies oppose the idea that age relates to discontinuity in learning and propose a linear and continuous effect of age on second language acquisition

throughout the whole life-span (Bialystok & Hakuta, 1999, Birdsong, 2005), and suggest that the effect of age is modulated by the amount of language use (De Carli et al., 2015).

The second factor impacting first and second language acquisition is type of linguistic properties. It has been observed that some linguistic phenomena are acquired early and some late, both in first language acquisition (e.g., Wexler, 1998) and in bilingual/second language acquisition (Unsworth et al., 2011; Tsimpli 2014). These phenomena can be explained in reference to the different developmental trajectories of different linguistic domains, but also in reference to the interactions between these domains: a well-documented distinction is between narrow syntax and interfaces (Avrutin 1999; Burkhardt 2005).

Narrow syntax refers to core syntactic properties such as word order (e.g. head-complement order in the verbal phrase) and it is usually acquired early, so that it seems to only require brief exposure. In the study of bilingual language acquisition, this conclusion is supported by the early and independent development of these properties in simultaneous bilinguals, i.e. in cases of reduced exposure to either pattern of word order (Moehring & Meisel, 2003, in Tsimpli, 2014). In contrast, structures on the interfaces require components external to syntax, such as semantics, pragmatics and non-linguistic cognitive resources, and are typically acquired late. These properties are more demanding in terms of number of types of information to integrate, and of processing constraints on such integration. Examples of these properties are the processing of pronouns, quantification, wh- questions and subject vs. object relative clauses. With regards to these 'external' properties, the hypothesis is that age of onset does not play a crucial role, i.e. the resources required to access and parse these structures remain accessible to older (bilingual) children (Tsimpli 2014). This hypothesis is supported for instance by data showing that English-Greek simultaneous, early and late bilinguals produced non-active verbs comparably, but all significantly differently than monolinguals (Unsworth et al., 2011).

To summarise, early phenomena related to narrow syntactic properties distinguish simultaneous bilingual children from early and late bilingual children, suggesting a primary relation with chronological age, while late phenomena differentiate bilingual children from

monolingual children, suggesting a main role of exposure (Tsimpli, 2014). However, as the mentioned study by Unsworth et al. (2014) shows, age, exposure and linguistic properties also interact with cross-linguistic differences, i.e. the fact that similar structures can be acquired at different ages in different languages (Yip & Matthews, 2007, Tsimpli, 2014).

Finally, linguistic properties can also be responsible for transfer between languages independently of the effect of age and exposure. For instance, Döpke's (1998) analysis of the development of verb placement in German-English children shows that the partial overlap of possible word orders in the two languages is related to the production of a hybrid word order in one of their languages (German). According to the author, these data suggest that "the children [are] acquiring the two languages in relation and in contrast to each other" (ibid. p. 581), as there does not seem to be any prominent effect of exposure nor dominance. Similarly, Hulk and Müller (2000) also report cross-linguistic interference in a Dutch-French child and a German-Italian one. Specifically, they show that the acquisition of Germanic root infinitives in these children is comparable to the patterns found in monolingual children; however, their acquisition of the object drop property is subject to cross-linguistic interference between their two languages. Both object drop and root infinitives are located at the interface between syntax and pragmatics: but object drop structures are similar (i.e. partially overlap) in the children's two languages, while root infinitives are different. The authors conclude that partial overlap of structures located at this external interface triggers cross-linguistic interference, independently of other factors such as exposure and age.

Taken together, these findings suggest that, in specific circumstances, bilinguals may display particular patterns of language use, that can be only partially understood in light of how linguistic history affects the acquisition of particular types of linguistic properties. In the next section (1.3), I discuss this hypothesis further, by relating acquisition to language processing.

## 1.3 Early vs. late language learners: fundamental difference or continuity?

Differences and similarities between early and late language learners are important to understand the relation between their two languages, that is, their degree of separation, in both linguistic and cognitive terms. In contrast to first language learners, second language learners have already acquired a native language; their cognitive system is more mature and has developed domain-general abilities that can participate in language learning, and their final attainment is most usually not native-like. For all these reasons, early approaches to the study of second language acquisition capitalised on the qualitative difference between the learner's native language and the second language. According to the Fundamental Difference Hypothesis (Bley-Vroman 1990, see 1.2), the ability to acquire language (or 'language acquisition device', Chomsky, 1965) in second language learners faces a challenge qualitatively different from first language acquisition: early contrastive accounts suggest that learners rely on similarities and differences between their native language and the target one, or that they develop a linguistic system separate from both L1 and L2 ("interlanguage", Selinker, 1972). Mediating between these two approaches, the concept of "transfer", as defined by Odlin (1989), highlights the influence of the native language on the language being acquired.

Crucially, all these accounts focus on linguistic structures: for instance, transfer is characterised as the influence of structures of one linguistic system on the other. Structures include categories, rules, relations and vocabulary entries (ibid., p. 31) and may be grammatical, semantic, pragmatic or cultural; they have "something to do with the storage of two knowledge systems within the same brain" (ibid., p. 28; see also Selinker, 1972, pp. 211-212). In this sense, the nature and main goal of these accounts is *representational*, that is, they aim at clarifying the properties of the learner's linguistic knowledge, focusing on the representational differences between the L1 and L2 grammars. For instance, consider the variability between and within late second language learners in some morpho-syntactic phenomena, such as finiteness, negation and inflectional morphology. According to some early studies, this variability is due to the fact that L2 learners cannot acquire hierarchical syntactic

structures but only linear strings (Meisel, 1997), or that their grammar contains defective functional categories (Hawkins & Chan, 1997; Beck, 1998). In such accounts, reference to non-structural factors is limited (e.g., individual variation, personality, motivation, see Odlin, 1989, Ch. 8), and almost no reference is made to the mechanisms or processes through which that knowledge is acquired (Hulstijn, 2002; Clahsen & Felser, 2006).

An alternative account of differences between first and second language acquisition focuses instead on processing mechanisms. According to the Shallow Structure Hypothesis (Clahsen & Felser, 2006, 2017), L2 learners can use the same processing mechanisms for sentence processing as L1 speakers; however, reduced knowledge of the target language (e.g., incomplete mastery of inflectional properties) increases the cognitive demand and drains the resources available for processing. For example, in the case of resolution of syntactic ambiguity, even if adult learners can access multiple cues, such as syntactic dependencies and lexico-semantic information, they seem to only rely on lexico-semantic, or non-structural, information (Clahsen & Felser, 2006). Therefore, adult learners engage in language processing in a qualitatively different way from native speakers: the syntactic representations that adult L2 learners compute for comprehension are shallower and less detailed than those of native speakers. Even if the Shallow Structure Hypothesis focuses on differences in processing mechanisms, it still shares two important aspects with representational accounts: first, differences between first and second language acquisition are reduced to a 'fundamental difference', and second, the motivation for this difference is ultimately to be found in the incomplete grammatical representations of L2 learners.

Other accounts focus on processing aspects, discarding the notion of 'fundamental differences' between L1 and L2 learners, and capitalise on the distinction between competence and performance to explain systematic traits of variability in bilingual acquisition. For example, with respect to morpho-syntactic acquisition, studies have shown that despite inflectional errors for tense and agreement, L2 learners do not use finite verbs in non-finite contexts (Prévost & White, 2000), and show a well-developed structure of the sentence and an abstract representation of tense and agreement (Lardiere, 1998). These studies suggest that

these patterns of errors in L2 speakers do not stem from an impairment of their grammatical knowledge, but rather from problems with the realization of surface morphology: limitations to processing capacity due to communicative pressure may lead them to use default inflectional forms (Missing Surface Inflection Hypothesis, Prévost & White, 2000; Haznedar, 2003).

A global reduction in processing capacity may also explain why L2 speakers show difficulties in integrating different types of information in on-line sentence comprehension: in a noisy condition, native speakers performed a word-monitoring task in the same way as second language learners, i.e. they failed to integrate syntactic and semantic information (Kilborn, 1992). In a similar line, the Interface Hypothesis (Sorace & Filiaci, 2006; Sorace, 2011, 2016) compares native-like performance of L2 speakers on narrowly syntactic phenomena, to their difficulties with structures at the interface between syntactic and extra-syntactic domains, such as discourse-pragmatics, like pronouns: these difficulties seem to be due to their reduced ability to integrate multiple sources of information, such as grammatical features and pragmatic or contextual conditions. This hypothesis is supported by studies showing non-native-like pronominal resolution in otherwise near-native bilingual speakers of Italian (Belletti, Bennati, & Sorace, 2007; Tsimpli, Argyri, Sorace & Heycock, 2004; Sorace & Filiaci, 2006; see chapter 7 for a detailed discussion).

A study by Hopp (2010) also finds that the performance of L2 speakers and the performance of native speakers in a stress condition (speeded grammaticality judgements task) are comparable, and gives further support to the view that there are no fundamental differences in grammatical representations nor in processing mechanisms between L1 and L2 speakers. He compares groups of L2 speakers with different degrees of proficiency and different L1 on case-marking in German, both with off-line measures (grammaticality judgements) and on-line measures (reading times). He finds an effect of L2 proficiency, in that only highly proficient speakers attain native-like performance in both grammatical knowledge and processing patterns. He also finds an effect of L1, as highly proficient speakers whose L1

differs from German from the point of view of subject-verb agreement perform poorer at increased processing demand conditions.

In these studies (e.g. Hopp 2010, Kilborn 1992), the lack of automaticity in L2 processing (which can be considered a basic difference between L1 and L2) is examined in terms of task demands such as time limits, noise, and communicative pressure. These factors affect processing capacity, a main component of which is working memory, that is, the ability to store information temporarily to make it available for processing. As it allows to store chunks and series, working memory (as defined by Baddeley & Hitch, 1974) contributes to language acquisition, for instance in terms of the development of phonotactic abilities, as well as word learning (see Szmalec, Brysbaert & Duyck, 2012) and it correlates with accuracy measures of sentence comprehension (Daneman & Carpenter, 1980; Daneman & Merikle, 1996) as well as processing speed (MacDonald, Just & Carpenter, 1992). Its role in second language acquisition and processing is supported by studies showing that differences in working memory in L2 speakers predict variability in morpho-syntactic and sentence processing, in both active and passive modalities, and in both oral and written form (Juffs & Harrington, 2011). However, the effects of individual variability in working memory seem to be mediated by further cognitive factors, such as attentional control (Novick, Trueswell & Thompson-Schill, 2005; Cunnings, 2017). In the next chapter, I will discuss further aspects that relate bilingual processing to attentional control, and I will discuss this relationship more in depth in chapter 3.

To summarise, early accounts focused on a fundamental difference between first and second language acquisition, either in terms of grammatical representations or in terms of processing mechanisms; this difference is related to the effect of age on the ability to acquire language. In contrast, more recent accounts focus on processing mechanisms, and support a continuity between first language and second language acquisition, in terms of the available mechanisms for linguistic development and processing. They also highlight the contribution of linguistic properties (e.g. cross-linguistic differences in certain types of structures) and of cognitive factors, such as working memory and attention. These factors also play a role in first

language acquisition and seem to be related to the variability between L2 speakers' attainments, suggesting that their effects may be exacerbated in the second language. In chapter 7, I will discuss this point in more detail.

## 1.4 Interim conclusion

The studies reviewed in this chapter show that the bilingual's two languages develop as distinct linguistic systems, however, they often interact with one another. This interaction appears to depend on language exposure, age of acquisition and type of linguistic properties. A key to understanding the role of these variables is provided by studies showing how processing factors contribute to linguistic attainment (1.3): different linguistic backgrounds represent different circumstances that affect how language processing is engaged. Thus, the studies discussed here discard the idea of a "fundamental difference" between first and second language speakers, and also suggest that variability in language processing across bilinguals is related to aspects of their experience as well as to cognitive factors, and may be independent of cross-linguistic differences. This chapter thus opens the following question: can we find linguistic effects of the bilingual experience, independently of phenomena of interference due to linguistic differences? And in what circumstances? In chapter 7, I address these questions experimentally. In the next chapter, I will expand on the link between language processing and cognitive resources in bilinguals. In chapter 3, I will then discuss how the bilingual experience may affect the management of cognitive resources non-specific to language.

# 2. Language co-activation during processing

As discussed in the previous chapter, research on bilingual language acquisition and learning has shown that the two languages develop as separate systems, however, cross-linguistic interference can be observed in both early and late bilinguals, in a variety of circumstances depending on features of the languages being acquired and on the linguistic experience of the speakers. Recent accounts of bilingual language development approach these issues in terms of processing factors. The mutual influence between the two languages is therefore a fundamental focus of interest in research on bilingual language processing. A central discovery in this field is the fact that the two languages are always active, to some degree, and thereby interact with one another. In this section, I review studies that show the extent of this parallel co-activation, and the mutual interaction of the two languages, that is, not only the influence of L1 on L2, but also vice versa. Research presents different hypotheses regarding the mechanisms that allow the two languages to be accessed separately, and the way these mechanisms interact with language experience, in terms of language proficiency, exposure and age of acquisition, and language-independent factors such as inhibitory control. The importance of the mutual influence of the two languages and of different aspects of the bilingual experience also emerges from the fact that bilingual processing is often examined comparing performance in L1 vs. performance in L2, rather than comparing bilinguals to monolinguals. In this chapter, I first review studies on language comprehension at the lexical level (2.1) and at the semantic level (2.2); I then examine word production (2.3) and I conclude considering the sentence level (2.4).

## 2.1 Lexical access in language comprehension

Despite early studies suggesting selective and independent access to each lexicon (e.g. Gerard & Scarborough, 1989; see Dijkstra, 2005), research on language comprehension suggests that bilingual word recognition occurs in a non-selective way, that is, searching through both lexicons. For example, lexical decision (deciding whether a word is real) in one language is facilitated after reading cognates in the other language, but slowed down after homographs and homophones (Dijkstra, Grainger & Van Heuven, 1999). Similarly, a bigger neighbourhood size (i.e., the number of words that can be obtained by varying only one letter of a given word) *within* languages facilitates word recognition, whereas a bigger neighbourhood size *across* languages results in the opposite effect (Van Heuven, Dijkstra & Grainger, 1998). These findings show that information at the semantic, orthographic and phonological levels from both languages interact in word recognition; in addition, this interaction has been found in both directions: from the L1 to the L2, as well as from the L2 to the L1 (Duyck, 2005).

The view that lexical representations are accessed in an integrated way is at the basis of the Bilingual Interactive Activation model (BIA, Dijkstra et al., 1999; Dijkstra & van Heuven, 2002; Thomas & van Heuven, 2005), a computational model that extends the Interactive Activation model of orthographic processing in visual word recognition of McClelland and Rumelhart (1981) to the bilingual domain. As illustrated in figure (2.1), the BIA model simulates the presentation of visual input containing letters: visual features of the letters at specific positions excite letter representations that contain these features, and inhibit those that do not; next, the excited letters spread the activation to words in both languages that contain those letters, and then the activation is passed on to language nodes, which in turn excite all the words from the same language and inhibit words from the other one. At the word level, word candidates within languages inhibit each other. After a few cycles of activation and inhibition that spread in both directions (i.e., up and down the four levels), the word that best matches the input reaches the threshold for recognition.

However, this model is not explicit with regards to the baseline level of activation of words from different languages. Studies show that these baseline levels may be modulated by the participants' proficiency, as reflected by asymmetries in cross-linguistic effects: while inhibition of L2 words after the presentation of L1 homographs also occurs in low proficient bilinguals, the opposite – inhibition of L1 words after the presentation of L2 homographs – only happens in proficient speakers (Bijeljac-Babic, Biardeau & Grainger, 1997; Jared & Kroll, 2001); in addition to language dominance, language fluency and the composition of the experiment's lists also modulate the magnitude of the effect, as performance in the L1 decreases after intensive exposure to L2 (Jared & Kroll, 2001).

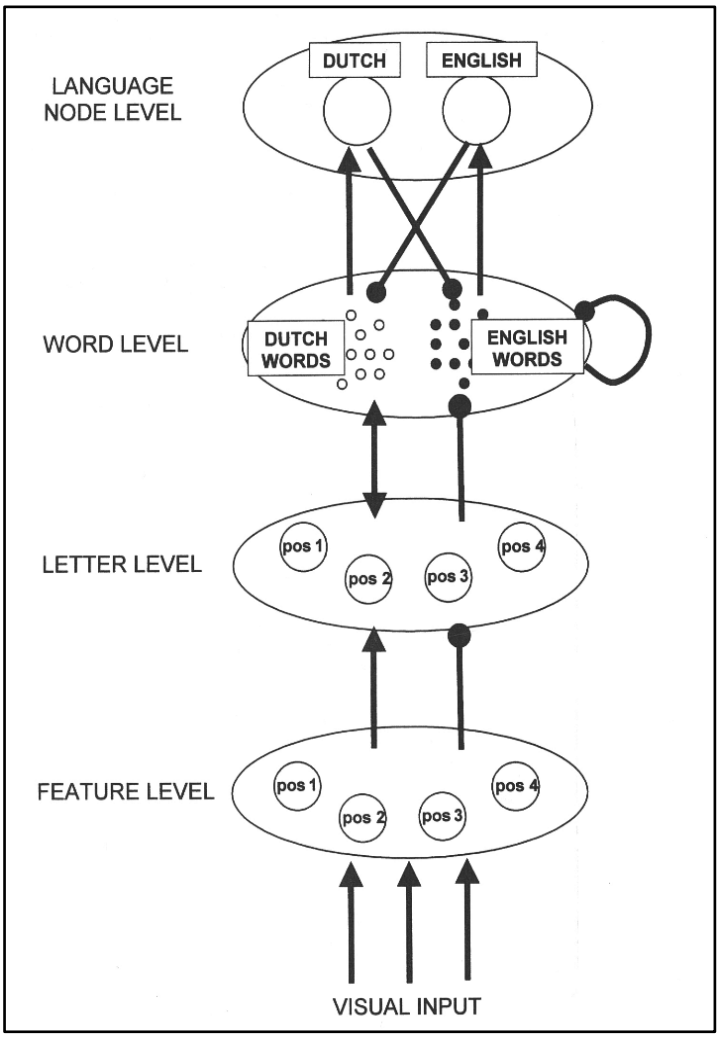



Figure 2.1 - Bilingual Interactive Activation model, from Thomas & Van Heuven, 2005. Arrows represent activation, circles represent inhibition.

The BIA model presents further limitations. First, it focuses only on the orthographic level, but cross-linguistic effects are also present when words are presented aurally (Weber & Cutler, 2004), and independently of orthography, as for example across languages with different scripts, such as Hebrew and English (Gollan, Forster & Frost, 1997). Secondly, it does not differentiate between processing and representational aspects of language nodes, therefore failing to explain how these are recruited and affected by both linguistic and non-linguistic context, and ultimately by aspects of the bilingual experience beyond proficiency, such as age of acquisition and exposure (but see the BIA+ model for an updated version of the BIA that approaches these aspects, Dijkstra & van Heuven, 2002).

## 2.2 Semantic access

The findings discussed in 2.1 support the view that lexical representations are accessed in an integrated way. But what about semantic and conceptual representations? Do words in the two languages map onto common conceptual representations, or are there separate conceptual structures? Various studies have addressed cross-linguistic effects at the semantic level. For example, semantic priming (i.e., naming a target word is facilitated after the presentation of a prime word semantically related to the target) also happens when the prime is presented in one language and the target word in the other language (de Groot & Nas, 1991). Cross-linguistic priming also occurs with negative priming paradigms (where the prime word needs to be ignored), causing inhibitory effects (Fox, 1996). Taken together, these results suggest that semantic representations are accessed in both languages, even without the speaker's awareness.

However, in Fox's (1996) study, negative priming occurred in both directions (L1 prime→L2 target and L2 prime→L1 target) if prime and target were translation equivalents, but only in one direction (L1 prime→L2 target) if prime and target were just semantically associated. Asymmetric directionality of cross-linguistic semantic interference is also reported by Kroll and Stewart (1994), where semantic interference happened only when fluent but

unbalanced bilinguals where translating words from the L1 to the L2, but not in the opposite direction. These results are explained by means of a model of semantic access, the Revised Hierarchical Model (RHM, Kroll & Stewart, 1994; Kroll & Tokowicz, 2005, see fig. 2.2). In the RHM, L1 words are more strongly connected to concepts than L2 words, which are, instead, more strongly connected to their corresponding translation in L1. Therefore this model posits a limitation to language non-specific access, in that access to L2 is mediated via access to the L1 translation equivalent.

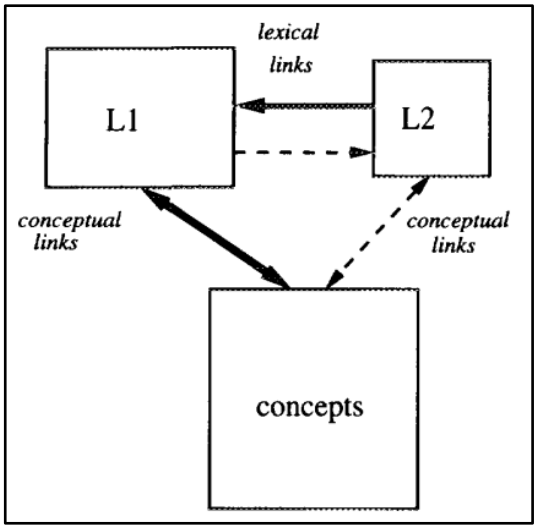



Figure 2.2 - Revised Hierarchical Model from Kroll & Stewart, 1994. The dashed line represents weaker links than the full line.

Various studies have shown that the degree of mediation of the L2 via the L1 is modulated by aspects of the bilingual experience. Talamas, Kroll and Dufour (1999) compared high and low proficient bilinguals using a translation recognition task (given a pair of words, participants decide whether the second word is the correct translation of the first one). In one condition, the two words were orthographically related, in the other condition, they were semantically related. The results showed that less proficient bilinguals were slower and less accurate in the form-related condition, whereas the more proficient ones were more affected

by semantic similarities. This study supports the RHM in showing semantic access to the L2 via the L1, and, crucially, it also shows that this asymmetry is mediated by language proficiency.

A separate study compared three groups of bilinguals (early proficient bilinguals, late proficient bilinguals and late less proficient ones) using a lexical decision priming paradigm with three types of L2-to-L1 primes (i. semantic primes, ii. mediated form primes, i.e. the translation of the prime word is orthographically and phonologically associated to the target word, and iii. form primes, i.e. orthographically and phonologically associated). Semantic and mediated form primes produced facilitation in early bilinguals only, whereas late proficient bilinguals showed inhibitory effects with form primes, and late less proficient bilinguals showed no priming effects in any condition (Silverberg & Samuel 2004). These results stress the role of age of acquisition, beyond proficiency, on L2 via L1 semantic integration.

More recent investigations looked into the effect of a further aspect of the bilingual experience on cross-linguistic interference: language exposure, which, as discussed in 1.1, is an important proxy for language dominance. Linck, Kroll and Sunderman (2009) compared two groups of highly proficient bilinguals: students immersed in a semester abroad and students at home, who were only exposed to their L2 in the classroom. In a translation recognition task from L2 to L1, with pairs of words in conditions similar to the mentioned study by Silverberg and Samuel (2004), immersed bilinguals displayed reduced interference from form neighbours, but more interference from semantic neighbours than non-immersed bilinguals. Linck and colleagues interpreted these results as evidence that immersed bilinguals processed the L2 more deeply, and suffered interference from the L1 less than non-immersed bilinguals.

Taken together, these studies complement the RHM showing that semantic access in bilinguals is not language specific, in that the L1 systematically interferes with the L2, but the degree of symmetry of language interference depends on proficiency, age of acquisition and exposure, in that bilinguals at the low end of the spectrum (low proficient, late bilinguals with less L2 exposure) are less likely to show L1 semantic interference, and more likely to show

lexical interference, while bilinguals at the high end of the spectrum show the reversed pattern, as well as more influence of the L2 on the L1.

However, further findings come at odds with the predictions of the RHM, showing highly proficient bilinguals systematically accessing the L1 through the L2. For instance, Marian and Spivey (2003) showed that Russian-English bilinguals looked at pictures of objects that have a Russian name orthographically related to the English target object as much as they would look at pictures of the English distractors, thereby showing automatic access to the L1 lexical representation in a context entirely in their L2. Similarly, Thierry and Wu administered a semantic relatedness task to Chinese-English bilinguals using English words only: half of the pairs of words, while unrelated in meaning, were orthographically (Thierry & Wu, 2007) or phonologically (Wu & Thierry, 2010) related in Chinese. Even if behavioural accuracy in the task was unaffected by the experimental manipulation, the participants' brain potentials showed an effect of form priming, i.e. a modulation of the N400 component. Unconscious access to L1 through L2 is also shown across modalities by a study examining bilinguals of American Sign Language (ASL, L1) and English (L2, Morford, Wilkinson, Villwock, Pinar & Kroll, 2011). A study by Guo and collaborators (2012) used a design similar to the study by Thierry and Wu (2007) but manipulated the amount of time that participants had to judge the semantic relatedness of the two L2 words: their results show that the activation of the L1 translation equivalent is accessed *after* the L2 word is understood (Guo, Misra, Tam & Kroll, 2012). Overall, these studies show that the L1 is *always* activated during L2 word processing, unconsciously, even in highly proficient bilinguals and in unilingual contexts, and even if it does not seem to functionally mediate L2 access – thereby showing the limitations of the RHM.

## 2.3 Word production

In comprehension, bilinguals cannot choose the language to use, whereas this choice – as well as the ability to subsequently restrict their production to the intended language at every

processing step – is entirely up to them in production (although, of course, as a function of the context). Moreover, while word recognition is primarily a bottom-up process, word production is a top-down one. So how is bilingual production restricted to the target language? As the choice of the target language has to do with both the linguistic and non-linguistic context, it is believed to take place at the higher, conceptual level (Costa, 2005; Green, 1998). But then, is lexical selection restricted to the lexical nodes of the target language or does it examine all candidates, independently of the language? Studies addressing this question present three possibilities, thereby dividing into language specific approaches, language non-specific approaches (or competition approaches), and frequency-based approaches.

### *2.3.1 Language-specific approaches*

Language-specific approaches posit a 'binding-by-checking' mechanism (see Costa, 2005), or a 'mental firewall' mechanism (Kroll & Gollan, 2015), by which, if the language of the lexical node does not match the intended language, the node is discarded. A study by Costa, Miozzo and Caramazza (1999) evaluated this hypothesis using a picture-word interference paradigm, in which Catalan-Spanish bilinguals named pictures in Catalan after either Catalan or Spanish distractors. According to the authors, if lexical access were not language specific, the translation equivalent would induce interference, i.e. it would activate lexical nodes from the non-target language to enter in competition with the target word. If, instead, the translation equivalent in the non-target language activates the corresponding semantic representation in the target language, this could then activate its corresponding lexical nodes in the target language, thereby explaining the facilitation effect.

Costa and collaborators found that identical distractors (i.e. the same word as the target) facilitated naming independently of the language in which it was presented (i.e. the same word or its translation). This finding was interpreted as evidence that information at the semantic level activates lexical nodes in both languages, but only the lexical nodes in the target language are considered for selection. However, hardly any studies have addressed the nature

of these language-specific selection mechanisms nor provided further evidence for their existence (Kroll & Gollan, 2015).

### *2.3.2 Language non-specific approaches*

An alternative account of lexical selection focuses instead on language competition, positing that lexical nodes in the unintended language need to be suppressed to avoid interference. The Inhibitory Control model (IC, Green, 1998) assumes that the regulation of language processes is akin to the regulation of actions in general, and that it is achieved through a language-independent control mechanism, that reactively inhibits the lexical nodes in the unintended language after the specification of the target language. According to the IC model (see fig. 2.3), inhibitory control takes place outside of the lexico-semantic system, and it is realised by a supervisory attentional system (SAS) that regulates language task schemas, i.e. configurations of action sequences that define specific tasks, such as translating or repeating a word. The SAS operates is tandem with the conceptualiser, a system independent of language

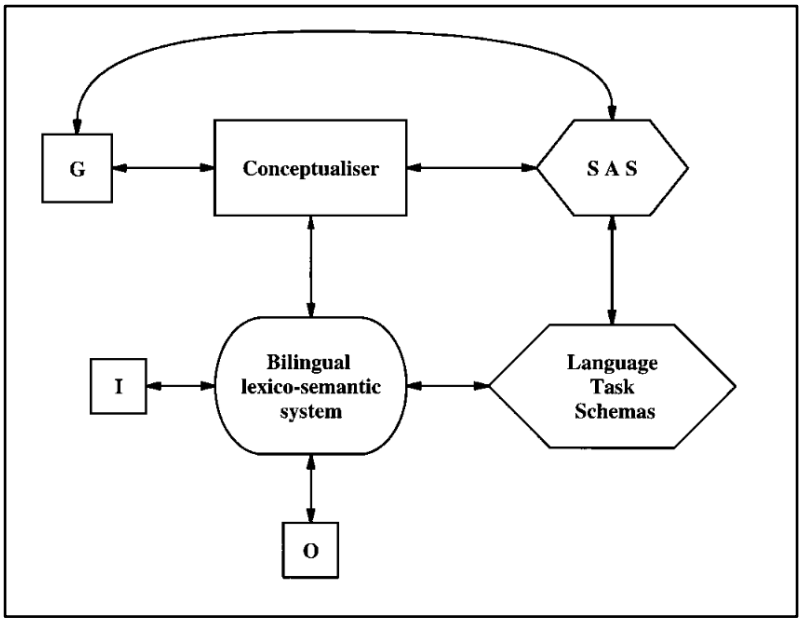



Figure 2.3 – Inhibitory Control model from Green, 1998

dedicated to building conceptual representations and choosing the target language, according to a specific goal (G).

Support for the competition approach can be found in cross-linguistic interference at the sub-lexical level, i.e. phonological or orthographical. According to a language-specific approach, if only the lexical nodes in the target language are selected, there should be no activation of the sub-lexical nodes relative to lexical nodes in the non-target language. However, this is not the case. For instance, phonological information of lexical items in the non-target language facilitates picture naming in the target language, as demonstrated by the fact that cognate words are named faster than non-cognate words (Costa, Caramazza & Sebastián-Gallés, 2000). Similarly, phonological information from the non-target language can interfere with phoneme monitoring tasks (deciding whether a sound is part of a given word) and naming in the target language (Hermans, Bongaerts, de Bot & Schreuder, 1998; Colomé, 2001; Schwartz, Kroll & Diaz, 2007; Martín, Macizo & Bajo, 2010).

Further support for the IC model can be found in studies on language switching. In cued language switching tasks, participants are asked to name pictures in either their L1 or L2, according to a visual cue. In some trials, the language to use is the same as the previous trial ('repeat' trials) while in other trials, the language is switched ('switch' trials). As in task switching, switch trials are slower than repeat trials: according to Green (1998) this happens because participants need not only to reconfigure the task schema (namely, the rule to follow or the language to choose) but also to inhibit the latest schema (the last language in use). According to the IC, switching from the less dominant language to the stronger one should give rise to longer latencies than vice versa, due to the stronger inhibition required to suppress the dominant language. This prediction is supported by studies of language switching that show asymmetric switch costs, i.e. bigger for the L1 than for the L2 (Meuter & Allport, 1999; Costa & Santestaban, 2004; Costa, Santesteban & Ivanova, 2006).

However, these studies also found overall longer naming latencies in L1 compared to L2, interpreted as a global effect of inhibition of the dominant language, i.e. at the whole language level, rather than trial by trial. While these findings are consistent with an inhibitory

account, such a global inhibition goes beyond the original proposal of the IC model. Recent studies suggest that these global effects may be due to other control components, such as proactive control, needed to pre-emptively counteract the activation of L1 (Ma, Li & Guo, 2016; Wu & Thierry, 2017). This hypothesis is supported by the fact that local and global effects are associated to different brain correlates (Guo, Liu, Misra & Kroll, 2011; Branzi, Martin, Abutalebi & Costa, 2014; Branzi, Della Rosa, Canini, Costa & Abutalebi, 2015)[1].

Moreover, the relation between control mechanisms and aspects of the bilingual experience is not specified in the IC account: while the magnitude of inhibitory effects appears to be modulated by language proficiency, as a proxy for dominance (e.g. Meuter & Allport, 1999; Costa & Santesteban, 2004; Costa et al., 2006), it has also been related to everyday frequency of language switching and context of use (Christoffels, Firk & Schillers, 2007; Prior & Gollan, 2011; Hartanto & Yang, 2016). The role of further aspects of the bilingual experience, such as language exposure and age of acquisition, and their effect on language competition, is still relatively unexplored. I examine this problem in chapter 6, presenting data showing the role of language proficiency, age of acquisition and language exposure on language control. In chapter 3 and 6 I discuss alternative models that appear of language control.

### *2.3.3 Frequency-based approach*

Finally, an account of bilingual lexical access focuses on lexical frequency across the two languages. A main assumption of this approach (Weaker Links Hypothesis, Gollan, Montoya, Cera & Sandoval, 2008, see also Kroll & Gollan, 2015) is that bilinguals are exposed to words in either language less frequently than monolinguals – an observation already proposed with

[1] However these studies define global and local control differently. Local control corresponds in all three cases to the mechanism at play at the level of the individual word, or trial. In contrast, global control corresponds to the mechanism responsible for production of the same lexical items in mixed-language contexts for Guo et al. (2011), but of different lexical items in Branzi et al., 2014, 2015. In these latter studies it thereby refers to control at the whole language level without the potential confound of lexical repetition. Branzi and colleagues refer to the global mechanism described by Guo and colleagues as 'local sustained' control.

respect to vocabulary growth in bilingual children by Pearson, Fernandez and Oller (1993), and strongly linked to the rate and trajectory of bilingual language acquisition, on the one hand, and language exposure, on the other (see 1.1). Lexical frequency is generally associated to ease of retrieval (either in terms of higher activation of frequent words, or in terms of stronger connections between them, see Gollan et al., 2008 for discussion). This approach therefore predicts that bilinguals should display longer naming latencies for low frequency words than monolinguals, as well as longer naming latencies for low frequency words in their non-dominant language compared to the dominant language. These frequency effects – demonstrated by studies such as Gollan et al. (2008) – are not directly predicted by the competition approach.

Additional evidence in support of the Weaker Links Hypothesis comes from studies on tip-of-the-tongue states (TOTs), i.e. the failure to retrieve a word associated with a feeling of imminent recall as well as access to partial information, such as length or first phoneme. TOT states are more frequent in bilinguals (Gollan & Silverberg, 2001), a fact compatible with both the competition approach and the frequency-based one. However, a study examining what conditions give rise to more TOTs in bilinguals shows that cognates are associated to *fewer* TOTs in bilinguals, and, independently of cognate status, the availability of the translation equivalent (i.e., knowing a word in both languages) also *decreases* the incidence of TOTs (Gollan & Acenas, 2004). While these results are hardly accounted for by a competition approach (which would predict stronger cross-language interference and therefore more TOTs in these two cases), they support the view that frequency across and within languages predicts lexical access in bilinguals. A similar conclusion is supported by a study on the effect of linguistic immersion on L1 production (parallel to studies on immersion in comprehension, see Linck et al., 2009 in 2.2). Baus, Costa and Carreiras (2013) examined immersed bilinguals longitudinally, i.e. at the beginning and at the end of a 6-month immersion period, on a picture naming task, and found longer naming latencies in L1 after the period of immersion for non-cognate words in comparison to cognates, in addition, the effects of immersion did not generalise to all words in the L1, supporting the independent effect of frequency on bilingual lexical access.

Even if in specific cases, such as the ones discussed, the competition approach and the frequency-based one make opposite predictions, these two accounts are not mutually exclusive – as also pointed out by proponents of the frequency-based approach (Gollan et al., 2008; Kroll & Gollan, 2015). This can be better understood in light of the distinction between global and local control mechanisms, as discussed above. For instance, frequency may play a role at a local level (word specific) and its effect could be, at least in some occasions, in the opposite direction than the effect of local inhibition (e.g. facilitation rather than interference). Therefore, in some circumstances local and global effects may be in divergent directions. This idea, albeit speculative, could explain differences in patterns of performance in language switching tasks, which may be modulated by specific aspects of the language experience of participants, as well as by task specificities (e.g., the composition of experimental lists of words, see Declerck & Philipp, 2015).

To conclude this section, among the accounts of lexical access in production, available findings support the competition approach, based on the role of language-independent control mechanisms, and the frequency-based approach. However, neither of these two approaches account for both local and global effects on language control. Before discussing in more detail further accounts of language control and reviewing research on the cognitive effects of language co-activation in the next chapter (3), I close this chapter discussing additional evidence for the co-activation of the two languages at the syntactic level.

## 2.4 Language co-activation at the sentence level

As discussed in the previous sections, bilinguals access lexical and semantic information in both languages in an integrated way – albeit to varying degrees as a function of their proficiency, age of acquisition and exposure, and characteristics of their languages such as lexical frequency. But what about language comprehension at the sentence level? Are both languages involved in syntactic processing? Several studies using syntactic priming paradigms

and event-related potentials (ERP) during sentence processing suggest that syntactic structures of one language are activated when processing the other language.

Syntactic priming occurs when the presentation of a prime sentence affects the processing of a target sentence containing a same or related structure, either facilitating it (e.g. enhanced recall) or modulating the likelihood of producing one structure over another. This phenomenon has been described as the persistence of syntactic representations, independently of lexical, semantic and phonological information, and it is useful to understand how syntactic structures are represented (Pickering & Branigan, 1999; Branigan, 2007; Tooley & Traxler, 2010). Syntactic priming has been shown to also occur across languages. For example, alternative dative structures in English (prepositional object vs. double-object) prime the production of the corresponding dative structure in German (German and English have both alternative structures), and vice versa (Loebell & Bock, 2003). However, not all structures show priming effects across languages: for example, passive structures do not show a priming effect between English and German (ibid.), but they do from Spanish to English (Hartsuiker, Pickering & Veltkamp, 2004), as passives in Spanish and English, but not in German, have the same word order. Similarly, relative clauses can be primed between German and Dutch, where these structures have the same word order, but not between Dutch and English, which differ from this point of view (Bernolet, Hartsuiker & Pickering, 2007). Also some structures that differ in the two languages can result in priming: among different passive structures in Dutch, not only the ones with the same word order prime the English passive, but also the ones with the same information structure (order of thematic roles, Bernolet, Hartsuiker & Pickering, 2009).

These findings are compatible with research on syntactic priming showing that the *locus* of priming can be found in context-free phrase structure rules specified for linear order (Branigan, 2007), although thematic and conceptual information also play a role (Cai, Pickering & Branigan, 2012; Griffin & Weinstein-Tull, 2003). Taken together, they suggest that at least some aspects of syntactic representations are shared between languages in bilinguals (Hartsuiker et al., 2004). Interestingly, the strength of cross-linguistic syntactic

priming effects – so, arguably, the degree of syntactic sharing between the two languages – is related to language proficiency, mirroring the effect of proficiency on integrated lexical and semantic access discussed above: more proficient bilinguals show stronger priming effects than less proficient ones (Bernolet, Hartsuiker & Pickering, 2013).

Also studies using ERP components during sentence processing support language co-activation at the syntactic level, and the modulating role of language history. For example, differences in the amplitude of components when reading English sentences show that Welsh-English bilinguals are ready to process a post-nominal adjective (ungrammatical in English), while English monolinguals are not: bilinguals seem to activate both syntactic systems, even when the two are incompatible in the current context (i.e., they are ungrammatical in the language in use, Thierry & Sanoudaki, 2012). In addition, the participants' relative fluency in the two languages modulates this effect, with highly fluent participants showing stronger effects and less fluent ones resembling English monolinguals (Sanoudaki & Thierry, 2015). Finally, another study found evidence of morpho-syntactic co-activation across languages, as Welsh-English bilinguals were faster to process English nouns manipulated according to the Welsh soft mutation (lenition of a set of initial phonomes after a determiner), than English nouns manipulated as to be ungrammatical mutations following the Welsh rule (Vaughan-Evans, Kuipers, Thierry & Jones, 2014).

These latter studies show co-activation of syntactic structures even in highly proficient bilinguals, and even when this may be detrimental to processing the target structure: from this point of view they support a non-specific account of language selection based on competition, extending it beyond the lexical level. However, the frequency of syntactic structures also seems to play a role in the degree of syntactic interference in sentence processing: in a study by Runnqvist, Gollan, Costa and Ferreira (2013), bilingual participants produced low-frequency structures slower than monolinguals. This finding supports and extends the frequency-based approach of language selection. However, it also shows the effect of cross-linguistic similarities on syntactic co-activation – broadly in line with the syntactic priming studies mentioned above: in the study by Runnqvist and colleagues, one bilingual group,

whose other language was similar to the target language from the point of view of the target structure, was faster in processing the target sentence then the second bilingual group, whose language instead differed from the target language.

To conclude, the research discussed in this section suggests that syntactic representations are shared across the bilinguals' two languages, although the degree of such co-activation is affected by distributional properties (i.e. frequency) and linguistic properties of syntactic structures (such as cross-linguistic similarities like word order), as well as by aspects of the linguistic experience, such as proficiency (operationalised for instance as fluency). However, the specific contribution as well as the possible interaction of these factors (together, arguably, with task specificities) still awaits further clarification, in particular to understand the scope and the nature of the mechanisms responsible for language selection.

## 2.5 Interim conclusion

Recent research on language processing supports integrated models of language access in bilinguals, and shows not only that L1 affects L2, but also vice versa: lexical, semantic and syntactic information is accessed in parallel in a variety of tasks (both in comprehension and in production), independently of the speaker's awareness. The magnitude and directionality of language co-activation is modulated by proficiency, age of acquisition, and language exposure. These findings therefore add substantial insight into early ways of thinking about the development and processing of L2, such as the Fundamental Difference Hypothesis (see 1.3), and support a continuity account of the ability to learn and process the two languages – that is, through integrated mechanisms and resources.

This idea, together with evidence for the mutual influence of one language over the other, suggests that the two languages of a bilingual are plastic and adaptive systems, from both a linguistic and a cognitive point of view. From the linguistic point of view, this adaptability is reflected by research on variability in bilinguals (e.g. Kilborn 1992; Sorace &

Filiaci, 2006, see 1.3), which shows how L2 attainment is modulated by a variety of aspects independent of grammatical knowledge and linked to processing factors; linguistic plasticity is also discussed by research on language attrition (e.g. Köpke & Schmid, 2004; Schmid, 2007), dedicated to understanding how the L1 changes through cross-linguistic influence and patterns of language exposure. From a cognitive point of view, the plasticity of bilingual language processing is reflected by its interactions with domain-general abilities, such as control mechanisms, as anticipated in chapter 1, and motivated in this chapter. In chapter 3, I will further discuss control mechanisms, also considering neuroimaging research that describes the computational challenge specific to the bilingual brain.

However, this field of research leaves open questions, concerning the degree of permeability of the L1 to the L2, which appears in some cases more pronounced in bilinguals at the high end of the spectrum (e.g. highly proficient, early bilinguals), while in other cases the opposite pattern is found (the L2 is more permeable to the L1): different linguistic levels (e.g. semantic vs. phonological) may be more or less open between languages, and potentially sensitive in different ways to factors such as proficiency, age of acquisition and language exposure – similarly to as was shown in bilingual language acquisition and learning (see chapter 1). In the next chapter I evaluate models of language control alternative to the IC model; in chapter 6, I will examine how these aspects shape the ability to switch languages in highly proficient bilinguals.

# 3. The relationship between bilingualism and executive functions

In the previous chapter, I discussed integrated models of language access that account for the fact that the two languages are simultaneously active, which is widely documented through experimental evidence. The competition-based model suggests that language co-activation is managed by an inhibitory control mechanism (Green, 1998). However, various aspects of bilingual processing seem to be affected by distributional properties of the linguistic input and modulated by aspects of the language experience, which suggest that there may be different components of control that operate at different levels (e.g., global, the level of the whole language system, vs. local, the level of individual representations). In this section, I discuss theoretical and empirical approaches to this issue. Specifically, I first examine the relationship between language processing and cognitive control (3.1); I then review alternative models of control mechanisms in bilinguals (3.2) and focus on the relationship between language control and cognitive control (3.3). Finally, I examine extensive research on the effects of bilingualism on cognitive control (3.4), and other cognitive abilities (3.5).

## 3.1 The relationship between language processing and cognitive control in the brain

The integrated models of language access discussed in chapter 2 provide support for the continuity hypothesis in bilingual language learning discussed in chapter 1, that is, the idea that the same mechanisms serve both languages. This conclusion is also supported by neuroimaging studies, showing that the two languages are implemented in the brain by the same functional network (Abutalebi, 2008). Extensive neuropsychological and neuroimaging research has showed that, even if language processing involves different types of computations implemented in different regions of the brain, there is a set of brain regions consistently

engaged in language comprehension and production: areas of frontal, temporal and parietal cortices, connected in a network via two dorsal and two ventral pathways through the white matter (Friederici & Gierhan, 2013; Fedorenko & Thompson-Schill, 2014, fig. 3.1). The stability of these patterns of activation and of connectivity suggests that the language network is indeed an integrated and stable functional system of the human brain (Fedorenko, 2014).

Of course, the fact that the two languages of a bilingual speaker are implemented by the same network does not exclude differences in processing between the two, but it explains these differences in terms of plastic adaptation of a single network to the use of two languages, rather than in terms of 'fundamental differences' (see 1.3), and predicts the mutual effects of the two languages on each other (Abutalebi, 2008; Abutalebi & Green, 2007; Buchweitz & Prat, 2013). Likewise, the convergence of both languages onto a single network does not imply that this network is activated exclusively or exactly in the same way by L1 and L2 processing: for example, various studies found more extended activations for L2 than L1, primarily in the prefrontal cortex, in particular at low levels of proficiency and of exposure (Abutalebi & Green, 2007, 2008; Hernandez, 2009; Buchweitz & Prat, 2013).

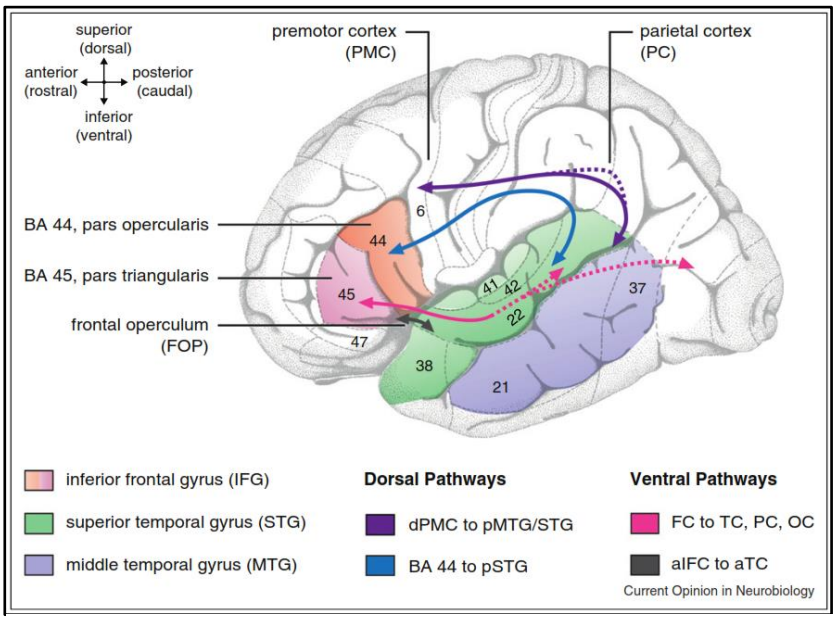



Figure 3.1 - Language network. From Friederici & Gierhan, 2013. dPMC: dorsal premotor cortex; pMTG/STG: posterior and middle temporal gyrus; FC: frontal cortex; TC: temporal cortex; PC: parietal cortex; OC: occipital cortex; aIFC: anterior inferior frontal cortex

These activations are outside the language network *stricto sensu* as described above, and include cortical areas in the prefrontal, parietal and anterior cingulate cortex as well as subcortical structures (Abutalebi & Green, 2007, 2008, 2016). Studies of patients with frontal lesions as well as neuroimaging data show that these areas belong to a separate network, involved in a variety of domain-general, goal-directed behaviours, such as attentional control, planning, set-shifting – that is, executive functions (Koechlin, Ody & Kouneiher, 2003; Jurado & Rosselli, 2007; Cole & Schneider, 2007; Fedorenko, 2014; see fig. 3.2).

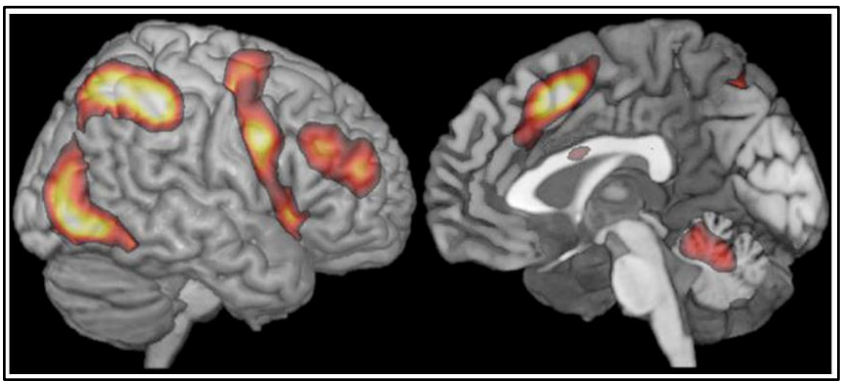


Figure 3.2 - Control network. A group-level representation based on average activity in left and right hemispheres during the following tasks: arithmetic addition, spatial working memory, verbal working memory, multi-source interference task (MSIT), a verbal version of MSIT, and Stroop (data from Fedorenko et al., 2013). Adapted from Fedorenko, 2014.

As anticipated in 1.3, the engagement of executive functions in language processing is well-attested by behavioural studies: for example, in order to understand ambiguous sentences, the listener needs to integrate multiple sources of information and override the preference or automaticity of a particular interpretation – a process that involves conflict detection and resolution (Novick, Trueswell & Thompson-Schill, 2005) and that improves after executive functions training (Novick, Hussey, Teubner-Rhodes, Harbison & Bunting, 2013). Studies on pronoun processing also show a relation between components of executive functions (working memory) and strategies for referential resolution (Nieuwland & van Berkum, 2006; Nieuwland 2014). In language production, the relationship between linguistic

computations and control mechanisms is supported, for instance, by studies showing the role of top-down attentional mechanisms and goal-directed processing on speech production (Strijkers, Holcomb & Costa, 2011; Strijkers, Yum, Grainger & Holcomb, 2011). The interaction – and yet the functional separation – of language and control networks in the brain is finally attested by several neuroimaging and neuropsychological studies in both monolinguals and bilinguals (Fedorenko, 2014; Ye & Zhou, 2009; Buchweitz & Prat, 2013; Abutalebi & Green, 2008, 2016).

In bilinguals, the interaction of language and control networks has been studied in particular in relation to language competition (Abutalebi & Green, 2008). Brain activity appears to be modulated by different levels of language competition, i.e. global, the level of the whole language system vs. local, the level of individual representations (see also 2.3). Competition at these two different levels gives rise to distinct ERP components (Branzi et al., 2014), and while both (global and local) language control effects map onto prefrontal and inferior parietal areas, local control also activates the dorsal anterior cingulate cortex and the pre-supplementary motor area (Branzi et al., 2015; Guo et al., 2011, but see note in 2.3.2).

Taken together, these findings show a relation between language-specific and domain-general control mechanisms, such as executive functions, but also suggest that language control is probably the result of other mechanisms beyond inhibition. But what are executive functions *exactly*? Executive functions are a set of high-level cognitive abilities that regulate and coordinate behaviour, facilitating cognitive adaptation and flexibility. However, executive functions are difficult to test in the laboratory, because of a) task impurity (tasks may require other abilities beyond executive functions), b) low correspondence between processes and behaviours (i.e., executive functions are related to many behaviours, and one behaviour may require more components of executive functions), c) task specificities and d) poor ecological validity. For all these reasons, while frequently mentioned and extensively studied, executive functions are unclearly defined and researchers do not agree on what the exact components are (Jurado & Rosselli, 2007). Moreover, executive functions differ considerably across individuals: these individual differences are the result of both developmental and genetic

factors, and challenge empirical measurements even further (Miyake et al., 2000; Miyake & Friedman, 2012; Friedman, 2016; Braver, Gray & Burgess, 2007; see 3.2 for a discussion of how some models of executive control discuss individual differences, and chapter 5, for a discussion of this problem from a methodological point of view).

While some approaches to the study of executive functions aim at identifying and separating different components ("divide and conquer" approach, Stocco & Prat, 2014), other approaches highlight the dynamic inter-dependence of different components. These two approaches agree about the core components of executive functions, including processes such as inhibition and goal-maintenance, as well as working memory (Stocco & Prat, 2014, Jurado & Rosselli, 2007); however, these approaches vary with regards to how they specify the mutual relations between control components. In the next section, I discuss influential models of executive control of particular relevance for research on bilingualism.

## 3.2 Models of cognitive control in bilinguals

While an extensive discussion of models of executive functions is beyond the scope of this work, in this section I focus on a set of models of cognitive control that are highly relevant for the study of bilingualism, either because they have been elaborated in this area of research or because they have been directly evaluated through empirical approaches in the study of bilingualism. As it will be discussed in detail in 3.4 and in chapter 5, research on bilingualism makes reference to a variety of models, and often to generic formulations of executive functions, that are not explicit about what the relevant components are, or that do not consider the problem of individual differences. Here, I identify a set of models to which these various approaches can be reduced to. These models capture main theoretical differences and are linked to methodological choices in the study of the effect of bilingualism on executive functions (see 3.4). They agree on one core component of executive functions, namely inhibition (figure 3.3). The seminal model in this set is the IC model by Green (1998), which, as discussed in 2.3.2, is based exclusively on inhibitory control and focuses primarily on its

effects at a local level, i.e. the individual linguistic representation. Other models posit further mechanisms of control, and by doing so overcome some limitations of the IC model, such as the existence of different levels of control, the interaction between them, and the source of individual differences.

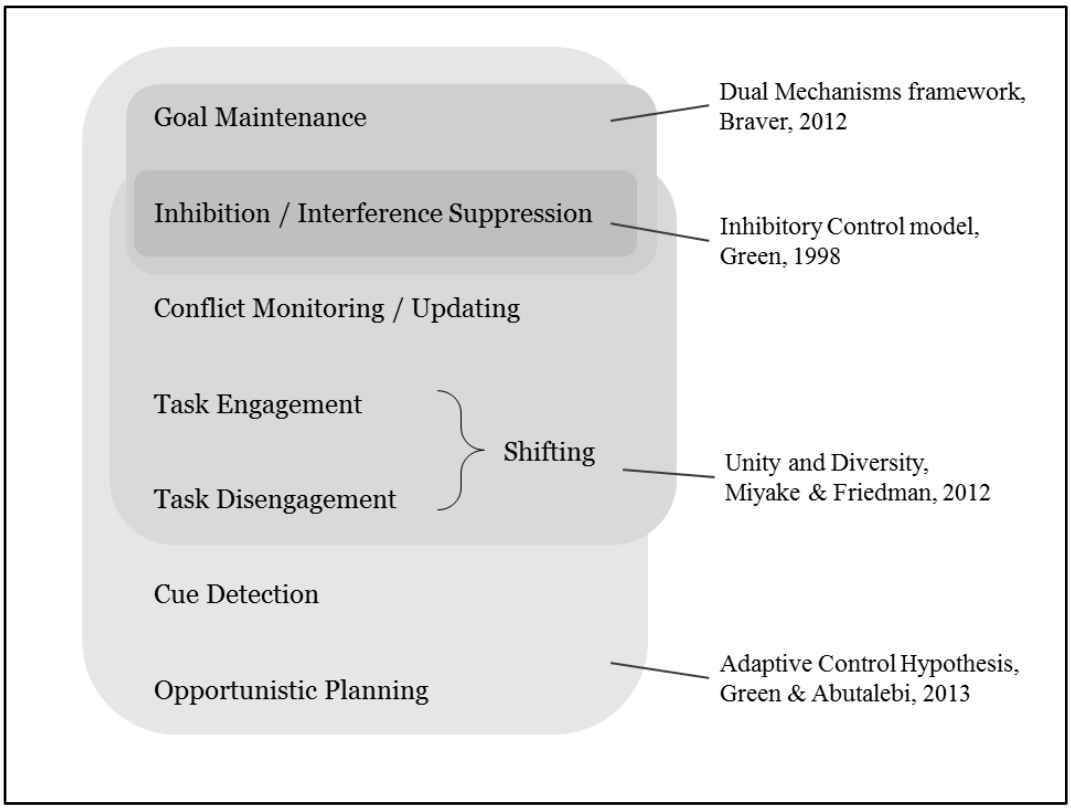



Figure 3.3 – Schematic representation of control mechanisms according to four control models.

### *3.2.1 Dual mechanisms framework*

An important model of cognitive control is the dual mechanisms framework (Braver et al., 2007; Braver, Paxton, Locke & Barch, 2009; Braver, 2012). This model approaches the problem of variability in cognitive control (i.e. differences within and between individuals as well as between groups) by postulating two distinct, but inter-dependent, mechanisms: reactive and proactive control. Reactive control is dedicated to the suppression of interference, and it

is recruited as a late correction, just-in-time mechanism – similarly to the inhibitory control mechanism postulated by Green (1998). Proactive control is a sustained type of attention dedicated to optimally orienting action and perception towards a goal. These two mechanisms are associated to the activity of different neuro-transmitters and with different time-courses, as well as with different localizations in the brain (while both mechanisms engage the prefrontal cortex, reactive control is also implemented in the anterior cingulate cortex, among other areas, while proactive control involves the midbrain dopamine system, i.e., subcortical pathways, Braver et al., 2007).

Postulating two distinct mechanisms may appear a non-parsimonious answer to the question of how cognitive control is carried out. However, Braver and colleagues argue that the existence of two mechanisms represents a computational trade-off that allows processing to be optimized in a flexible way (Braver et al., 2007; Braver, 2012). Moreover, the dual mechanisms framework explains individual variability in terms of differences in how individuals combine proactive and reactive control: while good cognitive control is the result of an optimal combination of the two, individuals (or groups, such as old adults vs. young adults) may rely more on one type of control than the other. The spatial and temporal interaction of these two components is reflected by different patterns of activation of brain areas in different populations exhibiting different control preferences (i.e. old adults, who are biased toward reactive control, and young adults, who prefer proactive control, Braver et al., 2009). For all these reasons, the dual mechanisms framework represents a biologically plausible model of cognitive control. With regards to language control in bilinguals, this framework seems to fit the distinction between global and local control described in 2.3 and 3.1 – whereby proactive control could be responsible for the global level, and reactive control for the local one. This is also suggested by studies on language mixing, that associate a proactive, global mechanism to mix costs (i.e. the difference between naming latencies in a single-language context and in a mixed-language context in language switching paradigms) and an inhibitory, local mechanism to switch costs (i.e. the difference between naming latencies when switching languages in successive trials, Ma, Li & Guo, 2016; Wu & Thierry, 2017; see chapter 6). Research on the dual mechanisms framework produced a laboratory task

of continuous performance that allows to test for differences in cognitive control (the AX-Continuous Performance Task, see 3.4 and chapter 5).

### *3.2.2 Unity and diversity*

An alternative approach to the problem of measuring and defining executive functions is the "unity and diversity" approach (Miyake et al., 2000; Miyake & Friedman, 2012). This account aims at capturing the organization of different executive functions components by analysing the correlations between several common tasks (the Wisconsin Card Sorting Test, Tower of Hanoi, random number generation, operation span and dual tasking; see Miyake et al., 2000). Miyake and colleagues' analysis highlights three components: inhibition, updating (i.e. monitoring and updating information stored in working memory), and shifting (i.e. the ability to switch between tasks). These components appear to be clearly distinguishable, in that they contribute differentially to performance on executive functions tasks, but they are not completely independent but rather correlated (hence the expression "unity and diversity"). In particular, all tasks appear to correlate with the inhibitory component, while the variance between the tasks is driven by the other two (shifting and updating, ibid.).

The "unity and diversity" approach allows the measurement of individual variability in executive functions and overcomes the problem of task impurity; however, it is not theoretical explicit (i.e. it is data-driven), nor does it suggest biological or computational ways in which it could be implemented in the brain/mind. With regards to the first point, it can be noted that different authors seem to interpret this approach more in favour of the "diversity" point of view (e.g. Stocco & Prat, 2014) or the "unity" point of view (e.g. Jurado & Rosselli, 2007). However, the "unity and diversity" model approaches the definition of executive functions is a way similar to the dual mechanisms framework: as the dynamic inter-dependence of distinct mechanisms. Nonetheless, lack of theoretical description and of biological or computational modelling make Miyake and colleagues' approach difficult to test.

### *3.2.3 Adaptive control hypothesis*

Like Green's IC model, the adaptive control hypothesis (Green & Abutalebi, 2013; Abutalebi & Green, 2016) is also specifically elaborated in relation to bilingual language control, and it also assumes a direct relation between language control and cognitive control (see 3.3 for a discussion of research that does not support such direct overlap). According to the adaptive control hypothesis, just as speakers adapt to the context from the linguistic point of view (e.g. by choosing a language or a register), control mechanisms also need to adapt to the context. The adaptive control hypothesis fundamentally extends the IC model, considering the interactional costs of not adapting to the context, and the fact that in language, but not in action in general, adaptation is particularly important (i.e., while carrying an object with one hand or the other leads to the same result, i.e. it is an *equifinal* solution, producing a sentence in one language or the other does not). Also, in line with what discussed so far, the adaptive control hypothesis acknowledges that linguistic competition extends over the whole speech production pipeline, so that there are different targets and different levels for control.

Consequently, Green and Abutalebi describe various interactional contexts that affect language control and multiple control mechanisms. Specifically, they identify three contexts for language control: single language (each language is spoken at the exclusion of the other, and the two languages compete), dual language (both languages are spoken but with different interlocutors, thus they compete), dense code-switching (the two languages are systematically integrated, so they do not compete but rather co-operate). These three contexts impose specific demands on language control mechanisms, that is, they may recruit some mechanisms but not others. Specifically, Green and Abutalebi posit eight control mechanisms (see fig. 3.4), which can be reduced to seven, by combining selective response inhibition and interference suppression (see Green & Abutalebi, 2013, p. 519; see fig. 3.3), or to six, if we consider task engagement and task disengagement as the two aspects of shifting (as in the "unity and diversity" approach).

Unlike the models discussed previously, the adaptive control hypothesis directly predicts the effects of language experience on the engagement of control processes, in particular of exposure and frequency of language switching (see also Green & Wei, 2014), a prediction supported by neuroimaging studies showing different cortical and subcortical activations in different language contexts (Abutalebi & Green, 2016). However, the specific nature of each of these eight mechanisms (or a different number, as discussed above) is not clear, nor is their interaction, or the way they take place at different linguistic levels (e.g. global vs. local, see Abutalebi & Green, 2016). Therefore, the adaptive control hypothesis is also a model difficult to test.

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

Figure 3.4 –Adaptive Control Hypothesis. Demands on language processes in bilingual speakers as a function of the interactional context relative to demands on the processes in monolingual speakers in a monolingual context. + indicates the context increases the demand on the control process (more so if bolded); = indicates that the context is neutral in its effects. Adapted from Green & Abutalebi, 2013.

To summarise this section, among models of interest for research on bilingualism, some (the IC model and the adaptive control hypothesis) have been elaborated specifically for bilingual language control, while others (dual mechanisms framework and "unity and diversity" approach) have been proposed outside this area of research but they have been evaluated and applied to the study of bilingualism in various ways, as I will discuss in section 3.4. All these models agree with the IC model in positing a crucial role of inhibition, however, they also propose further mechanisms. These mechanisms are argued to be *distinct but inter-dependent* – that is, optimal cognitive control is the result of a *dynamic combination* of distinct mechanisms, which depends on the individual and on the context – hence the link to individual

differences and the role of linguistic experience. However, among these models, the dual mechanisms framework is the only explicit model, that is, the only one that describes the scope of each mechanism, their time course, neural substrates and interactions.

### 3.3 The relationship between language control and cognitive control

As previously discussed (2.3.2; 3.2.3), an assumption common to the IC model and to the adaptive control hypothesis is that language is a type of action, so it possibly requires similar monitoring and regulating processes as other non-linguistic types of action. While intuitive, this point raises the issue of language-specificity vs. domain-generality of processes involved in language. The relationship between domain-specific and domain-general functions with respect to language has been hotly and constantly questioned in language research, from the extensive debate on domain-general learning mechanisms in language acquisition (e.g. Tomasello, 2000) vs. a domain-specific language acquisition device (e.g. Chomsky, 1965), to the quarrel about the functional specialisation of the language network in the brain (see Fedorenko & Thompson-Schill, 2014). A review of this considerable literature is outside the scope of this thesis. Here, I assume, in line with recent neuroimaging and neuropsychological research (Fedorenko, 2014), that linguistic computations are subserved by domain-specific mechanisms in conjunction with domain-general ones: the open question is not whether domain-general mechanisms participate in language processing, but *to what extent* and *under what circumstances* bilingual language processing recruits domain-general control mechanisms.

As anticipated above, domain-general control mechanisms seem to overlap with language control: neuroimaging studies using tasks of linguistic and non-linguistic control reveal an overlap of cortical activations in the two (e.g., De Baene, Duyck, Brass, & Carreiras, 2015), and behavioural studies show correlations between linguistic and non-linguistic switching tasks (Declerck, Grainger, Koch, & Philipp, 2017; Prior & Gollan, 2011). However, the recruitment of domain-general control areas during language switching is more

pronounced in low proficient bilinguals (Abutalebi & Green, 2007, 2008), or when processing the less dominant language (Abutalebi et al., 2013), independently of age of acquisition (Hernandez, 2009), a result argued to reflect that increase in proficiency is accompanied by a shift from controlled to automatic processes (Abutalebi & Green, 2007). Further studies suggest that, although linguistic and cognitive control are related, language control is at least partially independent from cognitive control. For example, a study on language switching and non-linguistic switching shows that the correlation between language control and cognitive control is limited to the non-dominant language (Prior & Gollan, 2013).

Another study examining intrusion errors (e.g., using a word from one language when speaking the other one) showed that cognitive control affects the ability to produce the intended language, but its effect does not interact with the linguistic manipulation of the task (Gollan & Goldrick, 2016). In addition, various studies found unrelated patterns of performance in linguistic and non-linguistic switching tasks (Calabria, Hernández, Branzi & Costa, 2012; Branzi, Calabria, Boscarino, & Costa, 2016), as well as a different effect of ageing on the two abilities (with age affecting non-linguistic switching but not language switching, Calabria, Branzi, Marne, Hernández & Costa, 2015).

Taken together, these findings show that linguistic and cognitive control are relatively independent and that their overlap during language processing is limited to specific cases, such as at lower levels of proficiency. In addition, studies on language switching show that highly proficient bilinguals have symmetric switch costs in their two languages, as well as between their L1 and their much weaker L3, while low proficient bilinguals show asymmetric switch costs, possibly as the result of using different, domain-general control mechanisms rather than language control (Costa & Santesteban, 2004; Costa, Santesteban & Ivanova, 2006; Calabria et al., 2012). Finally, how individuals combine linguistic and non-linguistic control during non-linguistic tasks also seems to depend on their linguistic experience: for example, bilinguals, but not monolinguals, recruit language control during non-linguistic tasks, as reflected by brain activity in language areas (left inferior frontal cortex and left striatum) during a non-verbal switching task (Garbin et al., 2010).

To summarise, linguistic and cognitive control are relatively independent mechanisms, nonetheless, bilingualism affects the degree of mutual interaction between the two – such as resorting to cognitive control for linguistic tasks, and vice versa. In other words, the findings discussed in this section suggest that the bilingual experience may affect cognitive control mechanisms beyond the scope of language processing. I discuss research addressing this question – and its limitations – in 3.4, and I examine this question experimentally in chapter 5. Finally, this section stresses the importance of the question relative to the exact role of aspects of the bilingual experience on language control – raised in the previous chapter and addressed experimentally in chapter 6.

## 3.4 Effects of bilingualism on cognitive control

In the last fifteen years, extensive research has examined the effects of bilingualism on cognitive control, assuming, as it has been discussed so far, that the co-activation of bilinguals' two languages leads to competition, which needs to be managed through control processes. As discussed in 3.3, language control is at least in part independent from domain-general control. However, the relation between linguistic and cognitive control suggest that – at least in some circumstances – bilingualism may represent a form of training: the ability to manage competing languages may transfer to the ability to manage competing non-linguistic information. Research in this field has produced a multitude of divergent results and a heated debate (Bialystok, Craik & Luk, 2012; Costa & Sebastián-Gallés, 2014; Paap 2014; Paap, Johnson & Sawi, 2015, 2016; Valian, 2015). In this section, I focus on studies that examine models of control discussed in 3.2, highlighting the discrepancies in their findings and some factors that may explain them. Further critical discussion of this literature can be found in chapter 5, where I examine the possible causes of discrepancies by comparing the performance of four groups of bilinguals on a task of executive functions.

### *3.4.1 Examining inhibitory control*

Early studies on the cognitive effects of bilingualism started off with the examination of Green's IC model, and therefore adopted tests of inhibitory control. The most common tests are the Simon task, the Stroop task and the Flanker task, which all require participants to respond to stimuli presenting contrasting – albeit irrelevant – information. The Simon task presents coloured targets (e.g. red and blue circles) and participants are instructed to respond with the right button to one target, and the left button to the other target. However, targets may appear either on the right or on the left of the screen, thereby matching or mismatching the location of the response button. Mismatching (or incongruent) trials typically yield longer response times. In the (non-verbal) Stroop task, targets can be arrows pointing right or left: participants have to respond on the basis of the direction of the arrow (e.g. right or left button), which matches or mismatches the position of the arrow on the screen (e.g. right or left side of the screen). Finally, the Flanker task presents a series of arrows, either in the same direction (e.g. → → → → →) or in contrasting directions (e.g. → → ← → →): participants need to answer on the basis of the direction of the central arrow (e.g. right or left button), while flanking arrows represent either matching or mismatching distractors.

Several studies adopting these paradigms have shown better performance in bilingual participants than in monolingual participants. For example, Bialystok, Craik, Klein and Viswanathan (2004) showed that bilingual participants responded faster than monolinguals on both congruent and incongruent trials in a Simon task, and also displayed a reduced incongruency effect; moreover, the difference between bilinguals and monolinguals was bigger among older participants. Tao, Marzecová, Taft, Asanowicz and Wodniecka (2011) showed that bilinguals outperformed monolinguals on a Flanker task, independently of age of L2 acquisition. In another study, bilingual participants outperformed monolinguals on a Stroop task, but not on a Simon task; in addition, bilinguals' performance on the two tasks differed (i.e. the Stroop effect was bigger than the Simon effect), while monolinguals performed in similar ways on the two tasks (Blumenfeld & Marian, 2014). These results support the idea – discussed in 3.3. – that bilinguals may recruit qualitatively different control mechanisms than monolinguals, but also suggest that these tasks may not correlate (see 3.4.2 for more

discussion). Interestingly, though, in this last study the difference between the Stroop and the Simon effect in bilinguals was modulated by the participants' bilingual experience: it was bigger in the group that reported more intense code-switching (in line with the adaptive control hypothesis, i.e. that different control mechanisms are engaged according to the interactional context, see 3.2.3). Similarly, bilinguals with more experience of daily language switching outperformed bilinguals with less switching experience on a Flanker and a Simon task, even at comparable levels of language proficiency (Verreyt, Woumans, Vandelanotte, Szmalec & Duyck, 2016). Finally, similar advantages have been found in bilingual children compared to monolingual children (e.g. Martin-Rhee & Bialystok, 2008; Poarch and van Hell, 2012; Poulin-Dubois, Blaye, Coutya & Bialystok, 2011).

In contrast, other studies did not find these effects. For example, Kousaie and Phillips (2012) compared non-immigrant bilinguals to monolinguals (and both young vs. old in a 2x2 design) on a Stroop task: while young bilinguals were generally faster than monolinguals, they displayed comparable incongruency effects; in addition, older participants did not show an effect of bilingualism. In another study, large samples of monolingual and bilingual participants showed comparable performances on both the Simon and the Flanker task (as well as on an antisaccade task and a task-switching task, Paap & Greenberg, 2013). A further study also examined a large database of participants to investigate the relation between age of acquisition, relative proficiency in the two languages and number of languages spoken on the performance of a similar battery of tests, and found no evidence for a bilingual advantage (Paap, Johnson & Sawi, 2014). Similarly, Paap and Sawi (2014) also did not find differences in the performance of bilinguals and monolinguals; interestingly, they examined bilingual participants with different linguistic experience, operationalised as a continuous measure, and analysed using regression. Finally, various studies reported no differences between bilingual and monolingual children on the Stroop and the Simon tasks (e.g., Namazi & Thordardottir, 2010; Esposito, Baker-Ward & Mueller, 2013; Duñabeitia et al., 2014).

### *3.4.2 Beyond inhibitory control*

As discussed in 3.1 and 3.2, the discrepancy between the findings reported in 3.4.1 may be related to the fact that the Simon, Stroop and Flanker tasks do not correlate with each other (Speckman, Rouder, Morey & Pratte, 2008; Pratte, Rouder, Morey & Feng, 2010; Miyake et al., 2000), thereby possibly reflecting different components of executive control, and the fact that the bilingual experience may involve more and diverse aspects of executive control (Hilchey & Klein, 2011). One particular study supports this possibility, by showing that the amount of monitoring required by a Flanker task affects the size of the incongruency effect and ultimately the 'appearance' or 'disappearance' of a bilingual advantage (Costa, Hernández, Costa-Faidella & Sebastián-Gallés, 2009). Together with the studies discussed in 3.4.1, this last finding suggests that the search for an effect of bilingualism on cognitive abilities requires the adoption of different models of executive control, that posit further components beyond inhibition, such as the dual mechanisms framework (reactive and proactive control) or the "unity and diversity" approach (inhibition, updating and shifting) – and consequently the use of different tasks sensitive to these components.

In keeping with the "unity and diversity" approach, Prior and MacWhinney (2010) compared bilingual and monolingual participants on a task-switching task, which taps into inhibition, but also monitoring and shifting processes. Bilinguals showed reduced switch costs (switching from one set of rules to the other in successive trials) compared to monolinguals, but no difference in mix costs (the difference between applying the same set of rules in a mixed-rule context and in a same-rule context), thereby suggesting different cognitive effects in the two groups, beyond inhibitory processes. Marzecová et al. (2013) also showed reduced switch costs in bilinguals, compared to monolinguals, in a switching task. Using a similar approach, Yow and Li (2015) examined a large group of bilinguals with different backgrounds on a battery of tasks, and found a positive effect of balanced proficiency on both a switching task and the Stroop task.

Other studies adopting the same approach found different performances between bilinguals and monolinguals in task-switching tasks, but no advantage (i.e. no reduced switch

costs in bilinguals). For instance, Prior (2012) did not find a reduction of switch costs, but a delay in reaction times in bilinguals. Different patterns of performance on a switching task between bilinguals and monolingual participants, but no difference in switch costs, are also reported by Hernández, Martin, Barceló and Costa (2013). Finally, other studies did not find any difference in task-switching performance: Kalia, Wilbourn and Ghio (2014) compared early and late bilinguals to monolinguals, and found no difference between early bilinguals and monolinguals and a disadvantage in late bilinguals; in addition, a comparison of bilinguals vs. monolinguals and musicians vs. non-musicians (in a 2x2 design) also did not reveal any difference in task-switching related to bilingualism (but found a positive effect of musical training, Moradzadeh, Blumenthal & Wiseheart, 2014).

In line with these studies, which suggest a modulation of control components other than inhibition – albeit with various and divergent results – it is also worth mentioning two studies by Morales and colleagues, who adopted a task of continuous performance (AX-CPT, see chapter 5 for a discussion of the paradigm) inspired by research on the dual mechanisms framework. Bilinguals outperformed monolinguals on critical trials requiring both proactive and reactive control (Morales, Gómez-Ariza & Bajo, 2013), and the analysis of ERP components showed different neural engagement in bilinguals compared to monolinguals (Morales, Yudes, Gómez-Ariza & Bajo, 2015, for further discussion of these studies see chapter 5).

Taken together, these findings do not support the existence of a 'bilingual advantage' (nor of a disadvantage) in cognitive control, but suggest a modulation of control components in bilinguals – that is, 'different styles' of engagement of cognitive control. Further studies support this view: for example, a comparison of bilingual and monolingual participants on a target-stimulus locating task (a spatial priming paradigm) found both reduced interference effects in bilinguals and larger inhibition of return effects (i.e. lower accuracy or longer reaction times on trials in which the target to be located is in the same position as the distractor in the previous trial, Treccani, Argyri, Sorace & Della Sala, 2009). This study suggests that differences in the engagement of inhibitory control may lead to apparent advantages (reduced

interference effects) as well as apparent disadvantages (larger measures for disengagement), depending on the nature of the task. Using a similar task, Mishra and colleagues (2012) also found a modulation of inhibition of return effects in bilinguals, related to L2 proficiency: highly proficient bilinguals showed increased inhibition of return effects compared to low proficient bilinguals, but with an earlier onset – suggesting a stronger engagement of inhibition but also a quicker disengagement (Mishra, Hilchey, Singh & Klein, 2012). Similarly, Grundy and Keyvani-Chahi (2017) report comparable magnitudes of inhibition of return in bilingual and monolingual children, but an earlier disappearance in bilinguals (i.e. the effect disappears after fewer trials in bilinguals compared to monolinguals, suggesting again a quicker disengagement). Two other studies did not find differences in inhibition of return effects between bilinguals and monolinguals (Hernández, Costa, Fuentes, Vivas & Sebastián-Gallés, 2010; Colzato et al., 2008). Colzato et al. (2008), however, discuss this result from the point of view of potential differences – between bilinguals and monolinguals – not only of reactive mechanisms but also proactive mechanisms, and the way these two are combined – coherently with the dual mechanisms framework.

### *3.4.3 Divergent results and possible causes*

To summarise, a multitude of studies on the effects of bilingualism on cognitive control fail to support the unequivocal existence of a 'bilingual advantage'. Taken together, they speak of possible *modulatory* effects of the bilingual experience on control mechanisms, but they do not say to what extent and under what circumstances this modulation occurs.

With regards to the role of specific aspects of the bilingual experience, research shows a scattered picture: studies that found cognitive benefits usually associate them to the higher end of the bilingual spectrum (e.g. higher proficiency: Hommel et al, 2011; Bialystok & Feng, 2009; Rosselli et al., 2016; Krizman, Skoe, Marian & Kraus, 2014; earlier age of acquisition: Schroeder & Marian, 2012; Pelham & Abrams, 2014; Tao et al., 2011; Carlson & Meltzoff, 2008; Kapa & Colombo, 2013; more experience with language switching: Festman, Rodriguez-Fornells & Munte, 2010; Verreyt et al., 2016; Prior & Gollan, 2011; Soveri,

Rodriguez-Fornells & Laine, 2011), but the exact role of these variables on mechanisms of control is not explicit, and many studies do not support their role at all (e.g. proficiency and age of acquisition: Kalia et al., 2014; Paap et al., 2014).

A methodological look at this extensive body of research suggests some possible causes for such a discrepancy (also extensively discussed, e.g. Paap et al., 2015). First, different studies have examined different bilingual populations (adults vs children, early vs late bilinguals, different language combinations and patterns of use), also, many studies present mixed bilingual samples (i.e. groups of individuals with different language combinations and backgrounds, broadly matched for age of acquisition and proficiency, e.g. Bialystok, Craik & Ruocco, 2006; Bialystok, Craik & Ryan, 2006, Bialystok et al., 2008, Morales et al., 2013, Moradzadeh et al., 2014; Paap & Sawi, 2014) or monolingual participants who study or know an L2, albeit with low to medium proficiency (e.g., Bialystok et al., 2004; Bialystok, Craik & Ryan, 2006; Marzecová et al., 2013; Morales et al., 2013; Paap & Greenberg, 2013; Paap & Sawi, 2014). These recruitment choices reveal empirical challenges for the study of bilingualism and reflect the fact that bilingualism is not a dichotomous variable (Luk & Bialystok, 2013; Bak, 2016). While the examination of different types of bilingual experience is key to the identification of the specific circumstances under which cognitive effects – if any – can be observed, the confusion of these variables is likely to cause non generalizable results.

Secondly, another cause of divergence among existing studies may be due to the use of analytical techniques that do not take into account individual variability – a key factor in executive functions, as discussed above (e.g. Braver et al., 2007; Miyake et al., 2000). For instance, the majority of studies in this field of research use ANOVA (most often these are studies finding a 'bilingual advantage', e.g., Bialystok et al., 2004, Bialystok, Craik & Ruocco, 2006; , Bialystok, Craik & Ryan, 2006, Bialystok et al., 2008; Marzecová et al., 2013; Mishra et al., 2012; Morales et al., 2013, 2015; but also studies that did not find these effects, e.g. Gathercole et al., 2014; Hernandez et al., 2013; Duñabeitia et al., 2014), and only a minority adopt techniques that allow the inclusion of individual variability, such as regression analysis

(e.g. Soveri et al., 2011; Yow & Li, 2015; Paap & Sawi, 2014; Paap et al., 2014). In chapter 5, I discuss these methodological problems further, and I show their impact on the detectability and the generalisability of cognitive effects of bilingualism. Before that, I conclude this chapter reviewing literature on other cognitive effects of bilingualism, which are tightly related to executive functions.

## 3.5 Further cognitive effects of bilingualism

As discussed in the previous section, research on the effects of bilingualism on cognitive control presents inconclusive results. However, other studies show that bilingualism has an effect on other cognitive abilities, related to executive functions, and fundamental for the development of communicative and social skills.

The pragmatic ability to adjust one's linguistic behaviour to the context is one such example. As discussed in chapter 1, 2-year old bilingual children can choose each language according to the interlocutor, use translation equivalents appropriately and recast their utterances with interlocutors who do not speak the language in use (Nicoladis & Genesee, 1996; Nicoladis, 1998; Genesee et al., 1995). This linguistic ability is connected to the understanding that people around us may speak different languages. Bilingual children seem to develop this skill earlier than monolingual children, as shown by a study comparing 20-month-old bilingual and monolingual children: while monolinguals were surprised when watching a third-party scenario with actors speaking in different languages, bilinguals were not (Pitts, Onishi & Vouloumanos, 2015).

Understanding that people may speak different languages is related to understanding that people have different mental states, desires and beliefs. This is a key component of Theory of Mind (ToM), a cognitive ability fundamental for communicative and social purposes and specific to humans (at least in its fullest sense, Call & Tomasello, 2008), that children develop around 4 years of age. Kovács (2009) hypothesised that bilingualism could improve ToM

development, either because of frequent language switching (as a form of different mental states among interlocutors), or indirectly through enhanced executive functions, which play a role in the ability to suppress one's own point of view (e.g. Nilsen & Graham, 2009). She found that bilingual 3-year old children outperformed age-matched monolinguals on both a standard false belief task (an actor hides an object in one location, in their absence another actor moves the object to a different location, and children are asked where the first actor will look for the object) and a linguistic one (the two actors do not speak the same language), suggesting that bilinguals' better performance was not only driven by experience with language-switching, but also reflected enhanced ToM. An advantage in ToM tasks has also been found in bilingual adults compared to monolingual adults (Rubio-Fernández & Glucksberg, 2012); in addition, bilingual children outperformed monolingual children on a task of communicative perspective taking, which also requires the ability to suppress egocentric points of view (Fan, Lieberman, Keysar & Kinzler, 2015).

Finally, bilingual children also appear to develop an understanding of pragmatic conventions (such as communicative maxims) earlier than monolingual children (Siegal et al., 2010), as well as metalinguistic awareness (Bialystok & Barac, 2012). Taken together, these skills – ToM, perspective taking, and communicative awareness, which are related to executive functions – are also implicated in general cognitive development. A study comparing students' outcome in Norwegian municipalities (where one or two written standards are used) supports the link between bilingualism and general cognitive abilities showing better outcomes in bilingual municipalities, after controlling for several indexes of socio-economic status (Vangsnes, Söderlund & Blekesaune, 2017).

## 3.6 Interim conclusion

The relationship between language and other cognitive abilities is well established in research on language. As discussed in this section, it appears to be modulated by the bilingual experience: non-linguistic control mechanisms interact with language control, depending on

aspects such as language proficiency, age of acquisition, frequency of switching. Four main models of cognitive control have been discussed to clarify this relationship; while they all consider inhibitory control, some posit further mechanisms and highlight that cognitive control is the result of a dynamic modulation of these mechanisms – thereby being open to the effect of linguistic experience as well as to individual differences. The vast research examining the effects of bilingualism on cognitive control has produced divergent results, and three main reasons have been put forward – insufficient link between theory and laboratory tasks, differences in bilingual populations, and inadequate analytical strategies. Following this discussion, in chapter 5 I will show the effect of these aspects on research on the cognitive effects of bilingualism, and in chapter 6 I will show the role of dimensions other than proficiency on language control.

# 4. Summary of the literature review and research questions

In this short chapter I recap the conclusions drawn from the literature reviewed in the previous three chapters, I formulate three research questions and introduce the experimental studies in which I address them.

In chapter 1, I discussed the development of the two languages as distinct linguistic systems, and how it is affected by the quality and quantity of linguistic exposure as well as by age. With respect to exposure, I discussed its relationship to bilinguals' linguistic performance, that is, its importance in understanding linguistic development and interference phenomena between the two languages. With respect to age, I presented two contrasting approaches: representational approaches that focus on 'fundamental differences' between first and second language acquisition, on the one hand, and on the other hand processing-based approaches that stress the role of cognitive aspects on the variability of bilinguals' linguistic performance. Both these approaches acknowledge the role of linguistic experience and of cross-linguistic similarities on the development of the two languages; however, only the latter approach suggests the possibility of independent effects of these two aspects. Therefore, this chapter raises a question as to whether the bilingual experience and certain types of linguistic properties give rise to cognitive contexts (characterised for instance by high processing demands) where we can observe different language processing strategies, independently of cross-linguistic differences.

The cognitive aspects of bilingual language processing were described in chapter 2, where I discussed evidence in favour of the simultaneous co-activation of the two languages, that is, behavioural and neural effects of the mutual influence of one language on the other. Competition and facilitation effects depend on cross-linguistic similarities (e.g. semantic vs. phonological similarity) as well as on aspects of linguistic history, in particular proficiency,

but also language exposure and age of acquisition. The available evidence, however, mismatches the existing theoretical models of language access, as empirical findings show both local and global effects of control over language competition (i.e., at the level of the individual representation vs. at the whole language level), while theoretical models focus primarily on local effects. Therefore, this chapter suggests the importance of examining the modulation of global and local effects of language control in language access, and the specific role, in shaping these effects, of dimensions of the bilingual experience beyond proficiency (the role of which has been examined previously): exposure and age of acquisition.

Chapter 2 also introduced the question as to whether the mechanisms recruited for language control are language-specific or domain-general. I explored this question in chapter 3, where I discussed theoretical models of control, and evidence in favour of partial independence of linguistic and cognitive control mechanisms. The relationship between linguistic and cognitive control appears to be modulated by the bilingual experience. Specifically, highly proficient bilinguals seem to recruit a linguistic control mechanism different from the one recruited by low proficient bilinguals, as demonstrated by language switching performance, as well as by neuroimaging data showing a wider involvement of the executive functions network in less proficient bilinguals during linguistic tasks. However, in some cases bilinguals also seem to recruit linguistic control for non-linguistic tasks. These findings suggest mutual influence of linguistic and cognitive control in bilinguals, however, studies addressing this issue provide inconclusive results. Therefore, chapter 3 introduces the importance of testing for the effects of bilingualism on cognitive control taking into account theoretical and methodological aspects that, as I discuss, hinder the generalisability of available findings (i.e. need of an explicit model of executive control in bilinguals, individual differences in executive functions, and selection of bilingual samples).

On these bases, I formulate the following research questions:

1. What are the effects of the bilingual experience on executive control, and what are the crucial factors to consider in the study of this relationship (study 1)?

2. How is the ability to handle competition between the two languages modulated by linguistic experience (study 2)?
3. Does the bilingual experience affect language processing independently of cross-linguistic interference (study 3)?

In what follows, I present three studies that address different aspects relevant for research on bilingualism: the cognitive effects of bilingualism (study 1), language control (study 2) and bilingual language processing (study 3)[2]. By doing so, I aim to integrate these sub-fields of research. In these studies, I examine groups of bilinguals with different experiences, in order to understand how relevant dimensions of their linguistic experience affect cognitive control, linguistic control and linguistic processing. Specifically, I tested the following groups:

1. Italian-dominant speakers, i.e. native Italian speakers living in Italy, with low to moderate knowledge of a second language (English) and low to moderate passive exposure to it;
2. Italian-English bilinguals, i.e. late, highly proficient bilinguals, native speakers of Italian who have been immersed in an English speaking context on average for three years before testing;
3. Italian-Sardinian bilinguals, i.e. early, highly proficient speakers of both languages, who live in Sardinia, where both languages are used (although Sardinian is the minority language);
4. Italian-Sardinian Passive bilinguals, i.e. early bilinguals who predominantly speak Italian but have a passive knowledge of Sardinian, who also live in Sardinia.

The first study (chapter 5) examines the cognitive effects of bilingualism addressing the need of a theoretically explicit model of executive functions, of the inclusion of measures of individual variability, and of the comparison of different groups of bilinguals. On the basis of

[2] These studies are presented in the format of independent papers. Chapter 5 and 6 have been submitted to peer-reviewed journals. Authorship and submission details are indicated in the subheading of each chapter as well as in the Declaration page.

the dual mechanisms framework, presented in chapter 3, I adopted the AX-Continuous Performance task (AX-CPT), which taps into proactive and reactive control. In a first analysis of accuracy on aggregated measures (that does not include individual variability), I find an advantage in early highly proficient bilinguals over late passive bilinguals. However, once I factor individual variability into the analysis, this advantage is not significant anymore. This study shows that bilinguals at the high end of the bilingual continuum (early highly proficient ones) optimally combine proactive and reactive control, but, ultimately, this ability seems to be primarily mediated by individual differences.

In the second study (chapter 6) I examine language access in two groups of highly proficient bilinguals using a cued language switching task, that is, looking into both language switch and mix costs. I focus on how these effects are modulated by proficiency, age of acquisition, language exposure and frequency of switching using regression analysis on naming latencies. My results show that the ability to switch between languages is not only modulated by proficiency, but also by exposure. This variable also affects language mixing. Age of acquisition, instead, predicts overall naming latencies in the L2. Together, these findings show that language access is shaped by multiple aspects of the bilingual experience, which together contribute to the definition of language dominance.

In the third study (chapter 7), I analyse the processing of Italian null and overt pronouns, which have been shown to be subject to variability across bilingual groups by previous research. I combine off-line and on-line measures using a Visual World eye-tracking paradigm and a forced-choice task. In experiment 1 I study Italian-dominant speakers, and I find a processing asymmetry between null and overt pronouns. In experiment 2 I examine Italian-English bilinguals, whose processing and interpretational measures do not differ from those of Italian-dominant speakers (in contrast to existing findings). Italian-Sardinian bilinguals (experiment 3), in contrast, show no difference between on-line measures for null and overt pronouns, supporting the hypothesis – advanced in chapter 1 – of linguistic effects of bilingualism independent of cross-linguistic differences (as both Italian and Sardinian allow null and overt pronouns and have similar pronominal inventories). These effects seem to be

specific to early, highly proficient bilinguals, however, as in experiment 4, Italian-Sardinian Passive bilinguals show the same pattern of processing and interpretational measures as Italian-dominant speakers.

As I will discuss in chapter 8, together these studies show the effects of specific aspects of the bilingual experience on both linguistic and cognitive processing, and suggest further links between these two domains.

# 5. Cognitive control in bilinguals: language experience and individual variability

(This paper has been submitted to *Bilingualism, Language and Cognition* in September 2017 and it is currently under revision. Bonfieni designed the study, ran the participants, analysed the data and wrote the original manuscript. Branigan, Pickering and Sorace acted as supervisors, gave feedback on each of these steps and contributed to the revision of the manuscript.)

## 5.1 Introduction

The relation between the bilingual linguistic experience and cognitive control has been the object of extensive research over the last 15 years. The acquisition and use of more than one language provide an ideal context for the study of cognitive plasticity, because the two languages of a bilingual are always active to some degree and interact with one another (Marian & Spivey, 2003; Blumenfeld & Marian, 2013; Thierry & Wu, 2007; Wu & Thierry, 2010; Thierry & Sanoudaki, 2012). The mechanisms underlying the ability to select the relevant language and to inhibit the irrelevant one may lead to a transfer of abilities to other cognitive domains, such as the ones responsible for selective attention and goal orientation, i.e. executive functions. Therefore, some aspects that characterise the bilingual experience may result in cognitive enhancement on non-verbal tasks engaging cognitive control. The hypothesis of a 'bilingual advantage' has been subject of extended research and controversy, as we discuss below; for this reason, in this study we consider theoretical and methodological aspects of that research that may limit its empirical generalizability. Specifically, we adopt a theoretically motivated experimental task that targets specific aspects of cognitive control; we compare different groups of bilinguals that represent a range of bilingual experiences, in order to identify what critical variables may result in a cognitive advantage, and we employ analytical techniques that account for the effects of individual variability.

The neurosciences and cognitive psychology provide evidence for a relationship between language processing and executive functions and for brain differences between bilinguals and monolinguals. There are overlaps and patterns of dynamic connectivity between brain areas dedicated to language processing and to cognitive control (Fedorenko & Thompson-Schill, 2014; Fedorenko 2014). Patterns of cortical activation, thickness and connectivity specific to bilinguals correlate with properties such as age of language acquisition and language proficiency (Buchweitz & Prat, 2013; Abutalebi et al., 2013; Ye and Zhou, 2009, García-Pentón, Pérez-Fernández, Iturria-Medina, Gillon-Dowens & Carreiras, 2014; Klein, Mok, Chen & Watkins, 2014). In addition, monolingual and bilingual participants show different patterns of activation during cognitive control tasks (Stocco & Prat, 2014; Rodríguez-Pujadas, et al., 2013). Although these findings do not directly support the existence of a bilingual advantage, they attest that specific aspects of the bilingual experience have a widespread impact on the brain's functionality.

In contrast, behavioural evidence for bilingual advantages is less conclusive and highly controversial. Many studies have used tests such as the Simon task, the flanker task, and the Stroop task, which engage attentional processes as they require the selection of an appropriate response in cases of conflicting information. Some of these found that bilinguals performed better than monolinguals and therefore support a bilingual cognitive advantage (Bialystok, Craik, Klein & Viswanathan 2004; Bialystok, Craik & Luk, 2008; Costa, Hernandez & Sebastián-Gallés, 2008; Costa & Sebastián-Gallés, 2014; Bialystok, Craik & Luk, 2012). However, others did not find any such effect (Paap & Greenberg, 2013; Paap & Sawi, 2014; Gathercole et al., 2014; Paap, 2014). These divergent results may be the consequence of variables such as socio-economic status or immigrant status, or effects of small sample sizes (Paap, Johnson & Sawi, 2015).

But these potential confounds only represent the tip of the iceberg of two main theoretical challenges in the study of bilingualism: the lack of a theory-driven approach to measuring cognitive control through laboratory tasks; and the large individual variability within bilingual groups, which results from the fact that bilingualism is a continuous, multi-

variate dimension (Luk & Bialystok 2013; Bak 2016), rather than a dichotomous one (i.e., bilingual vs monolingual). Bilingualism is in fact associated with a diversity of experiences in which multiple variables play a role (e.g. early or late age of acquisition, high or low proficiency, different contexts of language use). The particular type(s) of experience that may result in a 'bilingual advantage' need to be identified along these dimensions. At the same time, though, they are likely to interact with one another to create unique and diversified experiential profiles, thereby increasing aspects of variability between bilingual individuals, and obscuring their impact on non-linguistic cognitive aspects.

Research on bilingual cognitive control has been hampered by the lack of a theory-driven approach to measures of cognitive control. Tasks used in such research have little convergent validity, in that the measures they provide are poorly correlated, as highlighted by studies on bilinguals (Paap & Sawi, 2014) and monolinguals: for instance, the Stroop and the Simon effects may not correlate because they engage cognitive control processes in different ways, as reflected by the fact that they have different time-courses (Pratte, Rouder, Morey & Feng, 2010; Speckman, Rouder, Morey & Pratte, 2008). In the flanker task, differences between bilingual and monolingual participants depend on the manipulation of the amount of conflict that the task presents (Costa, Hernández, Costa-Faidella & Sebastián-Gallés, 2009). In addition, most research has used tasks that are 'impure', in the sense that they involve cognitive components other than executive functions, such as spatial attention and a variety of perceptual and motor mechanisms (Valian, 2015).

Researchers originally adopted these tasks because they assumed that the relationship between executive functions and bilingualism is based on one mechanism, namely inhibition, as proposed by the Inhibitory Control Model (Green, 1998). According to this model, bilinguals inhibit the language they are not using at every level of linguistic representation. However, this "segregational approach" to executive functions (or "divide and conquer approach"; Stocco & Prat, 2014), which tries to separate and address single mechanisms of cognitive control, has been criticised (Hartsuiker, 2015; Gade, 2015). For instance, some studies have shown differences between monolinguals and bilinguals in measures of

disengagement of attention, rather than in inhibition (Grundy & Keyvani-Chahi, 2017). Recent findings highlight the "unity and diversity" of executive functions mechanisms (Miyake & Friedman, 2012), that is to say, the correlations between distinct components of cognitive control such as updating, shifting and inhibition. These components dynamically adapt to the specific demands of different interactional contexts, and differ greatly across situations as well as individuals (Green & Abutalebi, 2013). Accordingly, some studies have used approaches such as latent-variable analysis to find the common properties measured by executive functions tasks (Friedman, 2016). But these approaches are data-driven, i.e., do not make explicit reference to the individual components that are recognised by theories of executive functions. Therefore it seems that the choice of the dependent variable in laboratory studies is not always based on a principled approach to executive functions and the specific components that could be implicated in bilingual language processing (Jared, 2015).

Consistent with the "unity and diversity" approach, Braver and colleagues have proposed an explicit dual-component model of cognitive control: the dual mechanisms framework (Braver, Gray & Burgess, 2007; Braver, 2012). According to this framework, cognitive control operates through two separate components: 'proactive control' and 'reactive control'. 'Proactive control' is specialised to the active maintenance of goal-relevant information, which directs attention, perception and action. 'Reactive control' is engaged as a 'late correction' mechanism after a sudden event that re-directs attention, similar to the inhibitory mechanism put forth by Green (1998). Importantly, Braver and colleagues argue that the existence of distinct, but interconnected, components of cognitive control allow information processing to be optimized in a flexible way, because each control mechanism is associated with a cognitive cost. Proactive control is highly reliable but cognitively expensive, because it requires sustained activation of contextual information. In contrast, reactive control activates relevant information only transiently, so it is less expensive, but potentially unreliable. The dynamics of these two components are also responsible for the variability in control strategies within and across individuals, and as such provide an explanation for the individual variability that is central to the "unity and diversity" account.

The dual mechanisms framework has been evaluated in different populations in both neuroimaging and behavioural studies. Proactive and reactive control correlate with flexible patterns of activation of the prefrontal cortex in neurologically normal adults (Braver, Paxton, Locke & Barch, 2009). Moreover, the AX-Continuous Performance Task (AX-CPT), a task of continuous performance designed to measure the interplay of these two control mechanisms, revealed differences between younger and older adults (Braver, Paxton, Locke & Barch, 2009; Paxton, Barch, Storandt & Braver, 2006). These findings suggest that people differ in the extent to which they modulate proactive and reactive control to optimize performance (Braver et al., 2001; Braver et al., 2007, 2009).

Specifically, the AX-CPT presents participants with sequences of letters, which include pairs of cues and probes. Participants have to press "yes" if they see an X (probe) following an A (cue). For any other cue-probe combination, they have to press "no". Moreover, between the cue and the probe a sequence of letters appear as distractors, and participants have to press "no" to each of them (see Fig. 5.1). There are four combinations of

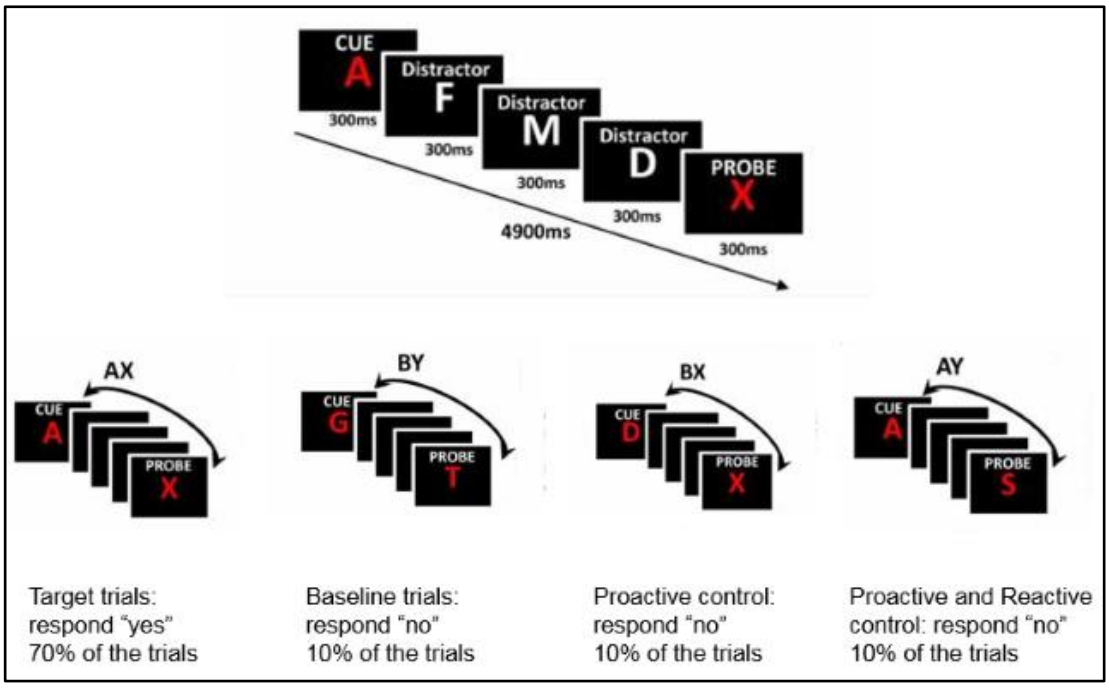



Figure 5.1 - Design of the AX-CPT: procedure (top) and types of trials (bottom). Adapted from Morales et al. (2013).

cues and probes: “AX” trials (correct cue and correct probe); “AY” trials (correct cue but incorrect probe, where Y stands for any probe other than X); “BX” trials, in which the cue is incorrect but the probe is correct (B stands for any cue other than A), and “BY” trials, in which neither the cue nor the probe is correct.

In the AX-CPT task, “AX” trials occur 70% of the time in order to bias participants to respond “yes”; “AY”, “BX”, “BY” trials each occur 10% of the time (and therefore their frequency is matched). In “AY” trials, participants first invoke proactive control to keep in memory the A cue and be prepared to respond “yes”, but then they need to suppress this tendency when they see the Y probe – that is to say, they need to engage reactive control. In “BX” trials, in contrast, participants tend to answer “yes” when they see the X probe, but they can suppress this tendency by relying on the information provided by the B cue, i.e. through proactive control alone. Both “AY” and “BX” trials therefore engage proactive control, but “AY” trials also engage reactive control (Paxton et al., 2006). Thus this task allows us to assess how individuals combine the two (proactive and reactive) control mechanisms in order to respond appropriately to the different trials. Finally, “BY” trials can be considered as baseline trials, as neither the cue nor the probe prompt a “yes” response.

Morales and colleagues (2013, 2015) used evidence from this task to argue that bilinguals showed an advantage over monolinguals in their ability to modulate proactive and reactive control. They hypothesized that the language selection mechanism responsible for suppressing irrelevant linguistic representations is related to reactive control, whereas the ability to monitor the context and to maintain activation of the relevant language is related to proactive control, and moreover that the two mechanisms need to be combined to manage two languages efficiently. Consequently, they predicted that bilinguals would show different patterns of performance on the AX-CPT task from monolinguals.

In one study, they administered the AX-CPT to a group of highly proficient bilinguals and to a group of monolinguals. Their analysis of aggregated accuracy scores showed that bilinguals made fewer errors than monolinguals on the “AY” trials, and that the groups did not differ on the other types of trial (“AX”, “BX”, “BY”) (Morales, Gómez-Ariza & Bajo, 2013).

To examine whether the bilingual advantage was the result of better reactive control alone, Morales and colleagues also administered a stop-signal task. This task specifically addresses reactive control by requiring participants to respond to stimuli but to suppress their response when a stop signal is presented. In this task, they found no differences between the two groups, suggesting that better performance on the "AY" trials indeed reflects a superior modulation of two cognitive control processes. In a second study, they found the same pattern of results with respect to accuracy (but not with respect to reaction times) and extended them through the analysis of ERP components related to reactive control, which showed differential activation between bilingual and monolingual participants (Morales, Yudes, Gómez-Ariza & Bajo, 2015).

Taken together, the existing evidence suggests that to adequately address the relationship between bilingualism and executive control, it is necessary both to adopt an explicit model of the relationship between language control and executive functions, and to use a task (such as the AX-CPT) that can discriminate the relevant components. Nonetheless, the selection of an appropriate task alone may not be sufficient: evidence about a bilingual advantage may also be susceptible to substantial individual variability in executive functions as well as in individual experience related to bilingualism.

One way to take individual variability into account is to use appropriate sample sizes and to carefully select (and match) participants. In these respects, Morales et al.'s (2013, 2015) conclusions may be affected by the small sample sizes (in the first study they examined 21 bilinguals and 23 monolinguals, in their second study they tested 25 bilinguals and 27 monolinguals), and by the inclusion of bilingual participants that were not matched for factors such as language dominance, combination, status, and contexts of use.

A stronger approach to addressing individual variability is to factor it into data analysis. Mixed-model ANOVA, as used by Morales et al., is a widespread analytical technique, but has substantial disadvantages: it allows only the specification of by-subject random effects (or by-item random effects), it is based on the aggregation of data-points, and it misrepresents accuracy data as normally distributed (Dixon, 2008). Mixed-effects models,

in contrast, allow for the specification of complete, theoretically motivated random effects structures, and are adequate to the analysis of binomial data such as accuracy (Barr, Levy, Scheepers & Tily, 2013). Studies that are based on ANOVA, as in much research on bilingualism and executive functions (e.g., Bialystok & Martin, 2004; Prior & MacWhinney, 2009; Mishra, Hilchey, Singh & Klein, 2012; Blumenfeld & Marian, 2014), may therefore be limited in their ability to determine the effects of individual variability in the critical components of executive functions. Critically, their conclusions may result from the unwarranted attribution of the variability present in their data to the group level, rather than to the individual level. The analysis of aggregated accuracy data using ANOVA, combined with reduced sample size, as in Morales et al. (2013, 2015), contribute to increases in Type I error rates (i.e., false positives).

Our study targets these problematic aspects in research on bilingualism and executive functions by adopting a theoretically motivated experimental test of executive functions (i.e., the AX-CPT) and analytical techniques that are robust to individual variability. By doing so, we ask whether any group differences stand up to an appropriate factorization of individual variability through the use of mixed-model regression and a complete random effect structure. Moreover, we compare patterns of performance across bilingual populations that differ between each other with respect to important aspects of their linguistic experience, such as age of acquisition and proficiency. We also adopt larger sample sizes than many previous studies, such as Morales et al. (i.e., $n > 30$ in each group; see Paap, Johnson & Sawi, 2015, for review and discussion).

In order to understand the role of specific dimensions of the bilingual experience, we compare four groups of Italian bilinguals whose experience ranges from early (i.e. they acquired their two languages before the age of 6), highly proficient bilingualism, to late (i.e. they acquired their second language after childhood), low proficient bilingualism. Specifically, we compared early highly proficient bilinguals (Italian-Sardinian), late highly proficient bilinguals (Italian-English), early passive bilinguals (Italian-Sardinian Passive), and late passive bilinguals (Italian late passive bilinguals). With respect to Sardinian full and passive

bilinguals, so far only two studies have addressed the cognitive effects of bilingualism in the Sardinian context. Focusing on children, Lauchlan and colleagues found an advantage among Italian-Sardinian children, with respect to Italian monolinguals, in a cognitive control test and in a vocabulary test (but not in a digit span test nor in an arithmetic test, Lauchlan, Parisi & Fadda, 2012). Another study similarly showed only limited differences in linguistic and cognitive tests between bilingual and monolingual children (Garraffa, Beveridge & Sorace, 2015). As a minority language, Sardinian is learnt and used informally, mainly at home and with friends, whereas Italian is the main language used at work and to access the media, and the medium of education. Our Italian-Sardinian highly proficient bilinguals reported learning both Italian and Sardinian during childhood, being fluent in both languages and using them daily. In contrast, our Italian-Sardinian Passive bilinguals reported on average limited productive proficiency in Sardinian, but high comprehension abilities, and consistent passive exposure (in particular oral) throughout their lifetime.

In contrast to Italian-Sardinian bilinguals, for our Italian-English bilinguals, high L2 proficiency was the result of formal education and of extensive, albeit recent, immersion (average length of residence in an English speaking country was 3.5 years, see section below). Finally, our Italian late passive bilingual participants also learnt English in school, but did not have advanced proficiency in English nor any language other than Italian, and no experience of prolonged immersion in an English-speaking environment. However, they all had a basic or medium proficiency in English, as required in school and university, and a consistent experience of passive use of the language (in particular written) throughout their studies. This last group presents a linguistic experience that locates it on a low end of a continuum of bilingual experiences (passive, late bilingualism). The inclusion of this group of participants reflects the fact that comparisons should be based on specific dimensions of the linguistic experience of participants, in order to determine what factors might contribute to any 'bilingual advantage'. Moreover, the inclusion of this group also reflects the pervasive nature of multilingualism, and the empirical limitations of a dichotomous approach to bilingualism (i.e., bilingual vs monolingual).

We hypothesise that the AX-CPT task is sensitive to individual differences in cognitive control and may reveal differences between our bilingual groups, in relation to their different experiences (age of acquisition and proficiency). Specifically, we examine if there is an advantage in accuracy among one or more groups in the "AY" condition, which measures the ability to combine the two mechanisms of cognitive control, while we expect all groups to perform equally well on "AX", "BX" and "BY" trials (which do not implicate both control mechanisms). If group differences based on linguistic experience are more prominent than individual variability in executive functions measures, these differences should emerge also after we have excluded explanations in terms of individual variability, i.e. not only the variation between subjects, but also – and crucially – the individual variability in the performance on each condition.

Therefore, we use Morales et al.'s (2013) procedure and initially adopt their analysis, i.e. an ANOVA on participants' overall proportion of accurate responses. We then examine how the inclusion of individual variability affects the pattern of results, by adopting a mixed-model regression analysis to examine accuracy on individual trials, and comparing different random effect structures.

## 5.2 Method

### *5.2.1 Participants*

A total of 201 participants were included in this study, divided in four groups. The common selection criteria were being a native Italian speaker, age (between 18 and 40 years old) and having no history of language or cognitive impairment. All participants completed a Language History Questionnaire that provided measures of their proficiency and exposure to their different languages (Marian, Blumendfeld & Kaushanskaya, 2007; Luk & Bialystok, 2013),

rated on Likert scales from 1 to 7 (where 1 is the minimum). Table (5.1) shows the differences across the groups.

1) *Italian-English bilinguals* (N = 54, 34 females), mean age 26 years (SD = 5.3, range 18 – 40). These participants were Italian native speakers who have been living in Scotland on average for 3.7 years (SD = 3.5, range: 6 months – 18 years) and were fluent in both Italian and English. 53 of them reported to be dominant in Italian and had acquired English in primary school, one of them acquired both languages in childhood and reported balanced proficiency in the two languages. These participants were recruited through the University of Edinburgh and through the Italian community in Edinburgh. One more participant was tested but later excluded from the analysis because of performance lower than 20% on all types of trial.
2) *Italian-Sardinian bilinguals* (N = 46, 23 females), mean age 30.5 years (SD = 6.6, range 18 – 39). These participants were tested in different locations in Sardinia. They were recruited through word of mouth and social networks. A further 9 participants were tested and excluded from the analysis (7 over 40 years of age, one for interruption of the task, and one for an error in the administration of the tasks).
3) *Italian-Sardinian passive bilinguals* (N = 43, 34 females), mean age 27.8 years (SD = 6, range 19 – 40). These participants were tested and recruited in Sardinia, also through word of mouth and social networks. All participants reported some proficiency in Sardinian, although 7 participants reported never having 'learnt Sardinian'[3]. 25 participants reported never having become fluent in Sardinian. 5 other participants were tested but excluded from the analysis (2 over 40 years of age, 2 for history of linguistic impairment, 1 for performance lower than 20% on all types of trial).
4) *Italian late passive bilinguals* (N = 58, 36 females), mean age 24.5 (SD = 2.5, range 20 – 35). These participants were recruited and tested at the University of Milan Bicocca, Italy. They reported a basic or medium proficiency in English, but no

[3] These participants nevertheless reported some proficiency in Sardinian: it appears that they may have perceived a discrepancy between passive proficiency and knowledge of the language, or that they may have interpreted 'learning Sardinian' as implying formal instruction.

experience of prolonged immersion in the language; however, they reported using English for their studies and to access the media. 1 participant reported never having learnt English, and 6 participants reported never having become fluent in English.

| | **Italian-English** | **Italian-Sardinian** | **Italian-Sardinian Passive** | **Italian late passive** |
|---|---|---|---|---|
| Age | 26.09 (5.28) | 30.48 (6.53) | 27.88 (5.95) | 24.52 (2.58) |
| Years of Education | 17.48 (2.93) | 15.48 (3.56) | 15.42 (2.81) | 16.22 (1.67) |
| L1 AoA | 0.15 (0.96) | 0.43 (1.05) | 0.00 (0.00) | 0.07 (0.41) |
| L1 AoA Fluent | 2.98 (0.84) | 3.52 (1.52) | 3.07 (0.26) | 3.71 (0.50) |
| L1 Speaking | 6.56 (0.63) | 6.11 (0.80) | 5.98 (0.60) | 5.91 (0.78) |
| L1 Writing | 6.26 (0.97) | 6.07 (0.90) | 5.81 (0.76) | 5.98 (0.87) |
| L1 Listening | 6.80 (0.41) | 6.54 (0.62) | 6.16 (0.78) | 6.38 (0.88) |
| L1 Reading | 6.72 (0.49) | 6.48 (0.66) | 6.21 (0.77) | 6.14 (0.78) |
| L1 Exposure | 4.29 (0.82) | 4.90 (1.04) | 6.29 (0.33) | 6.41 (0.44) |
| L2 AoA | 7.65 (3.10) | 0.93 (1.76) | 4.09 (4.43)† | 7.73 (2.90) † |
| L2 AoA Fluent | 17.91 (6.15) | 8.15 (7.23) | 10.63 (6.40) † | 15.47 (4.08) † |
| L2 Speaking | 5.59 (0.84) | 5.83 (0.93) | 3.26 (1.56) | 3.71 (1.44) |
| L2 Writing | 5.52 (0.97) | 5.02 (1.61) | 2.51 (1.47) | 3.93 (1.41) |
| L2 Listening | 6.02 (0.90) | 6.46 (0.66) | 4.79 (1.74) | 3.97 (1.64) |
| L2 Reading | 6.30 (0.72) | 6.04 (1.21) | 4.26 (1.72) | 4.50 (1.52) |
| L2 Exposure | 3.91 (0.76) | 3.51 (1.01) | 2.01 (0.82) | 1.93 (0.81) |
| Switch frequency | 4.91 (1.78) | 5.20 (1.69) | 3.16 (1.72) | 2.28 (1.36) |

Table 5.1- Mean and SD (in parentheses) for age and years of education (years), self-rated language proficiency, exposure, and age of acquisition (AoA) (Likert scales 1-7). Values marked with (†) represent means ignoring missing values.

First, from the point of view of linguistic experience, the groups differed in terms of exposure to Italian and Sardinian or English, proficiency in their L2, and frequency of switching between their languages (see table 5.1). These differences revealed that Italian-

Sardinian full bilinguals and Italian-English bilinguals were highly proficient bilinguals, that Italian-Sardinian Passive bilinguals were less highly proficient bilinguals, that Italian-Sardinian full and passive bilinguals were early bilinguals, and that Italian-English bilinguals were late bilinguals. Finally, Italian participants tested in Milan were late, passive bilinguals, rather than monolinguals.

Second, mean age and years of education (used as a proxy for socio-economic status) differed across groups. In addition, self-rated Italian proficiency was comparable among all Sardinian participants and Italian participants tested in Milan, whereas Italian-English participants gave higher ratings of their Italian proficiency. Questionnaire responses showed a relation between age, years of education, and self-rated Italian proficiency. Specifically, the number of years of education was correlated with ratings of Italian proficiency (speaking, writing, listening, and reading, all $r > 0.261$, all $p < .001$). Age was also correlated to years of education ($r = 0.298$, $p < .001$), and to Italian writing ($r = .179$, $p = .010$) and reading proficiency ($r = .139$, $p = .048$), as well as to L2 listening proficiency ($r = .169$, $p = .010$). For this reason, and in order to exclude the confounding effects of age and years of education on the performance on the AX-CPT task, these two measures were regressed out from the analysis (see next section).

### *5.2.2 Procedure and Design*

All participants were tested individually in a quiet room. The experimental session involved the AX-CPT, the Language History Questionnaire, two linguistic tasks for the highly proficient bilinguals (total duration 90 minutes), and one linguistic task for the passive bilinguals (total duration 60 minutes), for the purpose of a separate study. The order of the tasks was systematically counterbalanced across participants: among highly proficient bilingual participants (total $n = 100$), 29 took the AX-CPT as their first task, 30 took it as their second, and 41 as their third; among passive bilinguals (total $n = 101$), 48 took the AX-CPT as their first task, and 53 took it as their second. The other two tasks, for the highly proficient bilingual participants, were also counterbalanced in order. To control for any possible effect

of order of administration, we coded the order of the AX-CPT task for each participant as a categorical variable with three levels, and regressed it out from all our analyses, in the same way as we dealt with age and years of education (see next section). All tasks were presented on a 13'' laptop; the instructions and the Language History Questionnaire were in Italian. All participants signed a consent form and were reimbursed £7/h in Scotland and €7/h in Italy for their participation.

We adopted the version of the AX-CPT previously described. As mentioned, the AX-CPT presents fast sequences of letters in four types of trials ("AX", "AY", "BX", "BY", where Y stands for any probe other than X, and B stands for any cue other than A). Letters were presented one by one on a black screen for 300ms, with an interval between them of 1000ms, so that 4900ms elapsed between the cue and the probe. The task involved 100 trials (70 "AX", 10 "AY", 10 "BX", 10 "BY"). The sequence of trials and the sequences of distractors (i.e. any 3 letters except A and X, and K and Y for visual similarity) between the cues and the probes were randomized for each participant. Half the participants pressed the *z* key for "yes" and the *m* key for "no"; the other half pressed *m* for "yes" and *z* for "no". The experiment lasted approximately 13 minutes and was preceded by on-screen instructions, examples, and a practice session which included 10 practice trials with the same relative frequencies of type of trials as the remainder of the task. Half the way through the experiment participants were invited to take a break.

## 5.3 Results

As "AX" trials were more frequent than the other types of trials, separate analyses were carried out on accuracy and reaction times (RT) in "AX" trials, and on accuracy and RT in "AY", "BX", and "BY" trials; RT less than 100ms and greater than 1000ms, as well as RT for incorrect trials were excluded from the analysis (Morales et al., 2013, 2015; Braver et al., 2001). For each analysis, we regressed out age, years of education, and order of tasks by fitting a regression model on accuracy and RT with these three variables as predictors. The residuals

of these models were then used as the dependent variable for further analyses (Coco & Keller 2015).

We analysed the data in two ways. First, we analysed overall proportions of accurate responses in each condition following the analysis reported by Morales et al. (2013), i.e. ANOVA, in order to investigate whether there was a difference in accuracy between groups when variability between individuals and variability within individuals across conditions was not taken into account. Second, we examined how the factorization of individual variability affected the results, by running a mixed-model regression on the residuals of accuracy as a binomial variable, with a maximal random structure. The motivation to do so was to implement a better model of accuracy data and to use a larger number of data-points to include a more complete and theoretically motivated random effects structure: specifically, one that specifies a random intercept for subject and a random slope for condition by subject (Barr, Levy, Scheepers & Tily, 2013; Dixon, 2008). This random effects structure follows the hypothesis that not only does performance vary between individuals, but also individual performance varies across conditions.

| Condition | Italian-English | Italian-Sardinian | Italian-Sardinian Passive | Italian late passive |
|---|---|---|---|---|
| AX | 0.93 (0.06) | 0.89 (0.08) | 0.89 (0.09) | 0.9 (0.08) |
| AY | 0.75 (0.18) | 0.78 (0.18) | 0.69 (0.23) | 0.64 (0.23) |
| BX | 0.88 (0.16) | 0.84 (0.21) | 0.86 (0.18) | 0.85 (0.19) |
| BY | 0.92 (0.14) | 0.97 (0.07) | 0.93 (0.10) | 0.94 (0.10) |

Table 5.2 - Mean accuracy (proportions) and SD (in parentheses) across conditions and groups.

| Condition | Italian-English | Italian-Sardinian | Italian-Sardinian Passive | Italian late passive |
|---|---|---|---|---|
| AX | 321 (48) | 343 (56) | 321(47) | 326 (51) |
| AY | 464 (78) | 461 (97) | 437 (71) | 448 (73) |
| BX | 247 (58) | 284 (84) | 260 (54) | 267 (98) |
| BY | 274 (71) | 291 (82) | 280 (65) | 270 (80) |

Table 5.3 - Mean Reaction Times (ms) and SD (in parentheses) across conditions and groups.

### *5.3.1 Analysis of Accuracy Proportions*

We first analysed accuracy as overall proportions of accurate responses (i.e., aggregated over individual observations), adopting mixed regression models with a random intercept for subject. These mixed-model regressions are equivalent to repeated-measure ANOVAs, following Morales et al. (2013). We analysed "AX" trials separately from "AY", "BY", "BX" trials. For "AX", we fitted a mixed-model regression with a random intercept for subject and group as fixed effect. This analysis showed no difference between the groups ($p = .138$).

For the analysis of "AY", "BY", "BX" conditions, we fitted a mixed-model regression with a random intercept for subject, and group and condition as fixed effects. We found a main effect of condition ($p < .001$): accuracy was significantly lower in the "AY" condition

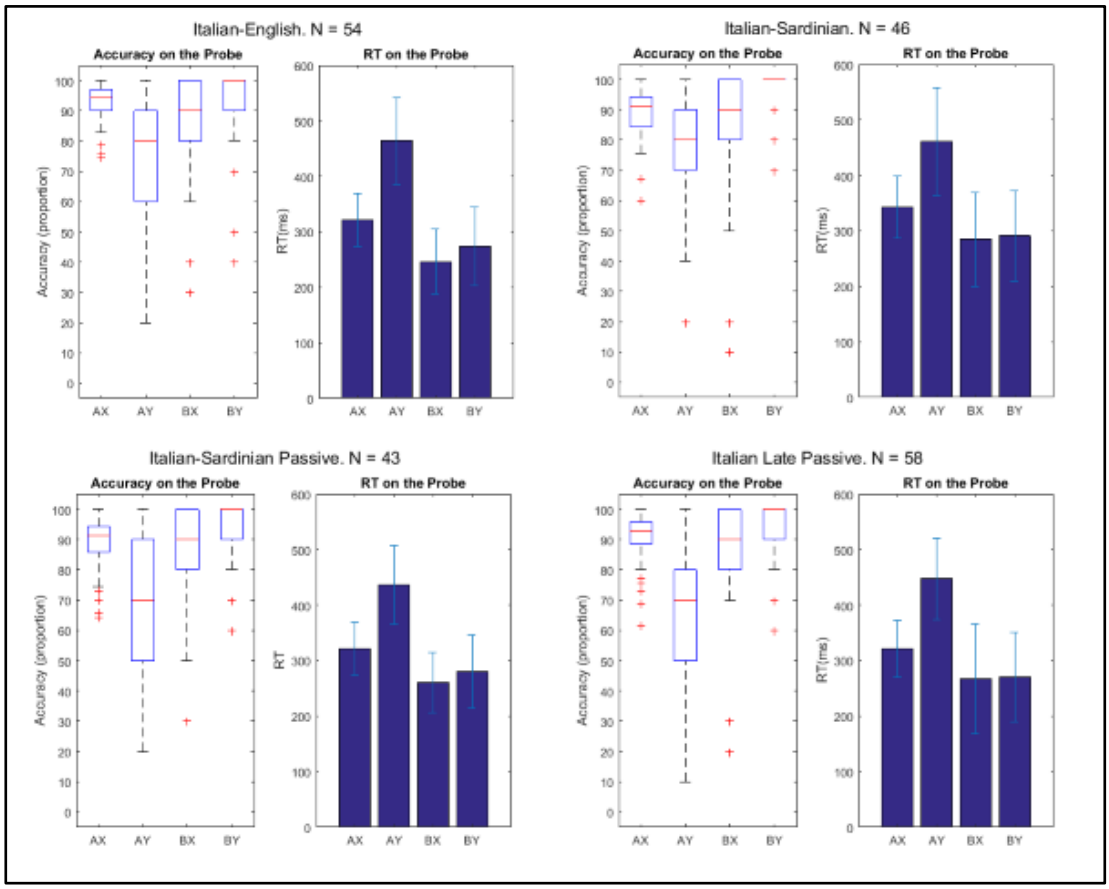



Figure 5.2 - Accuracy and Reaction Times (ms) on the probe across conditions and groups. Bars = SD.

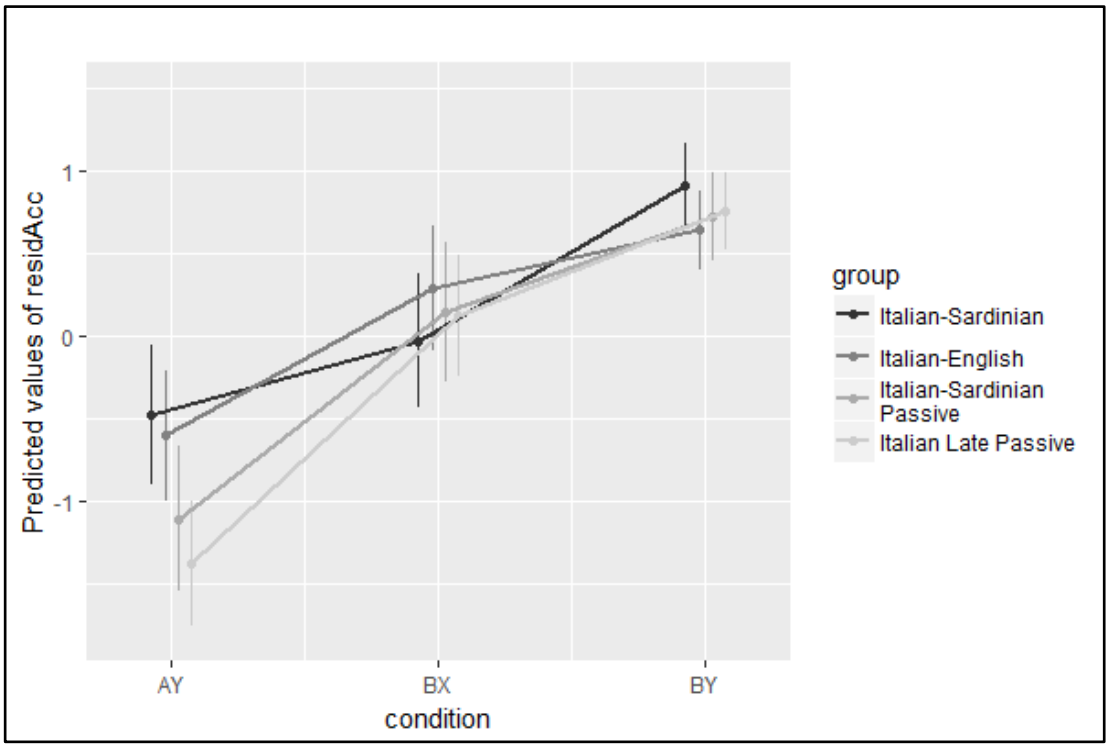



Figure 5.3 - Model fit of residuals of accuracy in “AY”, “BX”, “BY”. Bars = 95% C.I.

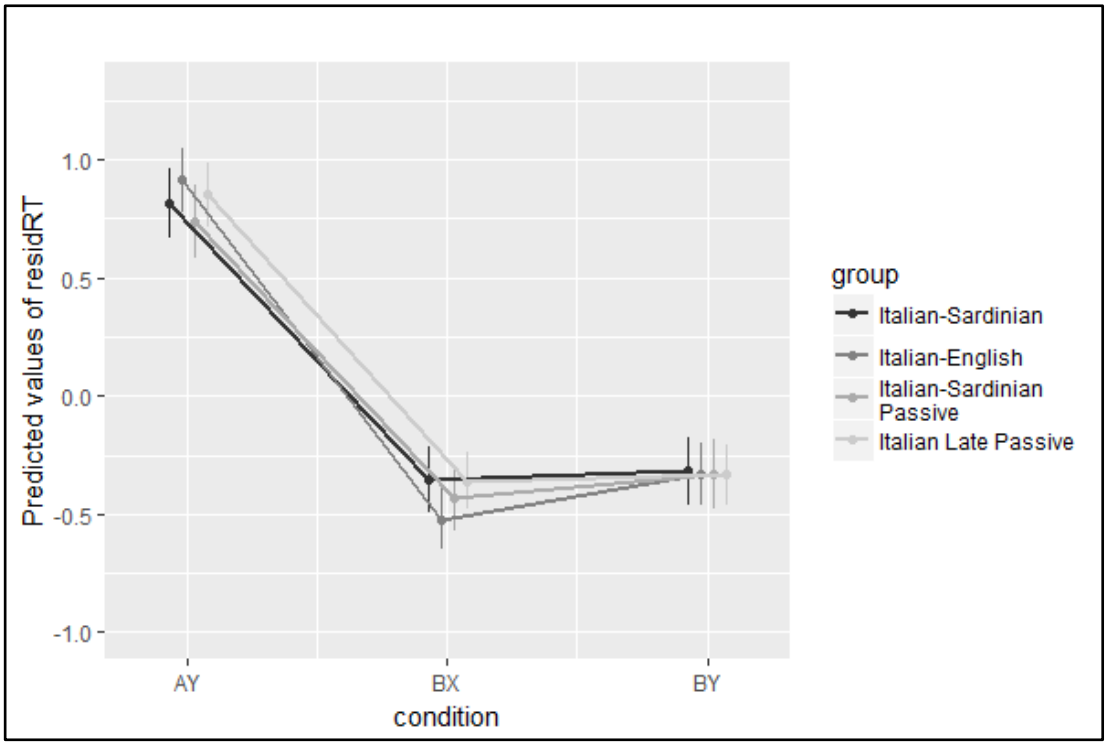



Figure 5.4 - Model fit of residuals of RT in “AY”, “BX”, “BY”. Bars = 95% C.I.

(β = -0.227, SE = 0.015, t = -15.158) and in the "BX" condition (β = -0.08, SE = 0.015, t = -5.494), compared to the "BY" condition (which constitutes the baseline). In these trials, the effect of group was not significant (p = .219), but the interaction between condition and group was significant (p = .002). Pairwise comparison (Tukey's test) showed that Italian-Sardinian bilinguals were significantly better on the "AY" condition than Italian late passive (adjusted p < .01); Italian-English participants also marginally outperformed Italian late passive (adjusted p = .059). Groups did not differ either in the "BX" condition (all adjusted p > .966) or in the "BY" condition (all adjusted p > .999).

### *5.3.2 Analysis of Reaction Times*

With regards to RT, we fitted two comparable linear mixed-model regressions, equivalent to repeated measure ANOVA (i.e. with only by-subject random intercept). In RT in "AX" trials, we found no difference between groups (p = .544). For RT in "AY", "BY", "BX" conditions, we fitted a comparable linear mixed-model regression including group and condition as fixed effects. There was a main effect of condition (p < .001), with longer RT in "AY" (β = 1.165, SE = 0.038, t = 30.461) and shorter RT in "BX" (β = -0.09, SE = 0.028, t = -3.162) with respect to "BY". While the effect of group was not significant (p = .817), there was a marginal interaction between group and condition (p = .069). Pairwise comparison (Tukey's test) did not show any significant difference between groups in individual conditions.

### *5.3.3 Binomial Mixed-model Regression of accuracy*

Our second analysis of accuracy aimed to evaluate whether the results obtained through the analysis of aggregated scores would hold after the inclusion of individual variability, i.e. random effects structure modelling variability between individuals, as well as variability within individuals across conditions. Therefore, we ran a further analysis on accuracy as a binomial dependent variable. We first regressed out age, years of education and order of trials, as in our first analysis.

For the "AX" condition, we fitted a mixed-model regression specifying a by-subject intercept and group as the fixed effect. As in our first analysis, we found no effect of group ($p = .118$).

For the "AY", "BY", and "BX" conditions, we fitted a mixed-model regression specifying a by-subject intercept and a condition by subject slope. Group and condition were the fixed effects. The effect of condition was significant ($p < .001$): performance in "AY" and in "BX" was significantly worse than in "BY" (respectively: $\beta = -1.659$, $SE = 0.110$, $t = -15.04$; $\beta = -0.614$, $SE = 0.093$, $t = -6.678$). The effect of group was not significant ($p = .428$), but the interaction between condition and group was significant ($p = .011$). However, pairwise comparison with Tukey's test showed that, in the "AY" condition, there was no difference between groups. In particular, the difference between Italian-Sardinian bilinguals and Italian late passive bilinguals was only marginally significant (adjusted $p = .072$). No difference was found across groups on "BX" and "BY" conditions.

To discriminate the specific contribution of the random effects structure we tested two further models. First, to demonstrate that the inclusion of both a random intercept by subject and a random slope for condition by subject was the critical factor affecting the generalizability of the interaction between groups and conditions on "AY" trials, we compared this model to a model of the residuals of accuracy (after the regression of age, years of education and order of tasks) that included only a random intercept by subject (i.e., did not include a random slope for condition by subject). While no differences were found across groups on "BX" and "BY" conditions (all adjusted $p > .94$), the performance of the Italian-Sardinian group on "AY" trials was significantly better than the performance of the Italian late passive group (adjusted $p < .01$), and so was the performance of the Italian-English group with respect to the Italian late passive group (adjusted $p = .011$). In a further model that eliminated the random structure altogether (i.e., included neither a random intercept by subject, nor a random slope for condition by subject), not only did both highly proficient bilingual groups show an advantage over the late passive group (all adjusted $p < .01$), but Italian-Sardinian bilinguals also performed significantly better on "AY" trials than the Italian-Sardinian passive bilinguals

(adjusted p = .018). Again, no difference was found across groups on "BX" and "BY" conditions.

## 5.4 Discussion and conclusion

The first aim of this study was to examine evidence for a bilingual advantage by using a task whose structure was theoretically motivated by an established model of executive functions and its proposed relation to language control in bilinguals. Specifically, we compared the performance of four different bilingual groups, which differed with respect to age of acquisition and proficiency, on the AX-CPT, a task of continuous performance previously used to evaluate the dual mechanisms framework of cognitive control (Braver et al., 2007; Braver 2012). The second aim was to evaluate whether group differences previously found using the same task stand up to the factorization of individual variability, and how they relate to specific differences in type of bilingual experience (along the dimensions of age of acquisition and proficiency). We now discuss our results relating to these aims in turn.

First, in a series of analyses that aggregated accuracy over individual observations only using by-subject intercepts as a measure of individual variability, we found a group difference in performance between Italian-Sardinian bilinguals and Italian late passive bilinguals, consistent with previous studies (Morales et al. 2013, 2015). Specifically, we found a significant interaction between group and condition in the accuracy of our participants, with the Italian-Sardinian bilingual group performing better than the Italian late passive group on the "AY" condition, but showing comparable performance on the "AX", "BX" and "BY" conditions. The Italian-English bilingual group performed marginally better on this condition with respect to the late passive group. Better performance on the "AY" condition – all other conditions being equal – can be argued to reflect the ability to adjust proactive and reactive control mechanisms to adapt to the context, following the assumption of a trade-off between the different mechanisms of cognitive control. These results are compatible with previous

claims for the existence of a bilingual advantage in the flexible engagement and modulation of mechanisms of cognitive control (Morales et al., 2013, 2015; Green & Abutalebi, 2013).

Importantly, among our four bilingual groups, we found a difference between early, highly proficient bilinguals on the one hand, and late, passive bilinguals on the other. We therefore extended the results of Morales et al. (2013, 2015), by suggesting a distinctive contribution of specific aspects of the bilingual experience on the modulation of control processes. Specifically, high proficiency in both active and passive modalities was related to better performance, but only early high proficient bilinguals performed significantly better than late, low proficient passive bilinguals. This suggests that both early age of acquisition and high proficiency may result in cognitive effects, but that each of these variable, individually examined, does not relate to better performance on cognitive control. This result highlights the interaction of different dimensions in the description of the bilingual experience, and the importance of focusing on specific aspects in the study of the relation between bilingualism and executive functions. The same analytical approach, however, did not show a difference between groups with respect to RT, contra Morales et al.'s (2013) results, but in keeping with Morales et al. (2015).

Second, we evaluated the generalizability of these findings, not only by using different populations and larger sample sizes than in Morales et al. (2013), but also by investigating whether group differences remained when we included an accurate measure of individual variability in the analysis, based on the hypothesis that individual variance in executive functions may represent an important confound in the study of bilingualism, and affect the generalizability of the findings. We therefore analysed raw accuracy, i.e. accuracy in binomial format rather than as proportion scores, using a mixed-model regression, that allowed us to model both random variability between subjects (by-subject intercepts) as well as individual variability across conditions (random slopes for condition by subject). This analysis supported the pattern and direction of data that we found in the analysis over proportions of accurate responses, but critically, it did not show a significant difference between groups on the "AY" condition.

To discriminate the contribution of the random effects structure to the analysis of this type of data, we compared the full random effects model to a by-subject-intercept-only model, as well as to a model with no random structure at all. When the random effects structure was simplified in this way, the results suggested group differences. The by-subject-intercept-only model suggested an advantage in favour of both highly proficient bilingual groups with respect to the late passive group. The model with no random effects structure further suggested an advantage for the Italian-Sardinian active bilinguals over the Italian-Sardinian Passive bilinguals (in addition to an advantage for both groups over the late passive group).

This comparison highlights the importance of considering individual variability in the study of the relationship between language and cognitive control, both methodologically and theoretically. Analyses that did not consider such variability (i.e., in which the random effects structure was reduced) produced results that were consistent with a bilingual advantage, independent of age of acquisition, and – when the random effects structure was completely eliminated – an advantage of highly proficient bilinguals over low proficient ones. But as our analyses show, the exclusion of individual variability misleadingly flattens the differences between our bilingual groups, and inflates the effect of group averaging, a statistical artefact not uncommon in psychological research (Speelman & McGann, 2013; Speelman & Muller Townsend, 2015). By doing so, it also inflates Type I error. Thus, the exclusion of individual variability can result in a spurious link between individual aspects of the bilingual experience (e.g. age of acquisition, language proficiency) and performance in cognitive control. Consequently, our findings demonstrate that the inappropriate factorization on individual variability can ultimately obscure the contribution of these specific dimensions to a model of bilingual language control, as well as of a model of the bilingual mind in terms of cognitive plasticity.

To conclude, our study does not support the unequivocal existence of cognitive effects related to the bilingual experience, examined with a particular focus on age of acquisition and proficiency, as we found no more than a marginal trend in favour of early, highly proficient bilinguals. But critically, we identified empirical aspects that limit our ability to measure the

effects of bilingualism on general cognition: as our study shows, this type of investigation cannot be meaningfully pursued without taking into account individual variability. These two results – the identification of an explicit theoretical model and a reliable task, on the one hand, and the demonstration of the role of individual variability in the study of bilingualism, on the other – point to new avenues for future research on the cognitive effects of the bilingual experience.

# 6. Language experience modulates bilingual language control: the effect of proficiency, age of acquisition, and exposure on language switching

(This paper has been submitted to *Acta Psychologica* in January 2018 and is currently under review. Bonfieni designed and programmed the experiment, ran the participants, analysed the data and wrote the original manuscript. Branigan, Pickering and Sorace acted as supervisors, gave feedback on each of these steps and contributed to the revision of the manuscript.)

## 6.1 Introduction

Bilinguals need to selectively access the appropriate language, both in comprehension and in production, according to the context and the interlocutor. This process is fast and often apparently seamless. Various studies have investigated bilinguals' ability to switch languages in order to understand the mechanisms of language control (e.g. Costa, Santesteban & Ivanova, 2006; Hartanto & Yang, 2016; Ma, Li & Guo, 2016; Abutalebi & Green, 2008; Baus, Branzi & Costa, 2015); however, it is not clear yet what factors affect this ability, and ultimately, how this ability relates to different types of bilingual experience. Bilingualism varies on many dimensions, such as proficiency (high or low, active or passive), age of language acquisition (early or late), and quantity and quality of language exposure (Luk & Bialystok, 2013; Bak, 2016). Identifying which of these dimensions affect language control is important for a cognitive model of this ability, and to understand its relationship with other linguistic and non-linguistic processes. In this study, we ask how bilingual experience modulates language control by examining both mix and switch costs through a cued language-switching task in two very different bilingual populations: late Italian-English highly proficient bilinguals, and early Italian-Sardinian balanced bilinguals.

Current research on bilingualism suggests that language selection represents the main cognitive challenge for the bilingual mind, since the two languages are simultaneously active, to some degree, and compete with each other. For instance, lexical access is subject to phonological interference across languages in comprehension (Marian & Spivey, 2003;

Blumenfeld & Marian, 2013; Thierry & Wu, 2007; Wu & Thierry, 2010) and in production (Costa, Miozzo, & Caramazza, 1999; Costa, Caramazza, & Sebastián-Gallés, 2000); syntactic processing is also prone to interference, as structures present in one language are activated when processing the other language (Bernolet, Hartsuiker, & Pickering, 2007; Sanoudaki & Thierry, 2015; Vaughan-Evans, Kuipers, Thierry, & Jones, 2014). Hence, at every level of linguistic processing, bilinguals need to restrict access to the relevant language and reduce competition from the irrelevant one. This process is referred to as 'language control'.

Research on the mechanisms underlying language control using language switching tasks has primarily examined switch costs in word production, that is, the delay when switching language between successive trials (see Declerck & Philipp, 2015). A prominent account of language control – Green's (1998) Inhibitory Control (IC) model – assumes that inhibition suppresses the competition from the irrelevant language. According to the IC model, the amount and time course of inhibition depend on the amount of activation of each language, which in turn depends on the specific language task demands. Evidence in support of this account comes from studies showing asymmetric switch costs between languages: switching into the dominant L1 takes longer than switching into the weaker L2 (Meuter & Allport, 1999; Costa & Santesteban, 2004; Costa et al., 2006). Asymmetric switch costs reflect the fact that more inhibition is required to suppress the dominant L1 during L2 access than vice versa. This explanation is supported by studies on highly proficient balanced bilinguals, showing symmetric switch costs between L1 and L2 (Costa & Santesteban, 2004; Costa et al., 2006; Calabria, Hernandez, Branzi, & Costa, 2012).

However, symmetric switch costs have also been found in low proficiency bilinguals (Christoffels, Firk, & Schillers, 2007; Prior & Gollan, 2011). In addition, some studies found overall faster naming (i.e. independently of switch costs) in L1 than in L2 (e.g. Macizo, Bajo, & Paolieri, 2012), consistent with the idea of higher activation of L1, whereas some of the previously mentioned studies (e.g. Costa & Santesteban, 2004) found shorter overall naming latencies in L2 than L1, suggesting that the L1 may be inhibited at a global level (i.e., language-wide) with respect to the L2 (Meuter & Allport, 1999), an effect also referred to as 'reversed dominance' (Gollan & Goldrick, 2016).

Taken together, these findings raise questions about the relation between language dominance and inhibitory processes responsible for language switch costs. Specifically, the discrepancies between these patterns suggest that besides a local (word- or trial-specific) effect of competition during language switching, there is a global (i.e., language-wide) effect that may be modulated by further control mechanisms as a function of the context: that is, depending on the languages spoken in the current situation and by the interlocutor, as well as the amount and type of code-mixing that characterises the situation (Green & Abutalebi, 2013). One such mechanism is proactive control, responsible for goal maintenance and preparatory attention. Studies analysing 'mix costs' (i.e., the global delay that occurs between a single language context and a mixed language one, such as in a cued language-switching task between blocked trials and mixed trials) found larger costs in L1 than in L2 (Prior & Gollan, 2011; Ma et al., 2016). This pattern has been interpreted as reflecting the amount of proactive control needed to facilitate access to the L2, that is, to pre-emptively counteract the higher activation level of L1 (Ma et al., 2016; Wu & Thierry, 2017). Hence, both mix and switch costs represent relevant measures of language control.

The hypothesis of a dynamic interplay of reactive and proactive control processes in language selection parallels an influential model of cognitive control – the dual mechanisms framework (Braver, Gray, & Burgess, 2007; Braver, 2012) – and, more broadly, a large body of research on executive functions in bilinguals that highlights the interaction of different control mechanisms (e.g., Miyake & Friedman, 2012; Friedman, 2016). In fact, numerous studies have addressed the relation between language control and cognitive control, albeit with mixed evidence. Domain-general control mechanisms seem to contribute to language selection (Gollan & Goldrick, 2016), and, conversely, language control in bilinguals seems to be implicated in non-linguistic cognitive tasks (Garbin et al., 2010; Branzi, Calabria, Gade, Fuentes, & Costa, 2016). Various studies posit an overlap between language control and cognitive control: language control may rely, at least in part, on domain-general control abilities, as suggested by correlations between linguistic and non-linguistic switching tasks (Prior & Gollan, 2011; Declerck, Grainger, Koch, & Phillip, 2017) and the overlap of cortical areas engaged in linguistic and non-linguistic control (Abutalebi & Green, 2008; Hernandez,

2009; De Baene, Duyck, Brass, & Carreiras, 2015; Coderre, Smith, van Heuven, & Horwitz, 2016). In contrast, other studies support the specialised and partly independent nature of language control, as they find no correlation between linguistic and non-linguistic switching tasks (Calabria et al., 2012; Calabria, Branzi, Marne, Hernández & Costa, 2015; Branzi, Calabria, Boscarino, & Costa, 2016).

The relation between language control and cognitive control is at the heart of much recent research on bilingualism, as some researchers claim that the computational challenge of language selection leads to the transfer of switching abilities to other cognitive domains, such as executive functions. Many studies have found that bilinguals outperform monolinguals on tests of executive functions (Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Luk, 2008; Costa, Hernández, & Sebastián-Gallés, 2008; Costa & Sebastián-Gallés, 2014; Bialystok, Craik, & Luk, 2012). However, other studies have not found such an advantage (Paap & Greenberg, 2013; Gathercole et al., 2014; Duñabeitia et al., 2014; Paap & Sawi, 2014). Thus, the evidence is mixed, and theoretical approaches that explicitly relate executive functions to specific aspects of the bilingual experience are sparse (Li & Grant, 2015). Understanding what factors affect the ability to select and access languages is, therefore, important not only to describe language control, but also to relate different dimensions of the bilingual experience to its cognitive effects.

Studies focusing on cued language switching show how some aspects of the bilingual experience affect language control. Specifically, much research on asymmetric switch costs has focused on dominance, operationalised as proficiency: the higher the L2 proficiency, the smaller the asymmetry in switch costs between the L1 and the L2 (Meuter & Allport, 1999; Costa & Santesteban, 2004; Costa et al., 2006). Higher levels of L2 proficiency have also been related to a qualitative difference in mechanisms of language control: highly proficient bilinguals may recruit different language control strategies from low proficient bilinguals, as suggested by the lack of asymmetry in switch costs between L1 and a much weaker L3 in highly proficient bilinguals (Costa & Santesteban, 2004; Costa et al., 2006; Calabria et al., 2012). Neuroimaging studies support this qualitative difference between high and low proficient bilinguals, as balanced bilinguals use the same cortical areas when performing

lexical access tasks in their two languages, whereas unbalanced bilinguals recruit additional frontal areas, dedicated to domain-general cognitive control (Abutalebi, 2008; Abutalebi & Green, 2007).

This qualitative difference suggests that the effect of proficiency on mechanisms of language control could be mediated by other dimensions of the bilingual experience. Indeed, studies show that other aspects interact with proficiency in the modulation of language control, such as frequency of language switching (Christoffels et al., 2007; Prior & Gollan, 2011) and interactional contexts of use (Hartanto & Yang, 2016). Beside these, two further factors related to language dominance, which could also mediate language control abilities, are language exposure and age of acquisition (AoA). With regards to the first, research shows that exposure – defined in terms of quantity and quality of linguistic input – is an important factor in dominance in early bilingualism (Unsworth et al., 2014; Unsworth, 2015, 2016), and it is related to L1 maintenance and processing in adult bilinguals (Chamorro, Sorace & Sturt, 2016). In addition, neuroimaging studies show that the amount of exposure modulates cortical activity during lexical retrieval (Perani et al., 2003). As for age of acquisition, it plays an extensive role in second language learning (Birdsong, 1999) and is strongly related to language dominance (Birdsong, 2014). It also affects the architecture of the bilingual brain, in terms of cortical activation relative to lexical access (Perani et al., 2003), language lateralization (Hull & Vaid, 2007), and cortical thickness of the inferior frontal gyri (Klein, Mok, Chen & Watkins, 2015). Moreover, some studies on the cognitive effects of bilingual experience relate age of acquisition to enhanced domain-general cognitive control (Luk, De Sa, & Bialystok, 2011; Tao, Marzecová, Taft, Asanowicz, & Wodniecka, 2011).

Exposure and age of acquisition seem therefore to constitute additional aspects of language dominance, but no study has directly addressed the specific role of exposure on language switching, and only one study has addressed the role of age of acquisition. Costa et al. (2006, experiment 1) tested highly proficient early Spanish-Basque bilinguals and highly proficient late Spanish-English bilinguals on a cued language switching task and found symmetric switch costs in both groups and no difference between the two groups, suggesting no effect of age of acquisition on the relative magnitude of switch costs in L1 and L2. However,

in that study the late bilingual group consisted of students enrolled in a professional school for interpreters, who may have already possessed considerable expertise in simultaneous language access. Simultaneous interpreters appear to control language differently from other bilinguals, as reflected by reduced and symmetric language switch costs (Morales, Padilla, Gómez-Ariza, & Bajo, 2015; Babcock & Vallesi, 2017; Ibáñez, Macizo, & Bajo, 2010; Aparicio, Heidlmayr, & Isel, 2017). In addition, the small sample size of Costa et al. (2006) may have reduced their study's statistical power.

In this study, we therefore examine what aspects of the bilingual experience, beyond proficiency, modulate language control, with a particular interest in L2 exposure and age of acquisition. To do so, we analyse both mix and switch cost in a cued language switching task in two bilingual samples, whose experience differs in terms of age of acquisition, language exposure, proficiency, and language distance: Italian-English bilinguals and Italian-Sardinian bilinguals. The Italian-English bilinguals are late bilinguals (i.e. they were first exposed to English in school after the age of 6 but only became fluent on average at the age of 19), who are currently primarily exposed to their L2 in their daily life, and whose proficiency, while high for both languages, is unbalanced. The Italian-Sardinian bilinguals are early bilinguals (they acquired both languages informally before the age of 6), highly proficient and balanced, and are currently exposed daily to both languages, in a diglossic pattern of use (i.e., a clear separation of contexts for Italian, used at work and school, and Sardinian, spoken with family and friends).

First, we are interested in the pattern of switch and mix costs in these two groups. In line with previous research (e.g. Meuter & Allport, 1999; Costa & Santestaban, 2004; Costa et al., 2006) higher proficiency in L1 than L2 should lead to a larger switch cost into L1 than into L2. Hence, we predict an asymmetric switch cost in the (unbalanced) Italian-English bilinguals and a symmetric switch cost in the (balanced) Italian-Sardinian bilinguals. As dominance – operationalised as proficiency – has also been related to bigger mix costs in the L1 than in the L2 (Prior & Gollan, 2011; Ma et al., 2016), we expect to find asymmetric mix costs (L1 > L2) in the Italian-English group, however, we would not predict such asymmetry in the Italian-Sardinian group.

Second, to shed light on the specific aspects of the bilingual language experience that affect mix and switch costs patterns, we treat bilingual experience as a continuous variable when analysing both groups' performance (pooled together) with respect to both mix and switch costs. Specifically, we investigate the role of L2 proficiency in the active modalities (speaking and writing) and in the passive modalities (listening and reading); amount of daily exposure, age of acquisition (i.e. beginning of consistent exposure) and age of acquired fluency; and daily frequency of language switching. This regression analysis allows us to investigate the relationship between these variables and language control in a more sensitive way, and it is theoretically motivated by the proposal that bilingualism is not a categorical variable (Luk & Bialystok, 2013; Birdsong, 2014; Hernandez, 2009). As we hypothesise that language proficiency is not the only factor that modulates language control, we expect to see effects of these variables on naming latencies and on the relative mix and switch costs in the two languages.

## 6.2 Method

### *6.2.2 Participants*

We tested 83 participants divided in two groups. The criteria for selection were to be native speakers of Italian and highly proficient speakers of English (group 1) or Sardinian (group 2), to be aged between 18 and 40, and to have no record of linguistic or cognitive impairment. All participants completed a language history questionnaire that provided measures of their proficiency and exposure to their different languages (Marian, Blumendfeld & Kaushanskaya, 2007; Luk & Bialystok, 2013), rated on Likert scales from 1 to 7 (where 1 is the minimum). Table (6.1) shows the differences across the groups.

1. *Italian-English bilinguals* (N = 37, 14 males, mean age 26.3 years, SD = 5.3). These participants were Italian native speakers who had been living in Scotland on average for 3.7 years at the time of testing (SD = 3.5, range: 6 months – 18 years). They were

recruited through the University of Edinburgh and through the Italian community in Edinburgh.

2. *Italian-Sardinian bilinguals* (N = 46, 22 males, mean age 30.4 years, SD = 6.4). These participants were recruited through word of mouth and social networks. Nine further participants were tested but later excluded because they were aged over 40 (N = 7), the task was interrupted (N = 1), or the participant made a high number of word substitutions when performing the task (N = 1, see below for details).

As shown in table (6.1), responses to the language history questionnaire revealed that the main differences between the two groups were age of L2 acquisition (i.e. of English or of Sardinian) and extent of language exposure, as the Italian-English bilinguals were late bilinguals, and their daily exposure to English was on average higher than exposure to Sardinian in the Italian-Sardinian group. L2 proficiency was comparable in the two groups, with the exception of oral comprehension, as the average rating for Sardinian, in the Italian-Sardinian group, was higher than the average rating for English, in the Italian-English group ($p = .001$). However, the comparison of L1 and L2 proficiency within groups showed that Italian-English bilinguals gave higher ratings for their oral production ($p < .001$), written production ($p < .001$) and oral comprehension ($p < .001$) in Italian than in English. Italian-Sardinian participants, in contrast, rated only their written production higher in Italian than in Sardinian ($p < .001$), consistent with the predominantly oral nature of Sardinian. Therefore, the Italian-English bilinguals were highly proficient but less balanced bilinguals, whereas the Italian-Sardinian bilinguals were more balanced.

Italian-English participants also gave higher ratings of their Italian oral proficiency than Italian-Sardinian participants; moreover, age and years of education (used as a proxy for socio-economic status), and age of L1 acquisition differed across groups. As these differences were unexpected, we evaluated the intra-reliability of the questionnaire with a correlational analysis to check for spurious correlations between the variables. Unexpected correlations may reflect a confounding effect of age and scholarisation. We found correlations between age, years of education, self-rated Italian proficiency, and age of acquired fluency in Italian. Specifically,

the number of years of education was positively correlated with ratings of Italian proficiency (speaking, writing, listening, and reading, all $r > 0.387$, all $p < .001$), and there was a negative correlation between years of education and age of acquired fluency in Italian ($r = -0.321$ , $p = .003$). Age was also correlated with years of education ($r = 0.278$, $p = .010$). For this reason, in order to exclude the confounding effects of age and years of education on performance in the language switching task, these two measures were regressed out of the analysis (see below).

| | **Italian-English** | **Italian-Sardinian** | **Comparison** |
|---|---|---|---|
| Age (years) | 26.3 (5.23) | 30.41 (6.38) | ** |
| Years of Education | 17.32 (2.65) | 15.48 (3.56) | * |
| L1 AoA (years) | 0.03 (0.16) | 0.5 (1.11) | * |
| L1 AoA Fluent | 3.05 (0.57) | 3.67 (1.79) | * |
| L1 speaking | 6.54 (0.56) | 6.11 (0.77) | ** |
| L1 writing | 6.3 (0.66) | 6.07 (0.9) | |
| L1 listening | 6.78 (0.42) | 6.54 (0.62) | |
| L1 reading | 6.73 (0.45) | 6.48 (0.66) | |
| L1 exposure | 4.25 (0.69) | 4.87 (1.04) | ** |
| L2 AoA (years) | 7.76 (3.12) | 0.93 (1.76) | *** |
| L2 AoA Fluent | 19.03 (6.43) | 8.3 (7.26) | *** |
| L2 speaking | 5.49 (0.84) | 5.83 (0.93) | |
| L2 writing | 5.38 (1.04) | 4.98 (1.61) | |
| L2 listening | 5.84 (0.9) | 6.43 (0.65) | ** |
| L2 reading | 6.19 (0.78) | 5.98 (1.29) | |
| L2 exposure | 3.92 (0.71) | 3.54 (1.01) | * |
| Switching frequency | 4.92 (1.79) | 5.24 (1.72) | |

Table 6.1 - Responses to the language history questionnaire in the two groups, and comparison (t-test for numerical variables, Wilcoxon test for ordinal variables): * : $p < .05$; ** : $p < .01$; *** : $p < .001$.

### *6.2.2 Materials, design and procedure*

We created two versions of a cued language switching experiment to measure both mix and switch costs. The design was identical for the two versions, except for the language combination (Italian-English and Italian-Sardinian) and the list of words. The experiment presented pictures of common objects one by one, displayed with a cue that indicated the language to use. For each version of the task, we chose 16 words of common objects with high frequency in each language. Italian words had a mean frequency of 232.9 (SD = 512.7, CoLFIS, Bertinetto et al., 2005); English words had a mean frequency of 2871.1 (SD = 3870.7, BNC, the University of Oxford, 2007). Frequencies were not comparable due to the difference in size of the corpora, which cannot be resolved through normalisation (CoLFIS: 3 million words, BNC: 100 million words). For the Italian-Sardinian set of words, a list of 50 highly frequent Italian words was examined and translated by 6 Sardinian speakers from different parts of Sardinia, in order to check for regional differences, and then rated for frequency (on a scale from 0 to 5, where 0 was the minimum; mean: 4.9, SD = 0.2). In both versions of the task, words were further selected on the basis of length in syllables and in phonemes; in the Italian-Sardinian version we selected words that agreed in gender and number in Italian and Sardinian, and that had an identical or minimally different translation in all parts of Sardinia. For this reason, the Sardinian set presented regional alternatives for some words. If the two

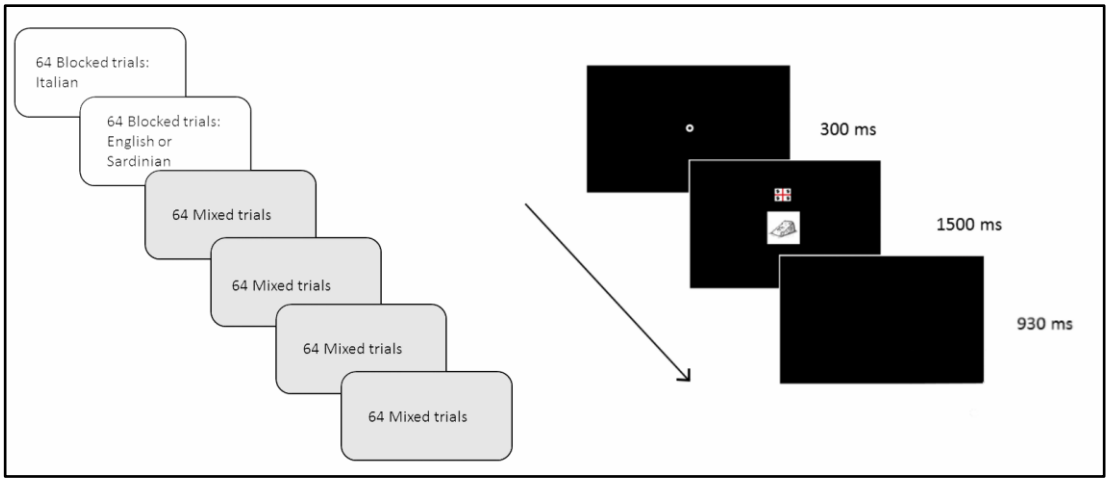



Figure 6.1 – Left: structure of the experiment. Right: structure of the trial.

alternatives were different in length, the longer one is used in the comparison (see Table 6.2 for the lists of words). For each word, we selected a black-and-white drawing on-line, which we evaluated through an on-line survey (15 Italian native speakers named a set of 38 pictures; we selected pictures with unanimous name agreement).

Participants named each picture as quickly and accurately as possible. Their verbal responses were recorded, and their response latencies constituted the dependent measure. To measure both mix and switch costs, there were two blocks of trials: 'blocked' (always use the same language) and 'mixed' (choose the language according to the cue). Half of mixed trials were 'switch' trials (change language from the previous trial) and half were 'repeat' trials (same language as the previous trial). In total, there were two sets of blocked trials (one for each language) and four sets of mixed trials (two switch sets and two repeat sets, one for each language), so that for each language there were 64 trials for each type. The experiment began with two sets of blocked trials, first in Italian, and then in English or in Sardinian, and then it presented the four mixed sets. The total number of experimental trials was 384 (see Figure 6.1 for a schematic representation of the design).

In each set of trials, and for each participant, pictures were randomized avoiding consecutive repetitions; all pictures appeared 27 times in the experiment. In mixed trials, the sequence of switch and repeat trials was pseudo-randomized by participant, so that the number of trials for each language and type was the same (switch or repeat). Also, to avoid any possible effect of the sequential order of repeat and switch trials, no more than three consecutive trials of the same type (switch or repeat) appeared sequentially. Every 32 trials, participants could take a break. In mixed blocks, a dummy trial (i.e. neither switch nor repeat) was inserted after each break (8 in total, so that 8 pictures could appear one extra time, or one picture could appear 8 extra times, or up to 7 pictures could appear more than one extra time). Half of the dummy trials were in Italian, and half were in English or in Sardinian, alternated (in Italian for the first half set of mixed trials, in L2 for the second half set, in Italian for the third and so forth) and counterbalanced across participants (in L1 for the first half set of trials for participant 1, in L2 for participant 2, and so forth).

| Italian-English | | | | | | Italian-Sardinian | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Italian** | **n syll** | **n phon** | **English** | **n syll** | **n phon** | **Italian** | **n syll** | **n phon** | **Sardinian** | **n syll** | **n phon** |
| farfalla | 3 | 8 | butterfly | 3 | 7 | farfalla | 3 | 8 | mariposa | 4 | 8 |
| dito | 2 | 4 | finger | 2 | 5 | dito | 2 | 4 | poddighe | 3 | 7 |
| gomito | 3 | 6 | elbow | 2 | 4 | gomito | 3 | 6 | cuidu/cuvidu | 3 | 6 |
| occhiali | 3 | 7 | glasses | 2 | 6 | occhiali | 3 | 7 | ulleras/ispijitos | 4 | 8 |
| tenda | 2 | 5 | curtain | 2 | 5 | chiave | 2 | 5 | giae/crai | 2 | 4 |
| mela | 2 | 4 | apple | 2 | 4 | ciliegia | 3 | 7 | cariasa | 3 | 7 |
| fiore | 2 | 5 | flower | 2 | 4 | cavallo | 3 | 7 | caddu/covaddu | 3 | 7 |
| scimmia | 2 | 6 | monkey | 2 | 5 | gallina | 3 | 7 | pudda | 2 | 5 |
| fungo | 2 | 5 | mushroom | 2 | 6 | formaggio | 3 | 8 | casu | 2 | 4 |
| doccia | 2 | 5 | shower | 2 | 3 | gamba | 2 | 5 | anca | 2 | 4 |
| torre | 2 | 5 | tower | 2 | 3 | gonna | 2 | 5 | munnedda/vardetta | 3 | 8 |
| matita | 3 | 6 | pencil | 2 | 6 | porta | 2 | 5 | ghenna/gianna | 2 | 5 |
| zucca | 2 | 5 | pumpkin | 2 | 7 | sedia | 2 | 5 | cadrea/cadira | 3 | 6 |
| fiume | 2 | 5 | river | 2 | 4 | uccello | 3 | 7 | puzone/pilloni | 3 | 7 |
| scala | 2 | 5 | ladder | 2 | 4 | croce | 2 | 5 | rughe | 2 | 5 |
| re | 1 | 2 | king | 1 | 3 | casa | 2 | 4 | domo | 2 | 4 |
| mean | 2.18 | 5.18 | | 2 | 4.75 | | 2.5 | 5.93 | | 2.63 | 5.93 |
| st.dev. | 0.54 | 1.32 | | 0.36 | 1.34 | | 0.51 | 1.34 | | 0.61 | 1.5 |

Table 6.2 – Sets of words. Length in syllables (‘n syll’) and in phonemes (‘n phon’) are matched between L1 and L2 (t-tests, all p >.3).

In each trial, a fixation dot was presented for 300 ms. Then the picture appeared in the centre of the screen for 1500 ms, presented simultaneously with a language cue. After that, a black empty screen was presented for 930 ms. Participants' responses were recorded from the appearance of the picture until the appearance of the following fixation dot (see Fig. 6.1). To dissociate cue switching and language switching, we chose two cues for each language (i.e. two Italian flags, two flags of the United Kingdom, and two Sardinian flags; Heikoop, Declerck, Los & Koch, 2016). The cues alternated regularly independently of the type of trial in all blocks.

The experiment began with a practice session, which included 16 blocked trials in each language (the whole set of pictures was presented first in L1 and then in L2) and 16 mixed language trials. At the end of practice trials, if a word different from the intended word was selected, the experimenter suggested the correct word. If the participant reported knowing the word, it was used in the experiment, otherwise the experiment proceeded with the alternative word spontaneously produced by the participant. This procedure allowed Italian-Sardinian participants to complete the task using the regional variants of the words that they were familiar with. Variants typically varied in one or two phonemes (e.g. "ulléras"/"ullérasa", 'glasses'); we ignored these differences after ensuring post-hoc that their length matched in number of syllables and phonemes with the Italian words. However, 13 participants substituted up to 4 Sardinian words with an Italian cognate (e.g. sard. "occhiàlese" instead of "ulléras" for ita. "occhiali", 'glasses'), 4 participants substituted up to 3 Sardinian words with the Italian translation, and 2 participants substituted 1 Italian word with a Sardinian cognate. Cognate words were excluded from the analysis; Italian forms were also excluded, together with the following trial and their corresponding trial in Italian (see Table 6.5 for the percentage of items excluded from the analysis by type of trial). Participants who substituted more than 6 out of 16 words were excluded from the experiment (N = 1).

The experiment lasted about 30 minutes. It was presented on a 13" laptop on OpenSesame 3.0 (Mathôt, Schreij, & Theeuwes, 2012). The task was administered in an experimental session (total duration: 90 minutes) that included the language history questionnaire, a further linguistic experiment and a test of executive functions for the purpose of another study. The order of tasks was varied between participants and groups, so that 14 participants in the Italian-English group took the language switching task first, 8 second, and 15 third. In the Italian-Sardinian group, 11 took it first, 12 second and 23 third. The order of the other two tasks was also varied across participants. To control for any possible effect of order of administration, we coded the order of the language switching task for each participant as a categorical variable with three levels, and regressed it out from all our analyses, in the same way as we dealt with age and years of education (see next section). The instructions and the language history questionnaire were in Italian. All participants signed a consent form and

received £7/h in Scotland and €7/h in Sardinia for their participation.

### *6.2.3 Data pre-processing and analysis*

We used an algorithm to determine voice-onset in Matlab© R2015a (the MathWorks, Inc., 2015) and conducted manual analysis to check for miscalculations of the algorithm and to determine response accuracy. Responses were coded as errors if the participant did not answer or used the wrong language or the wrong word. In such cases, the trial was marked as wrong and excluded from the analysis; the following trial was also excluded from the analysis. Trials in which the participant hesitated, or produced incomplete or "corrected" answers or non-verbal sounds before answering, were also counted as errors and excluded from the analysis; the following trial was retained. Practice and dummy trials were excluded from the analysis. Three trials in the Italian-Sardinian dataset were excluded for environmental noise that did not allow detection of voice onset.

Given the small percentage of errors, as well as the impossibility of determining accuracy when Italian forms were used in Sardinian, accuracy rates were not further analysed (presented in tables 6.3 and 6.5). For each participant and type of trial, we calculated the mean and the standard deviation of response times (RT), and excluded as outliers RT that were 3 standard deviations from the mean (Costa & Santesteban 2004; Costa et al., 2006; Calabria et al., 2012; Macizo et al., 2012).

To control for any possible effect of age, years of education, and order of administration of the tasks, we first fitted a linear regression model on RT including these three variables as predictors. We then extracted the residuals of these models and analysed them using mixed-model regression (Coco & Keller, 2015). Specifically, we fitted a model on residuals of RT, and type of trial and language as fixed effects; for the random structure, we specified a random intercept by participant, by language, and by word, as well as random slopes for type of trial by participant, for language by participant, and for language by word.

## 6.3 Results

First, we present a by-group analysis of switch and mix costs separately, in line with previous studies (e.g. Ma et al., 2016). Then, we directly examine the role of specific aspects of bilingual language experience as continuous predictors (proficiency, age of acquisition, exposure and daily frequency of switching) on both costs on the whole dataset.

### *6.3.1 Italian-English*

The analysis of switch cost (RT in repeat and switch trials) showed a main effect of type of trial ($p < .001$), reflecting the fact that switch trials were slower than repeat trials ($\beta = 46.038$, $SE = 6.277$, $t = 7.335$), as well as a main effect of language ($p = .011$), as both repeat and switch trials were faster in English than in Italian ($\beta = -44.064$, $SE = 14.024$, $t = -3.142$). We also found an interaction between type of trial and language ($p = .010$), as the switch cost when switching into English was larger than when switching into Italian ($\beta = 16.809$, $SE = 6.545$, $t = 2.568$).

| Type of trial | % Correct | % Outliers | % Excluded |
|---|---|---|---|
| Blocked (English) | 98.78 | 1.65 | 3.08 |
| Blocked (Italian) | 98.14 | 1.48 | 3.89 |
| Repeat (English) | 98.48 | 1.56 | 3.84 |
| Repeat (Italian) | 96.28 | 1.10 | 6.59 |
| Switch (English) | 97.13 | 1.31 | 5.45 |
| Switch (Italian) | 94.05 | 0.93 | 7.26 |
| Total | 97.15 | 1.34 | 5.02 |

Table 6.3– Percentage of errors and excluded data in the Italian-English group. The percentages of correct and excluded data do not sum to 100 because of different coding of incorrect responses (see Data Pre-Processing).

The analysis of mix cost (RT in blocked and repeat trials) showed a main effect of type of trial ($p < .001$), as repeat trials were slower than blocked trials ($\beta = 114.090$, SE = 8.004, t = 14.253), as well as a main effect of language ($p = .033$): trials in English were faster than trials in Italian ($\beta = -16.490$, SE = 14.198, t = -1.161). There was also an interaction between type of trial and language ($p < .001$), as the mix cost in English was smaller than in Italian ($\beta = -27.750$, SE = 5.777, t = -4.804).

| **Type of trial** | **Italian** | **English** |
|---|---|---|
| Blocked trials (RT) | 814 (84) | 798 (67) |
| Repeat trials (RT) | 928 (99) | 884 (89) |
| Switch trials (RT) | 973 (108) | 948 (113) |
| Mix cost | 114 (59) | 86 (46) |
| Switch cost | 45 (43) | 64 (39) |

Table 6.4 – Mean RT in ms (and SD in parentheses) in Italian and English. Mix cost = repeat – blocked; Switch cost = switch – repeat.

### *6.3.2 Italian-Sardinian*

The analysis of switch cost (RT in repeat and switch trials) showed a main effect of type of trial ($p < .001$), as switch trials were slower than repeat trials ($\beta = 40.743$, SE = 5.103, t = 7.984), as well as a main effect of language ($p = .007$), as repeat and switch trials were faster in Sardinian than in Italian ($\beta = -38.758$, SE = 12.303, t = -3.150). The interaction between type of trial and language did not reach significance ($p = .081$), indicating no prominent asymmetry in switch cost between Italian and Sardinian.

The analysis of mix cost (RT in blocked and repeat trials) showed a main effect of type of trial ($p < .001$), reflecting the fact that repeat trials were slower than blocked trials ($\beta = 110.913$, SE = 8.891, t = 12.474). The effect of language was not significant ($p = .238$), but the interaction between type of trial and language was significant ($p < .001$), as the mix cost in Sardinian was smaller than in Italian ($\beta = -45.410$, SE = 5.878, t = -7.725)

| Type of trial | % Correct | % Cognates | % Italian | % Outliers | % Excluded |
|---|---|---|---|---|---|
| Blocked (Sardinian) | 98.91 | 10.43 | 1.63 | 1.66 | 16.27 |
| Blocked (Italian) | 99.12 | 0.14 | 1.63 | 1.26 | 5.74 |
| Repeat (Sardinian) | 97.96 | 10.90 | 1.90 | 1.12 | 17.22 |
| Repeat (Italian) | 98.03 | 0.07 | 1.60 | 1.12 | 7.61 |
| Switch (Sardinian) | 97.11 | 10.19 | 1.46 | 0.88 | 17.39 |
| Switch (Italian) | 96.94 | 0.14 | 1.43 | 0.95 | 8.15 |
| Total | 98.00 | 5.34 | 1.60 | 1.17 | 12.11 |

Table 6.5 - Percentage of errors and excluded data in the Italian-Sardinian group. The percentages of correct and excluded data do not sum to 100 because of different coding of incorrect responses (see Data Pre-Processing).

| Type of trial | Italian | Sardinian |
|---|---|---|
| Blocked trials (RT) | 843 (81) | 852 (64) |
| Repeat trials (RT) | 956 (78) | 918 (86) |
| Switch trials (RT) | 995 (88) | 968 (95) |
| Mix cost | 112 (70) | 66 (61) |
| Switch cost | 40 (37) | 50 (49) |

Table 6.6 – Mean RT in ms (and SD in parentheses) in Italian and Sardinian. Mix cost = repeat – blocked; Switch cost = switch – repeat.

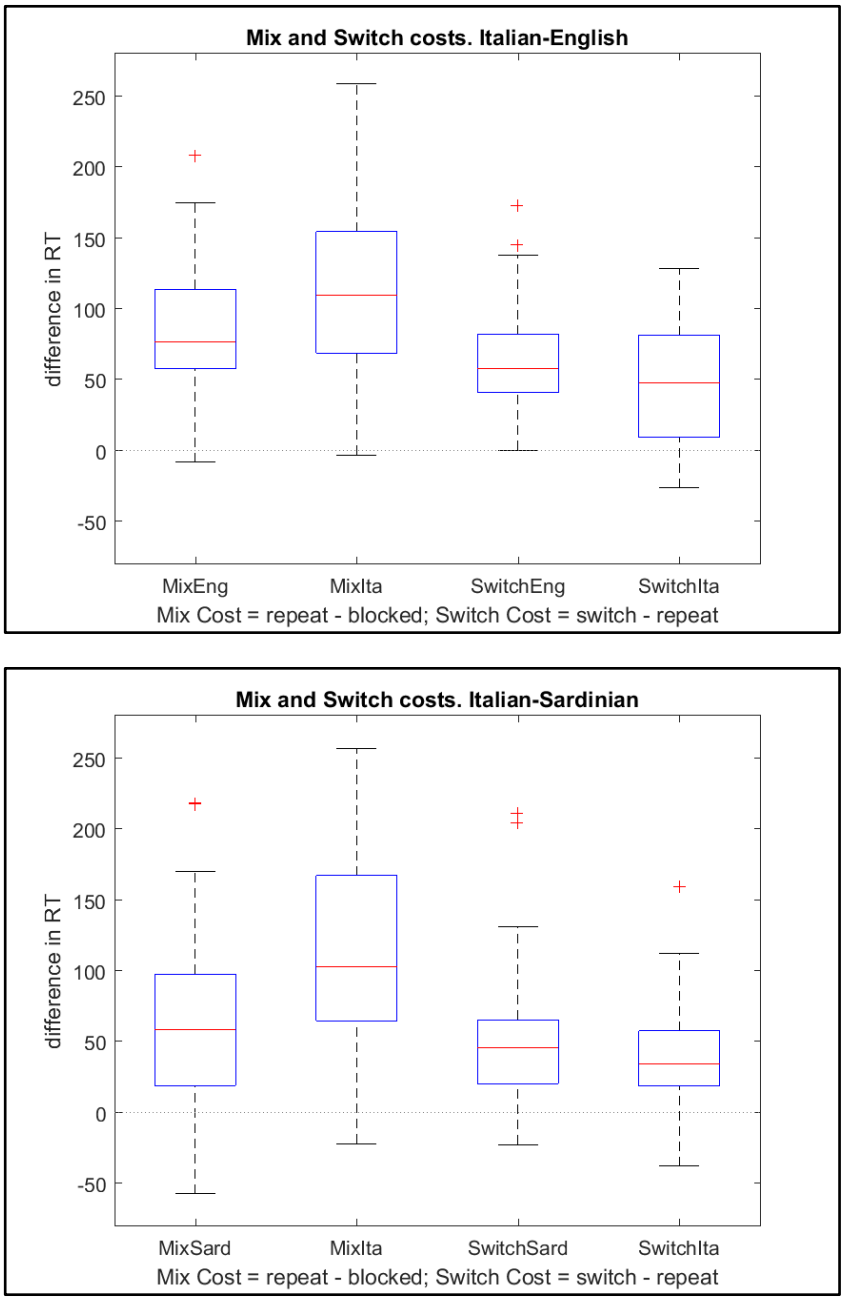



Figure 6.2 - Mix and switch costs in the Italian-English group (top) and in the Italian-Sardinian group (bottom). Types of costs from left to right: mix cost in L2 ('MixEng', top, and 'MixSard', bottom), mix cost in Italian ('MixIta'); switch cost in L2 ('SwitchEng', top, and 'SwitchSard', bottom), switch cost in Italian ('SwitchIta').

### *6.3.3 Regression analysis with continuous predictors*

To explore the relation between language control and bilingual experience, we further analysed RT by type of trial and language, introducing continuous variables extracted from the language history questionnaire as predictors. Specifically, we pooled together data from the two groups of participants and used the following as predictors: second language proficiency, age of second language acquisition, average daily exposure to the second language, and daily frequency of language switching. With regards to second language proficiency, we considered both active proficiency (an aggregated score of speaking and writing) and passive proficiency (listening and reading). With regards to age of acquisition of the second language, we analysed the age of acquisition as both onset of exposure and the age of acquired fluency. For this analysis, we ran a model on RT in the three types of trials, as we were interested in comparing the role of these measures of linguistic experience on both types of language costs. We first fitted a model with age, years of education, and order of tasks as predictors. We then analysed the residuals of that model through mixed-model regression specifying the same random effect structure as in the previous analyses, and using as predictors type of trial, language (L1 vs. L2) and active and passive proficiency, age of acquisition and age of acquired fluency, daily exposure and daily frequency of language switching.

Active language proficiency, age of acquisition, and language exposure significantly improved the model. Specifically, the interaction of active language proficiency with type of trial significantly improved the model ($p = 0.12$), reflecting the fact that faster switch trials (in both languages) were related to higher L2 proficiency ($\beta = -17.833$, $SE = 6.568$, $t = -2.715$). Passive proficiency, however, did not improve the fit of the model ($p = .733$). The interaction of age of language acquisition with language significantly improved the model ($p = .008$), as a later age of L2 acquisition accounted for faster naming in L2 ($\beta = -15.851$, $SE = 5.777$, $t = -2.744$). However, age of acquired fluency did not improve the model ($p = .806$). Finally, daily exposure to L2 also improved the model, as it interacted with both type of trial (marginal trend: $p = .053$) and language ($p = .029$): higher exposure to L2 predicted smaller mix costs in L1 ($\beta = -20.039$, $SE = 6.325$, $t = -3.128$); it also marginally predicted smaller switch costs in L1 ($\beta = -10.385$, $SE = 5.834$, $t = -1.780$). Daily frequency of switching did not improve the fit of the model ($p = .331$).

## 6.4 Discussion

In a cued language switching task involving Italian-English and Italian-Sardinian bilinguals, we found an asymmetric switch cost in Italian-English bilinguals when we analysed performance by group. Interestingly, the switch cost was larger in L2 than in L1. This was surprising according to previous studies where switch costs were larger for L1 than for L2, and related accounts of language control that link proficiency, as a proxy for dominance, to strength of inhibition (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004; Costa et al., 2006). In the Italian-Sardinian group, in contrast, we found a symmetric switch cost, in line with the previously mentioned studies on highly proficient, balanced bilinguals. Mix costs were asymmetric in both groups: mix costs into Italian were larger than into English and into Sardinian. In the case of the Italian-English bilinguals, i.e. the less balanced of our groups, this is consistent with previous findings on language mixing that relate mix costs and dominance (Ma et al., 2016; Prior & Gollan, 2011). However, this is unexpected in the case of the Italian-Sardinian participants, whose two languages were more balanced, at least from the point of view of proficiency. As our two groups displayed different switch costs but more similar mix costs, taken together these results support the view that mix and switch costs index different mechanisms of language selection, as suggested by previous research that interprets switch costs in relation to reactive inhibitory processes (e.g. Costa & Santesteban, 2004; Costa et al., 2006) and mix costs in relation to proactive processes (e.g. Ma et al., 2016; Wu & Thierry, 2017).

In addition, as the two groups differ in language experience, the fact that mix costs were comparable in the two groups while switch costs were not suggests that these costs may relate in different ways to aspects of language experience. Our analysis of variables related to the bilingual experience supports this hypothesis in a number of respects. First, L2 proficiency affected switch costs. The effect of proficiency is in keeping with previous research (Meuter & Allport, 1999; Costa & Santesteban, 2004; Costa et al., 2006), but extends its impact on switch costs to both languages, and localises its effect to active proficiency (as opposed to

passive proficiency): higher active L2 proficiency predicted faster switch trials in both languages.

Second, L2 daily exposure also affected switch costs: higher L2 exposure predicted both reduced switch and mix costs in L1. In relation to switch costs, higher L2 exposure appears to reduce the burden of reactively inhibiting L1; in relation to proactive control accounts of mix costs (Ma et al., 2016, Wu & Thierry, 2017), it appears to alleviate the load of proactively suppressing L1. These data show that more exposure to the L2 makes it generally easier to access and switch between the two languages, as it seem to reduce the dominance of the L1. This suggestion is in line with research on linguistic attrition, that shows that exposure to the L2 affects how the L1 is processed and ultimately maintained (e.g. Chamorro et al., 2016).

Third, later age of acquisition predicted faster naming in L2, in line with Costa et al. (2006). This result does not point to a direct role for age of acquisition on local language selection (i.e., age of acquisition did not interact with trial type), but clarifies how this variable affects language access. Specifically, we suggest that, in language switching contexts, early L2 acquisition relates to longer word-naming latencies in L2, in the same way as longer naming latencies in L1 are related to L1 dominance in previous research (e.g. Costa & Santesteban, 2004). That is, age of acquisition seems to complement the definition of dominance: the earlier acquired, the more dominant the language. Thereby this variable represents an important aspect in the ability to access a language.

Last, and contrary to previous studies (Christoffels et al., 2007; Prior & Gollan, 2011), our results did not show an effect of daily frequency of language switching on the modulation of either naming times or mix/switch costs. This unexpected result should be considered in the light of one possible limitation of our study, specifically our use of self-reported measures of variables of interest connected to the language experience. Self-reported measures are considered reliable, as they correlate to objective measures for instance of proficiency (Marian et al., 2007; Luk & Bialystok, 2013). We evaluated the inter-reliability of our measurements through post-hoc analyses in which we checked that measures of L1 proficiency correlated

with each other, and similarly for measures of L2 proficiency. In this way, we were able to identify potential confounds such as those described in the procedure section (i.e., age and years of education). Nevertheless, it could be the case that some of our variables of interest were not captured precisely, as participants may have interpreted the questions in different ways, despite our care to avoid any ambiguity in wording. If participants differed in their interpretation of some questions, we would expect to find no effect of the variables most affected by ambiguity. This may be the case of daily frequency of switching, as our question referred to various conversational contexts (i.e., sentences, conversations, situations). This could also be the case of age of acquired fluency in L2, as participants may have interpreted more or less strictly what 'fluency' means, for example in reference to different contexts of use of English or Sardinian.

A further limitation of our study lies in the fact that the differences between the two groups are not only captured by the continuous variables examined in our regression analysis, but also by language distance (i.e. Italian and Sardinian being typologically closer than Italian and English), language status and type of contexts of use. Our regression analysis did not include these categorical variables, however, these aspects may also have effects on language control and on language dominance beyond proficiency, exposure and age of acquisition.

## 6.5 Conclusion

Our study shows a dynamic interplay of multiple dimensions of the bilingual experience in the modulation of language access and control. Beyond L2 proficiency, language switching is also modulated by daily L2 exposure, which also mediates language mixing. Finally, L2 age of acquisition predicts overall latencies in accessing the L2. These results show that language dominance is not only language proficiency, and provide a bridge between mechanisms of language control and specific aspects of language experience. Our study suggests that future research should focus on aspects of bilingualism that extend beyond proficiency, and

emphasises the importance of adopting a multidimensional perspective to accurately capture the multifaceted nature of bilingualism and its relationship to language control.

# 7. Effects of active bilingualism on pronoun processing in Italian: a visual world study

## 7.1 Introduction

Identifying what an interlocutor's expressions refer to is one key aspect of language comprehension. Yet referential relations are often ambiguous, in particular with respect to anaphoric expressions such as pronouns. Examples (1-2) illustrate this ambiguity in Italian, a language where pronouns can be omitted (null pronoun, represented as Ø; 1) or pronounced (overt pronoun, *lei*; 2). In principle, both the null pronoun in (1) and the overt pronoun in (2) could refer to either the subject ('the waitress') or the object ('the researcher').

(1) La cameriera chiama la ricercatrice mentre i messicani mangiano. Ø e' molto severa.
The waitress calls the researcher while the Mexicans eat. Ø is very strict.

(2) La cameriera chiama la ricercatrice mentre i messicani mangiano. Lei e' molto severa.
The waitress calls the researcher while the Mexicans eat. She is very strict.

Carminati (2002, 2005) has suggested that the null pronoun in (1) is preferentially interpreted as referring to the subject of the previous sentence ('the waitress'), whereas the overt pronoun in (2) is preferentially interpreted as referring to the object ('the researcher'). However, experimental studies of how Italian native speakers interpret null and overt pronouns have yielded inconsistent results, suggesting that this process is more complex and variable than previously assumed (Tsimpli, Argyri, Sorace & Heycock, 2004; Belletti, Bennati, & Sorace, 2007; Sorace & Filiaci, 2006). Individuals' interpretational preferences appear to be influenced by many factors beyond the referents' syntactic position. These include other properties of the utterances relating to discourse pragmatics (e.g. accessibility, topic and focus,

e.g. Ariel, 1990, see Almor & Nair, 2007), semantics (e.g., verb-based implicit causality, Koornneef & van Berkum, 2006, see De la Fuente, Hemforth, Colonna & Schimke, 2016); differences in people's cognitive capacities relating to executive functions (e.g. Nieuwland & van Berkum, 2006, 2008); and – most relevantly for this study – language background. In particular, bilingual speakers of null subject languages show different interpretational preferences from monolingual speakers of these languages, specifically with respect to overt pronouns (Tsimpli et al., 2004; Belletti, et al., 2007; Sorace & Filiaci, 2006). These studies suggest that the bilingual experience could constitute a further source of variability in anaphora resolution.

How are null and overt pronouns interpreted in Italian? How are they processed in real time? Is pronoun processing affected by the linguistic experience? In this study, we tackle these questions by examining real time processing of null and overt pronouns, combining off-line data (forced-choice responses) and on-line data (eye movements and reaction times), in four groups of Italian native speakers with differing bilingual experience. There are, of course, many forms of bilingualism: as highlighted by recent research, bilingualism is a multi-variate continuum (Luk & Bialystok 2013, Bak 2016). For example, bilinguals' two languages may be similar or dissimilar in particular respects (e.g., both allowing null pronouns, or one but not the other allowing null pronouns); some bilinguals learn their L2 during early childhood (early bilinguals), whereas others learn it during later childhood or as adults (late bilinguals); and some bilinguals actively produce and comprehend both their languages (active bilinguals) whereas others may actively produce only one language (passive bilinguals). Hence, in our study we examine pronoun interpretation and processing in bilingual Italian native speakers who have different language combinations (varying in whether they allow null subjects) and different types of bilingual experience (early vs late bilingualism; active vs passive).

Experiment 1 investigates participants at the low end of the bilingual continuum: native speakers of Italian who live in Italy and predominantly use Italian, although their linguistic experience is also characterised by a widespread passive use of English (acquired at high school or during higher education). This type of participant is often referred to as

'monolingual' in the literature (e.g. Carminati, 2002), but we suggest it is more accurately characterised as 'L1 dominant' – in this case, Italian dominant. In experiment 2 we turn to native speakers of Italian who live in an English-speaking environment and are highly proficient in English (a language that does not allow null pronouns). These participants are 'active' late bilinguals, who acquired English in school after puberty (they reported receiving first exposure to English as a foreign language at school, on average at age 8, and becoming fluent on average at age 18). Experiment 3 examines Italian-Sardinian active, early bilinguals living in Sardinia, who started acquiring their two languages (both of which allow null pronouns) before the age of 8. Finally, experiment 4 looks at Italian-Sardinian passive early bilinguals living in Sardinia, who understand Sardinian but do not speak it.

### *7.1.1 Effects of non-linguistic factors on pronoun processing*

Beyond syntactic constraints, pragmatic and cognitive factors also play a role in pronominal resolution. One pragmatic factor is the accessibility of the referent: the most explicit expressions, such as full noun phrases (NP) tend to refer to the least accessible referents, while the least explicit expressions (i.e., pronouns) tend to refer to the most accessible referents (Ariel, 1990). This inverse relationship between informativity and accessibility interacts with further factors in the interpretation and processing of pronouns. For example, Almor and colleagues examined acceptability and processing cost (i.e. reading times) of sentences containing null and overt pronouns in speakers of Brazilian Portuguese (Almor, de Carvalho Maia, Cunha Lima, Vernice & Gelormini-Lezama, 2017). Acceptability ratings showed that participants interpreted as more acceptable sentences where an overt pronoun referred to the subject antecedent, than sentences in which a null pronoun referred to the same antecedent. However, participants were slower to read sentences in which the subject antecedent was referred to using an overt pronoun, than sentences in which it was referred to using a null pronoun. The contrast between on-line and off-line measures suggests that the inverse relationship between informativity and accessibility affects how pronouns are ultimately

interpreted, whereas language specific statistics like the frequency of anaphoric forms directly affect real-time processing.

Studies using on-line measures of linguistic processing, such as self-paced reading, visual world eye-tracking and event-related potentials (ERP), have identified further non-linguistic factors that play a role in the real time processing of pronouns. For instance, an ERP study examining the interpretation of contextually ambiguous pronouns in Dutch found that readers with a higher working memory span were more sensitive to referential ambiguity than readers with a lower working memory span (Nieuwland & Van Berkum, 2006). Moreover, in sentences like 'the aunt said that he won the lottery', high span readers were more likely than low span readers to link the mismatching pronoun 'he' to an unmentioned antecedent, rather than processing it as unacceptable (Nieuwland, 2014). Additional non-linguistic factors that contribute to pronoun processing include visual attention and order of presentation of the referents (Arnold & Lao, 2015), contextual bias and world knowledge (Kehler & Rohde, 2016), and perspective taking (Hendriks, Koster & Hoeks, 2014). Overall, many factors influence pronoun resolution and characterise it as a probabilistic process (Greene, McKoon & Ratcliff, 1992; Arnold, Eisenband, Brown-Schmidt & Trueswell, 2000; Kehler & Rohde, 2016).

### *7.1.2 Pronoun processing in Italian*

Carminati (2002, 2005)'s account of anaphora resolution in Italian approaches the interpretation of pronouns primarily from a structural perspective, i.e. focusing on the syntactic configurations of pronouns and available antecedents. Specifically, she proposes that the null pronoun prefers the antecedent in the subject position, while the overt pronoun prefers the antecedent in a lower non-subject position (Position of Antecedent Strategy, PAS). In Carminati (2002, exp. 2), a group of Italian native speakers (psychology students at an Italian university) expressed their interpretational preferences of sentences similar to (1-2) in a forced-choice task. The results showed a marked preference for the subject antecedent in the

case of the null pronoun (80% of responses), and a marked preference for the object antecedent in the case of the overt pronoun (83%).

However, such a marked polarization of preferences for null and overt pronouns has not been found in other studies. In three picture verification tasks (Tsimpli et al., 2004; Belletti et al., 2007; Sorace & Filiaci, 2006) with sentences similar to (1-2), Italian monolingual speakers interpreted the overt pronoun as co-referential with the object antecedent more often than the null pronoun, in line with Carminati's data (on average, 80% selection of object antecedent for the overt pronoun vs 50% for the null pronoun). However, these studies showed no clear preference for either the subject or object antecedent in the interpretation of the null pronoun; that is, participants were equally likely to select either antecedent for the null pronoun.

These findings suggest an asymmetry between null and overt pronouns, such that only the overt pronoun, but not the null pronoun, is associated with a marked interpretational preference. The discrepancy between these studies may stem from the fact that Carminati's PAS describes the speakers' ultimate preference, but may not reflect real time processing of null and overt pronouns. Different experimental procedures may be more sensitive to processing aspects of anaphora resolution, for instance in terms of type of task or overall proportion of items containing a pronoun, which may increase the participants' awareness of the experimental contrast. If this is the case, this discrepancy may reflect the difference between the representational knowledge of pronominal interpretation and how these interpretations are processed in real time.

In our first experiment we addressed this possibility by examining null and overt pronouns in Italian-dominant speakers. We examined off-line measures using a forced-choice task where participants were explicitly asked about their interpretation of the antecedent of a null or overt pronoun. We additionally examined on-line measures (eye movements over the time course of experimental sentences) using a visual world eye-tracking paradigm. This paradigm is ideal to examine referential resolution in ambiguous sentences in real time, as eye movements reflect the level of attention towards the linguistic referent (Altmann & Kamide,

1999; Spivey, Tanenhaus, Eberhard & Sedivy, 2002; see Huettig, Rommers & Meyer, 2011). This paradigm has proved insightful in understanding anaphora resolution (e.g. Järvikivi, van Gompel, Hyönä & Bertram, 2005; Arnold et al., 2000), though it has not yet been used to study Italian pronoun processing. In addition to eye movements, we also collected reaction times in the forced-choice task, as a further measure of the time course of the resolution of null and overt pronouns.

We expected the overt pronoun to be associated with the object antecedent more often than the null pronoun in both on-line and off-line measures. If the inconsistent results in previous studies are due to methodological concerns that affect the generalizability of Carminati's data, both on-line and off-line data should reflect the ambiguity of the null pronoun, as in studies by Tsimpli et al. (2004), Belletti et al. (2007) and Sorace and Filiaci (2006). If, however, the difference between those findings and Carminati's data is due to the difference between processing aspects and ultimate preferences, we expect marked interpretational preferences to emerge for both pronouns, in off-line measures, but time course differences in on-line measures, and different proportions of looks towards the antecedents (i.e. marked preference for the object after an overt pronoun vs. limited or no preference for the subject antecedent after a null pronoun).

### *7.1.3 Pronoun processing in Italian-English bilinguals*

The studies mentioned above (Nieuwland & Van Berkum, 2006; Nieuwland, 2014; Arnold & Lao, 2014; Kehler & Rohde, 2016; Hendriks et al., 2014) show that individuals may vary in the way they interpret and process pronouns. Variability has also been demonstrated between groups of speakers: in a set of studies using sentences like (1-2), bilingual speakers of Italian and English (a language that does not allow null pronouns) were more likely than Italian monolinguals to associate an overt pronoun to the subject antecedent (Belletti et al., 2007; Tsimpli et al., 2004; Sorace & Filiaci, 2006; Sorace, Serratrice, Filiaci & Baldo, 2009). Bilinguals and monolinguals may differ in how they produce and interpret linguistic structures because of the mutual influence of one language over the other (Odlin, 1989; Köpke & Schmid

2004, Schmid 2007). Hence, bilinguals whose languages differ from the point of view of null pronouns (i.e. one language allows them while the other does not) may interpret pronouns differently than monolinguals because of the partial overlap of their two grammars: the least constrained system (i.e. the non null subject language, which has only overt pronouns) affects the more constrained system (i.e. the null subject language, which has both null and overt pronouns), and the option common to both systems (i.e. the overt pronoun) is overextended in the language that has both options (Serratrice, Sorace, Filiaci & Baldo, 2009). This hypothesis would explain why bilingual participants in previous studies tended to interpret the overt pronoun as referring to the subject antecedent more often than monolingual participants.

An alternative explanation focuses on the processing mechanisms involved in understanding and using different types of grammatical structures. As suggested by the Interface Hypothesis (IH, Sorace & Filiaci, 2006; Sorace 2011, 2016), structures such as pronouns that occur at the interface between syntactic and extra-syntactic domains, namely discourse-pragmatics, require the integration of multiple sources of information, such as grammatical features and pragmatic or contextual conditions (as opposed to narrowly syntactic properties like word order). The IH focuses on the cognitive resources needed to integrate this information, which may overlap in part with the resources required to handle language competition in bilinguals, such as executive control (De Baene, Duyck, Brass & Carreiras 2015; Coderre, Smith, Van Heuven & Horwitz, 2015; Abutalebi & Green, 2008; Sorace, 2016; but see Branzi, Calabria, Boscarino & Costa, 2016). Consequently, in an attempt to minimise this computational effort, bilingual speakers may simplify their processing strategies (e.g. resort to default forms), thereby processing interface structures differently from monolingual speakers.

However, the majority of the available studies examined pronoun interpretation off-line (i.e. picture verification tasks, Belletti et al., 2007; Tsimpli et al., 2004; Sorace & Filiaci, 2006; Sorace et al., 2009), so that their conclusions about the underlying processing strategies may be limited. A recent study by Chamorro, Sorace and Sturt (2016) compared acceptability judgements and processing costs (measured by eye-tracking during reading) of null and overt

Spanish pronouns in monolingual Spanish speakers and bilingual Spanish-English speakers. While the two groups did not differ in their acceptability ratings, eye movements suggested that bilinguals had reduced discrimination between the two pronouns in their antecedent preferences (Chamorro et al., 2016). Chamorro et al. concluded that their participants' bilingual experience with English did not affect their knowledge representations, but did affect their ability to process interface structures.

In the case of Italian pronouns, current findings are inconclusive regarding whether the difference between bilinguals and monolinguals relates to differences in real time processing. Moreover, the available studies used different types of experimental sentences (e.g. in terms of linear order of pronouns and antecedents), and tested different populations (children and adults, early and late bilinguals), so that it is difficult to generalise the interpretational preferences of monolingual and bilingual Italian speakers.

We addressed this question in our second experiment, where we examined Italian-English bilinguals, combining on-line measures and off-line measures. If these participants interpret the overt pronoun as referring to the subject antecedent more often than Italian-dominant speakers (i.e. they 'overextend' the interpretation of the overt pronoun), they should show no antecedent preference for the overt pronoun in off-line measures. Following the IH, the same pattern is expected in online measures, reflecting different processing strategies in these bilingual speakers.

### *7.1.4 Pronoun processing in Italian-Sardinian bilinguals*

The IH, focusing on processing aspects, also predicts that differences can be observed between monolinguals and bilinguals independently of cross-linguistic interference, as in bilinguals using two languages that both present null and overt pronouns (Sorace & Filiaci, 2006; Sorace 2011). Sorace et al. (2009) indeed found overextension of the overt pronoun in Italian-Spanish bilingual children (see also Sorace & Serratrice, 2009), and similar results have been found in

bilingual speakers of other null subject languages of the same type as Italian, such as Spanish and Greek (Margaza & Bel, 2006; Bini, 1993; Lozano, 2006, Mendes & Iribarren, 2007).

However no difference was found between Italian monolinguals and Croatian-Italian bilinguals, two null subject languages from different typological families (Kraš, 2016). Another potential challenge to the IH comes from a study comparing Spanish monolinguals and Italian monolinguals, in which Spanish speakers were more likely to interpret the overt pronoun as referring to the subject antecedent than Italian speakers (Filiaci, Sorace & Carreiras, 2013). The authors concluded that the interpretational differences of Italian-Spanish bilinguals in previous studies are due to cross-linguistic differences between Italian and Spanish. These mixed findings leave the following questions open: do bilingual speakers whose languages both allow null and overt pronouns interpret pronouns differently from monolinguals? Do they process them differently? Are their interpretations and processing strategies comparable to those of bilinguals whose languages are different from the point of view of null and overt pronouns? We addressed these questions in experiment 3, where we examined bilingual speakers of Italian and Sardinian. Italian-Sardinian bilingualism represents a previously unstudied combination of two typologically similar null subject languages with similar pronominal inventories. Based on existing descriptive studies, we assume no cross-linguistic difference between Italian and Sardinian from the point of view of their pronominal inventories and of the grammatical properties associated with the null subject grammatical system (e.g. post-verbal subjects, Jones, 1993; Pittau, 1991).

The Italian-Sardinian bilinguals who took part in experiment 3 were highly proficient early bilinguals (i.e. learnt both Italian and Sardinian before the age of 8). We expected Italian-Sardinian bilinguals to show a difference between the two pronouns in off-line measures, that is, to associate the overt pronoun with the object antecedent more often than the null pronoun (like Italian-dominant speakers). In contrast, if the experience of managing two languages affects pronoun processing, as suggested by the IH, we would expect a reduced difference, or no difference at all, between antecedent preferences for the subject and the object antecedent during real time processing of overt pronouns.

However, if Italian-English bilinguals (exp. 2) and Italian-Sardinian active bilinguals (exp. 3) have different interpretational preferences or processing strategies from Italian-dominant speakers, these might be related to different patterns of language use or to any other aspect of their bilingual experience. To identify the aspects of the bilingual experience that may affect pronominal processing, in experiment 4, we tested Italian-Sardinian Passive bilinguals. These participants are exposed to both languages since childhood, and understand both languages, but only speak Italian; according to a socio-linguistic survey, they constitute the 29% of the Sardinian population (Lupinu et al., 2007). Participants in experiment 3 and 4 have very similar linguistic experiences: a life-long exposure to the same languages, same linguistic environment and contexts of use. However, only the experience of participants in experiment 3 is characterised by active and sustained management of two languages. As this aspect has been associated with effects on cognitive resources available for language processing (Sorace, 2016), we expect participants in experiment 4 to behave more similarly to Italian-dominant speakers that to Italian-Sardinian full bilinguals. Specifically, we expect Italian-Sardinian Passive bilinguals to associate the overt pronoun to the object antecedent more often than the null pronoun in off-line and on-line measures.

### *7.1.5 Summary of the aims of the current study*

Our study aims to clarify how null and overt pronouns are interpreted in Italian speakers, how these interpretations are processed, and whether the bilingual experience affects pronoun interpretation, processing, or both. To determine what aspects of the bilingual experience may contribute to differences in pronominal resolution, we examine four groups of native Italian speakers with different types and degrees of bilingualism. In experiment 1 we focus on Italian-dominant speakers; in experiment 2 we examine Italian-English bilinguals; in experiment 3 we look at Italian-Sardinian bilinguals; and in experiment 4 we test Italian-Sardinian Passive bilinguals. For all groups, we combined on-line measures of real-time processing, namely eye movements in a visual world experiment, and off-line measures, i.e., forced-choice responses.

By doing so, we aim at discriminating the temporal dynamics of the resolution of null and overt pronouns from the speakers' ultimate preference.

## 7.2 Experiment 1: Italian-Dominant Bilinguals

In our first experiment, we examined the processing of null and overt pronouns in Italian-dominant speakers. In off-line measures (key-press responses) we expect the overt pronoun to refer to the object antecedent more often than the null pronoun. If Carminati's PAS captures the interpretation and processing of pronouns, we expect polarised antecedent preferences for both pronouns. If, however, as suggested by previous findings (Tsimpli et al., 2004; Belletti, et al., 2007; Sorace & Filiaci, 2006), the overt pronoun is strongly associated with the object antecedent, while the null pronoun is not strongly associated with either antecedent, we expect differences in off-line measures (in terms of proportions of antecedent preferences) and in on-line measures (proportions of looks towards the antecedents and time course). Finally, RT in the forced-choice task may also mirror a processing difference between null and overt pronouns: we expect shorter RT for pronouns with a stronger association to either antecedent.

### *7.2.1 Experimental design and materials*

We designed a Visual World experiment in which participants listened to Italian sentences while seeing pictures on a computer monitor, and were then asked a forced-choice question about the interpretation of the sentence. See Figure 7.1 for a visual representation of the experimental design.

We created 36 experimental items. Each item involved an array of four pictures and an associated sentence. The different types of sentences are presented in Table 7.1. All sentences were bi-clausal. In experimental sentences the subject and the object of the main clause agreed in number (always singular) and gender (half of the sentences contained feminine entities); at the end of the main clause a temporal phrase (beginning with 'while' or 'when') introduced a plural entity, to divert participants' attention away from previous referents. After the main clause, the probe sentence presented a verb, an adverb and an adjective ('null' condition) or an overt pronoun, a verb, an adverb and an adjective ('overt' condition). The verb and the adjective agreed in number and gender with the subject and object referents presented in the main clause (hereafter, 'subject' and 'object antecedent').

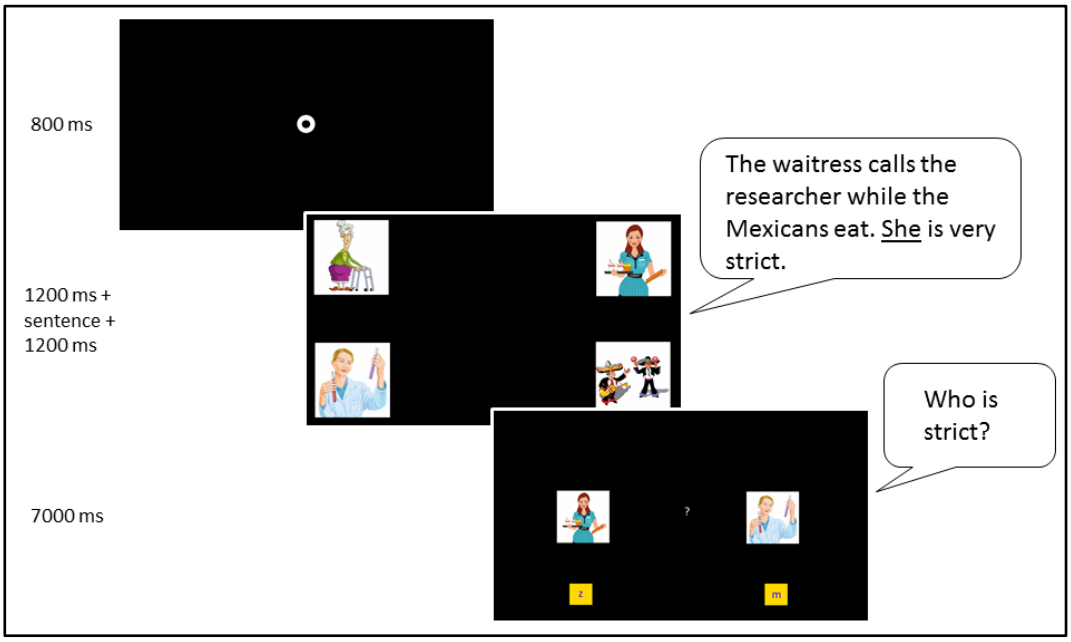



Figure 7.1 - Structure of the trial

To prevent participants from predicting the structure of 'null' and 'overt' sentences, 'lure' sentences were created with a similar structure but with a full Noun Phrase (NP) instead

of a pronoun. This NP had the same gender and number as the subject and object NPs in the main clause. Half of the lure items contained a feminine NP.

We additionally created 36 filler items. Each filler involved an array of four pictures together with an associated sentence. Filler sentences involved three types of structure (transitive main clause, coordinated main clause, intransitive main clause) and did not present any pronoun.

We created four lists, each containing 72 items (36 experimental items and 36 filler items). Within each list, there were 12 experimental items containing a null pronoun, 12 experimental items containing an overt pronoun, and 12 experimental items containing a full NP. The same carrier sentences and the same entities appeared in each list, but carrier sentences and entities were paired differently across lists. Within each list, each entity appeared in six (experimental or filler) items overall, always with different entities (e.g., the waitress never appeared more than once in conjunction with the researcher). The reason to do so was to avoid semantic associations between entities and adjectives. Likewise, semantically related entities (e.g. the dancer and the singer) could not occur in the same sentence; across sentences, we avoided stereotyped schemas and recurring narratives. We created 4 extra filler items for the practice trials, using novel entities and pictures.

We selected cartoon colour pictures on-line, and ran an on-line picture naming study (34 Italian native speakers living in Italy) to choose the most frequent name and exclude pictures for which respondents did not agree on a name. We then edited pictures to be 272*272 pixels in size; the corresponding Regions of Interest (ROI) on screen were 58 pixels bigger than the pictures on each side; ROI did not touch each other. The position of the pictures on the screen was counterbalanced during the presentation of the sentence (each antecedent type would appear in each corner of the screen an equal number of times) and during the presentation of the question (each antecedent would appear on the left side of the screen 50% of the time).

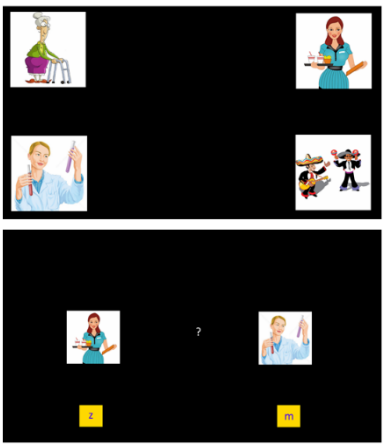
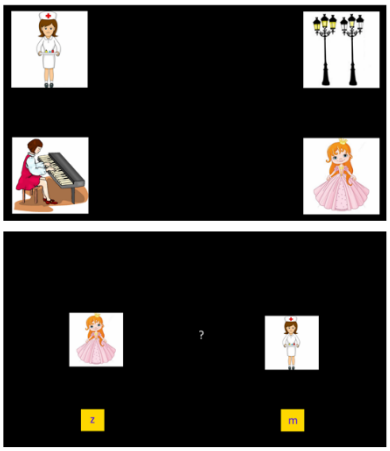
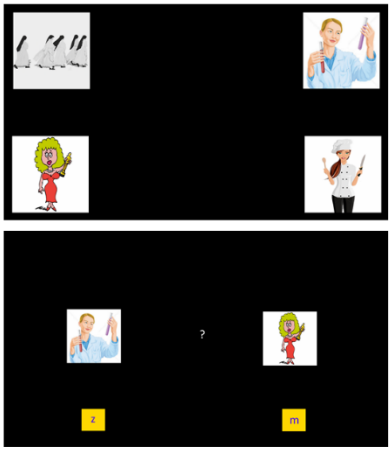
| | | |
|---|---|---|
| Null | La cameriera chiama la ricercatrice mentre i messicani mangiano. E' molto severa<br><br>The waitress calls the researcher(fem.) while the Mexicans eat. (She) is very strict(fem.)<br><br>Chi e' severo?<br><br>Who is strict? |  |
| Overt | La principessa nota l'infermiera mentre i lampioni si accendono. Lei e' davvero esigente<br><br>The princess notices the nurse while the street lamps switch on. She is really demanding.<br><br>Chi e' esigente?<br><br>Who is demanding? |  |
| Lure | L'attrice sbircia la cuoca mentre le suore passeggiano. La ricercatrice osserva la scena pensosa.<br><br>The actress peeps at the cook while the nuns take a stroll. The researcher observes the scene thoughtfully<br><br>Chi e' pensoso?<br><br>Who is thoughtful? |  |

Table 7.1 – Examples of sentences and array of pictures (from List 1)

### *7.2.2 Procedure*

While participants heard the experimental sentence, they looked at the array of pictures presented on screen (four pictures, one in each corner) that depicted the subject, the object, the plural entity, and a distractor. Pictures were presented for 1200 ms before the sentence onset and stayed on screen for the whole duration of the sentence plus 1200 ms.

A question was presented aurally 1200 ms after the end of each sentence, asking the participant who was referred to by the probe sentence. Simultaneously, the two pictures of the antecedents were presented, one on the left and one on the right; the participant answered by pressing either the left key ('z') or the right key ('m'). Sentences and questions were recorded by a native Italian speaker with an unmarked accent and neutral intonation.

The sequence of sentences was pseudo-randomized by participant, so that only up to two filler items could appear sequentially, and only up to two experimental (‘null’, ‘overt’ or lure) items could appear sequentially.

The experiment was run on a 13" laptop on OpenSesame 3.0 (creative commons, Mathôt, Schreij, & Theeuwes, 2012) with a monitor resolution of 1366 * 768. An Eye-Tribe© eye-tracker was installed at a fixed distance of 60 cm from the participant's eyes. The eye-tracker was calibrated at the beginning of the experiment; after 24 and 48 items participants took a break and re-calibrated. Every trial was preceded by a drift correction procedure.

Participants were tested individually in a quiet room. The experiment lasted approximately 25 minutes and participants were randomly assigned to experimental lists. The experimental session included the visual world experiment, a language history questionnaire, as well as a test of executive functions (for the purpose of a separate study). The order of tasks was varied across participants. The total duration of the experimental session was 60 minutes. All instructions were in Italian. All participants signed a consent form and were reimbursed for their time (€7/h).

| | Italian-dominant | Italian-English | Italian-Sardinian | Italian-Sardinian Passive |
|---|---|---|---|---|
| **Age (years)** | 24.28 (2.42) | 25.64 (4.31) | 31 (6.9) | 28.39 (6.48) |
| **Years of Education** | 16.33 (1.66) | 17.36 (2.54) | 15.63 (3.36) | 15.32 (2.86) |
| **L1 AoA** | 0.02 (0.15) | 0.22 (1.16) | 0.53 (1.12) | 0 (0) |
| **L1 AoA Fluent** | 3.76 (0.48) | 3 (0.94) | 3.68 (1.91) | 3.08 (0.27) |
| **L1 speaking** | 5.93 (0.79) | 6.56 (0.64) | 6.13 (0.77) | 5.97 (0.58) |
| **L1 writing** | 5.93 (0.89) | 6.22 (1.03) | 6.03 (0.9) | 5.82 (0.76) |
| **L1 listening** | 6.43 (0.77) | 6.78 (0.42) | 6.53 (0.55) | 6.16 (0.71) |
| **L1 reading** | 6.11 (0.73) | 6.69 (0.52) | 6.53 (0.6) | 6.26 (0.71) |
| **L1 exposure** | 6.47 (0.26) | 4.28 (0.85) | 4.88 (1.01) | 6.22 (0.57) |
| **L2 AoA** | 7.71 (2.67)* | 8.17 (2.83) | 1.21 (2.22) | 4.39 (4.69)* |
| **L2 AoA Fluent** | 15.43 (3.8)* | 18.61 (5.88) | 8.18 (7.06) | 10.85 (6.25)* |
| **L2 speaking** | 3.76 (1.25) | 5.47 (0.83) | 5.89 (0.85) | 3.21 (1.42) |
| **L2 writing** | 3.96 (1.25) | 5.44 (0.9) | 5.29 (1.62) | 2.42 (1.5) |
| **L2 listening** | 4 (1.4) | 6.03 (0.83) | 6.55 (0.55) | 4.71 (1.75) |
| **L2 reading** | 4.5 (1.3) | 6.17 (0.69) | 6.11 (1.35) | 3.97 (1.83) |
| **L2 exposure** | 1.95 (0.66) | 3.87 (0.71) | 3.66 (0.98) | 2 (0.8) |
| **Switch frequency** | 2.24 (1.29) | 4.86 (1.8) | 5.32 (1.64) | 3.21 (1.78) |

Table 7.2 - Mean and SD (in brackets) for age and years of education, self-rated rated language proficiency and exposure, age of acquisition (AoA), and frequency of language switching across groups. Values marked with (*) represent means ignoring missing values.

### *7.2.3 Participants*

46 Italian native speakers (36 females, mean age 24.28, range 20 – 35) were recruited and tested at the University of Milan Bicocca, Italy. Selection requirements were to be an Italian native speaker, have no record of linguistic or cognitive impairment, to be aged between 18 and 40, have no advanced knowledge of any foreign language or dialect, and no experience of immersion in a non-Italian environment for more than 3 months. However, all these participants had a basic or intermediate proficiency in English, as required in school and university, through the First Certificate in English (FCE, Cambridge English Language

Assessment), or equivalent tests. Table (7.2) summarizes their responses to the Language History Questionnaire. 13 other participants were tested but excluded from the analysis for percentage of discarded eye-tracking data higher than 18% (N = 9) or for failure of eye-tracking equipment (N = 4).

### *7.2.4 Data pre-processing*

The Eye-Tribe© portable eye-tracker has a sampling capacity of 30 Hz or 60 Hz. We used 30 Hz sampling to avoid reducing the tracking area (50cm x 30cm x 65cm), obtaining one data point on average every 33ms. We synchronised eye-tracking data with the time course of the auditory stimuli, defined in 3 time windows corresponding to the verb, the adverb and the adjective (each window begins 200 ms after the onset of each critical word, Allopenna, Magnuson & Tanenhaus, 1998). Data relative to fixations to the distractor, to the plural entity or outside of ROI, as well as data relative to practice, lure and filler items were not further analysed.

### *7.2.5 Data analysis*

We analysed responses and reaction times (RT) to the forced-choice task, as well as fixations throughout time windows, using RStudio© 1.0.136 (RStudio Team, 2016). For all these measures, we fitted mixed-model regressions using the statistical package lme4 (Bates, Maechler, Bolker, & Walker, 2015). For responses and RT, we specified a by-subject random intercept and a random slope for condition by subject, as the inclusion of by-trial random intercept produced high correlations in the random effects structure, indicating overfitting. For fixations, we specified a by-subject random intercept and a random slope for condition by subject, and a by-trial random intercept and a random slope for condition by trial. Responses and fixations were analysed using binomial logistic regression. For both measures, we coded the choice of subject antecedent as one binomial variable, and the choice of object antecedent as a separate binomial variable. For responses, the separate coding was motivated by the

presence of null responses (i.e. no press, 1.2% of data across groups and conditions); as the analyses of subject and object responses gave identical results in all groups, we present only the results of the analysis of subject responses. For fixations, subject and object responses were not complementary due to fixations to the other two ROIs (distractor and plural entity), as well as fixations outside ROIs. We therefore present the analyses of both binomial variables. Finally, RT were analysed using linear regression. For all these analyses, we evaluated the main effect of condition ('null' vs 'overt' trials) through forward model comparison. In the analysis of fixations, we evaluated how eye movements towards the antecedents unfolded over the time course of the sentence by including the effect of time window ('verb', 'adverb', 'adjective') and the interaction between time window and condition, also through forward model comparison. Tables (7.3-7.4-7.5) present proportions of responses, RT and fixations across conditions and groups.

### *7.2.6 Results*

The analysis of key-press responses showed a significant effect of condition ($p < .001$), in that there were significantly fewer subject responses after an overt pronoun than after a null pronoun (ß = -0.735, SE = 0.144, z = -5.095). The analysis of RT also showed a main effect of condition ($p = .001$), as responses were given significantly faster after an overt pronoun (ß = -218.75, SE = 66.01, t = -3.314) than a null pronoun.

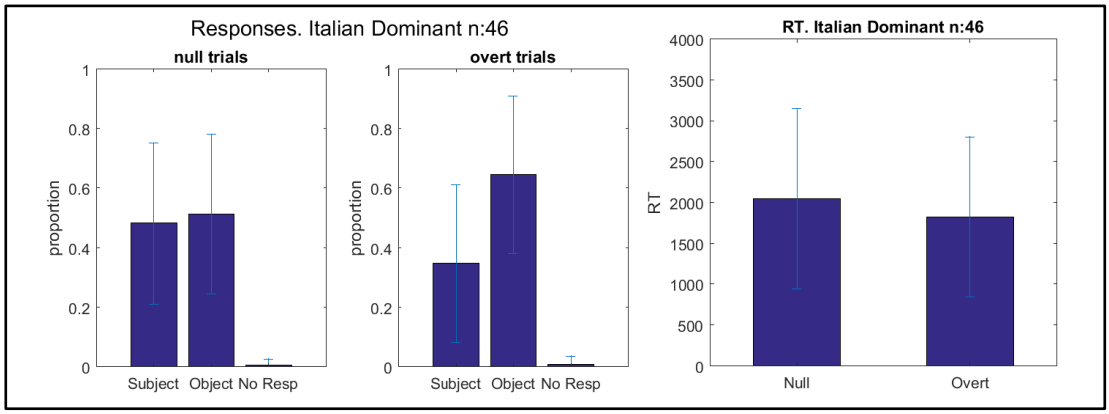



Figure 7.2 - Responses and RT in Italian-dominant. Bars = ±1 SD

The analysis of fixations to the subject antecedent showed no differences between 'null' and 'overt' trials (p = .437), but a difference through time windows (p < .001), as there were less looks to the subject antecedent during the adverb, than during the verb (ß = -0.201, SE = 0.054, z = -3.670), and more looks to the subject during the adjective than during the verb (ß = 0.155, SE = 0.048, z = 3.229). The interaction between condition and time window was significant (p < .001), as during the adjective there were more looks to the subject antecedent in 'null' trials than in 'overt' trials (ß = 0.317, SE = 0.068, z = 4.540).

Fixations to the object antecedent, in contrast, differed significantly by condition (p = .004), as there were more looks to the object after an overt pronoun than after a null pronoun (ß = 0.049, SE = 0.168, z = 2.426). Object fixations also differed by time window (p < .001), as they increased during the adverb (ß = 0.112, SE = 0.059, z = 1.885) as well as during the adjective (ß = 0.566, SE = 0.053, z = 10.667). The interaction between condition and time window was not significant (p = .511).

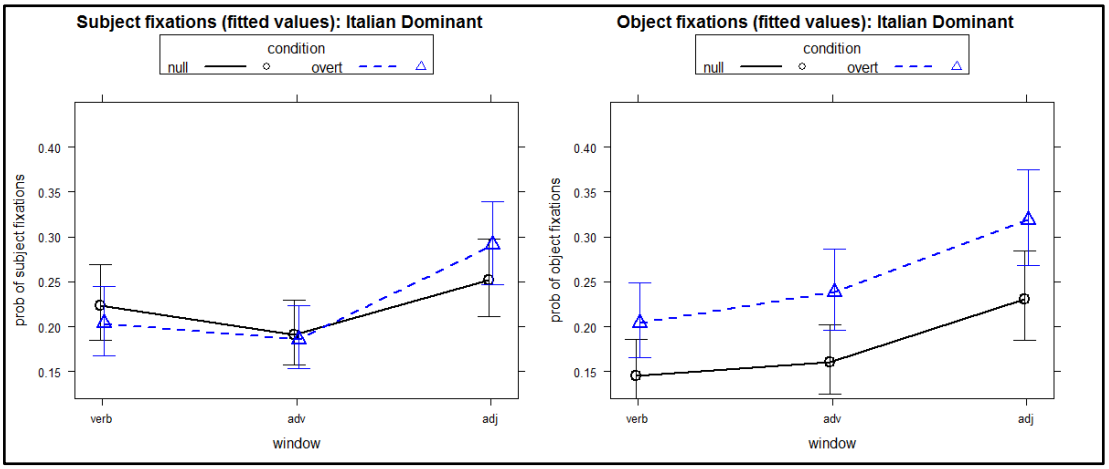



Figure 7.3 - Subject and Object fixations during time windows (fitted values) in Italian-dominant. Time windows: verb, adverb, adjective. Bars = 95% C.I.

### *7.2.7 Discussion*

Italian-dominant participants interpreted null and overt pronouns differently, that is, they associated the overt pronoun to the object antecedent more than the null pronoun, in line with Carminati's PAS. This pattern emerged in key-press responses as well as in the analysis of object fixations. Subject fixations, in contrast, did not show any difference between types of pronoun. With respect to the time course of pronoun processing, subject fixations increased significantly while participants were listening to the adjective (i.e. the last word in the probe sentence). In contrast, object fixations already increased significantly during the adverb, indicating a faster processing of reference to the second antecedent. A time difference between the processing of null and overt pronouns also emerged in the analysis of RT to the forced-choice task: answers to 'overt' trials were on average faster than answers to 'null' trials. The pattern of results found in on-line measures supports an asymmetry in processing strategies of null and overt pronouns, as the latter, but not the former, is associated with a marked preference for an antecedent (specifically, the object) as well as with faster responses. These results are consistent with the lack of clear antecedent preferences for null pronouns found in previous studies through off-line measures (Tsimpli et al., 2004; Belletti et al., 2007; Sorace & Filiaci, 2006).

## 7.3 Experiment 2: Italian-English Bilinguals

In our second experiment, we examined Italian-English bilinguals. Following research on the effects of cross-linguistic interference in bilinguals, we expected key-press responses to show a reduced or no difference between antecedents for overt pronouns. Following the IH, we expected this pattern to emerge in on-line measures, i.e. no difference in eye movements toward either antecedent after an overt pronoun, as well as a reduced or no difference in RT to key-press responses between sentences containing a null pronoun and sentences containing an overt pronoun.

### *7.3.1 Experimental design and materials, data pre-processing and data analysis*

Experimental design and materials, data pre-processing and data analysis were identical to experiment 1.

### *7.3.2 Procedure*

The procedure was identical to experiment 1, except for the fact that these participants took a further linguistic task in the experimental session (total duration 90 minutes).

### *7.3.3 Participants*

36 Italian-English bilinguals (20 females, mean age 25.64 years, range 19 – 36) were recruited in Edinburgh through university channels and through the local Italian community. Further selection requirements in addition to those for participants to experiment 1 were high proficiency and fluency in English and having lived in an English speaking environment for at least 6 months. 35 participants were dominant in Italian and had acquired English in primary school; one of them acquired both languages in childhood and reported a balanced proficiency. 15 more participants were tested but excluded from the analysis due to high percentage of discarded eye-tracking data (N = 9) or equipment failure (N = 6).

### *7.3.4 Results*

The analysis of responses showed an effect of condition ($p < .001$), with participants being less likely to choose a subject antecedent for an overt pronoun than for a null pronoun (ß = -0526. SE = 0.153, z = -3.433). The analysis of RT also showed an effect of condition ($p = .026$), as responses in 'overt' trials were significantly faster than in 'null' trials (ß = -167.31, SE = 75.42, t = -2.218).

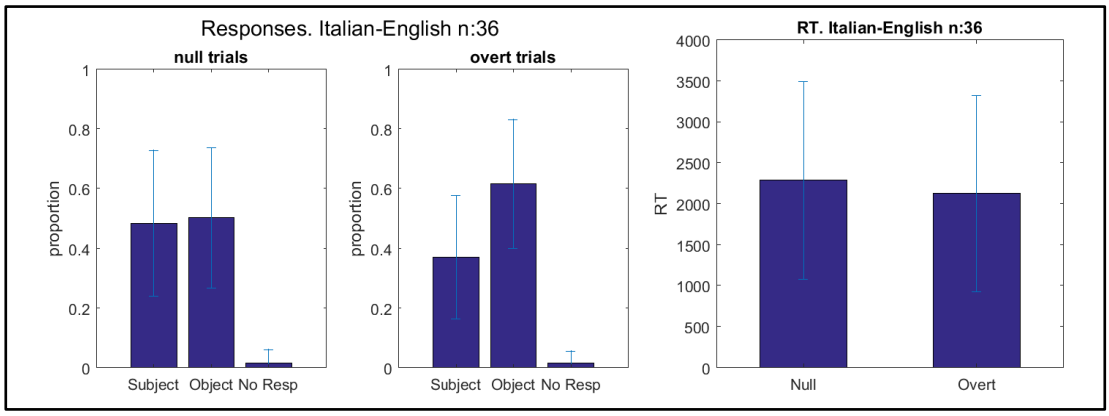



Figure 7.4 - Responses and RT in Italian-English bilinguals. Bars = ±1 SD

The analysis of subject fixations revealed no difference between 'null' and 'overt' trials ($p = .909$). There was a significant main effect of time window ($p < .001$), reflecting the fact that looks to the subject increased over the time windows, in particular there were significantly more looks to the subject during the adjective than during the verb (ß = 0.424, SE = 0.056, z = 7.503). The interaction between condition and time window did not reach significance ($p = .069$).

In contrast, object fixations differed significantly between 'null' and 'overt' trials ($p = .001$), as participants looked more at the object antecedent after an overt pronoun than after a null pronoun (ß = 0.525, SE = 0.153, z = 3.417). There was a main effect of time window ($p < .001$), as fixations to the object significantly increased during the adverb (ß = 0.204, SE = 0.068, z = 3.004) and during the adjective (ß = 0.428, SE = 0.061, z = 6.984). The interaction between time window and condition was also significant ($p < .001$), reflecting the fact that participants looked more to the object antecedent after having heard an overt pronoun, and significantly more so than after a null pronoun during the adverb (ß = 0.501, SE = 0.093, z = 2.350) and during the adjective (ß = 0.501, SE = 0.084, z = 5.902).

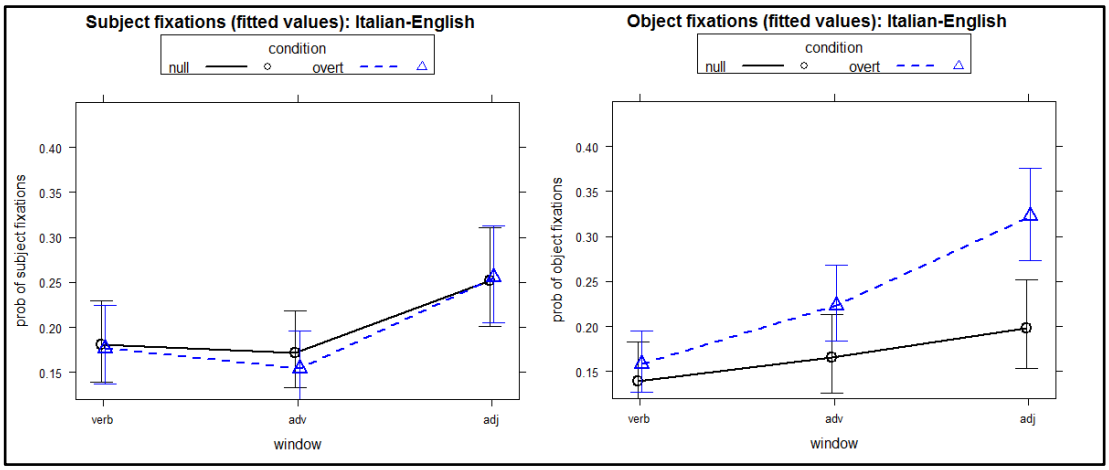



Figure 7.5 - Subject and Object fixations during time windows (fitted values) in Italian-English bilinguals. Time windows: verb, adverb, adjective. Bars = 95% C.I.

### *7.3.5 Discussion*

Italian-English bilinguals associated the overt pronoun significantly more often to the object antecedent than the null pronoun, both in their key-press responses, and in their eye movements. Like in Italian-dominant (experiment 1), only eye movements towards the object antecedent showed a difference between pronouns, while eye movements towards the subject antecedent did not. Moreover, responses to sentences containing an overt pronoun were faster than responses to sentences containing a null pronoun. Hence, our experiment does not replicate previous patterns of anaphora resolution in Italian-English bilinguals (Belletti et al., 2007; Sorace & Filiaci, 2006). These results are contrary to a prediction based on the effects of cross-linguistic interference on pronoun interpretation, as well as on the IH, based on processing aspects related to the bilingual experience. We evaluate possible explanations in the General Discussion (7.7).

## 7.4 Experiment 3: Italian-Sardinian Bilinguals

We conducted the same experiment with Italian-Sardinian highly proficient, early bilinguals. As we assume no cross-linguistic difference between Italian and Sardinian from the point of view of null subject properties and pronominal inventories, we expected a clear difference in antecedent preferences for null and overt pronouns in off-line measures, as in Italian-dominant speakers. However, following the IH, we expected no difference between subject and object antecedents after an overt pronoun (or a reduced difference in comparison to Italian-dominant speakers in experiment 1) in on-line measures. We also expected a reduced or no difference in RT to key-press responses between sentences containing a null pronoun and sentences containing a full pronoun.

### *7.4.1 Experimental design and materials, data pre-processing and data analysis*

Experimental design and materials, data pre-processing and data analysis were identical to experiment 1.

### *7.4.2 Procedure*

The procedure was identical to experiment 2.

### *7.4.3 Participants*

38 Italian-Sardinian bilinguals (20 females, mean age 31, range 18 – 42) were tested in different locations in Sardinia. Further selection requirements in addition to those for participants to experiment 1 were to have advanced knowledge and fluency in Sardinian. Other 17 participants were tested and excluded from the analysis for high percentage of discarded eye-tracking data (N = 6) or for equipment failure (N = 11).

### *7.4.4 Results*

Italian-Sardinian bilinguals showed a different interpretation of null and overt pronouns in their key-press responses (p = .002), as they gave significantly less subject responses after an overt pronoun than after a null pronoun (ß = -0.604, SE = 0.196, z = -3.085). However, there was no significant difference in RT to responses after the two types of trials (p = .520).

The analysis of subject fixations did not show differences between 'null' and 'overt' trials (p = .922). Fixations to the subject antecedent increased significantly across time

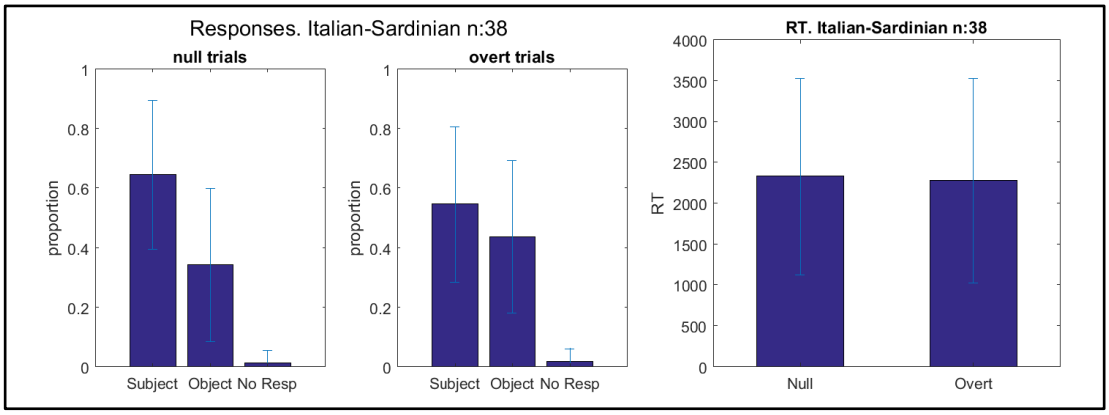



Figure 7.6 - Responses and RT in Italian-Sardinian bilinguals. Bars = ±1 SD

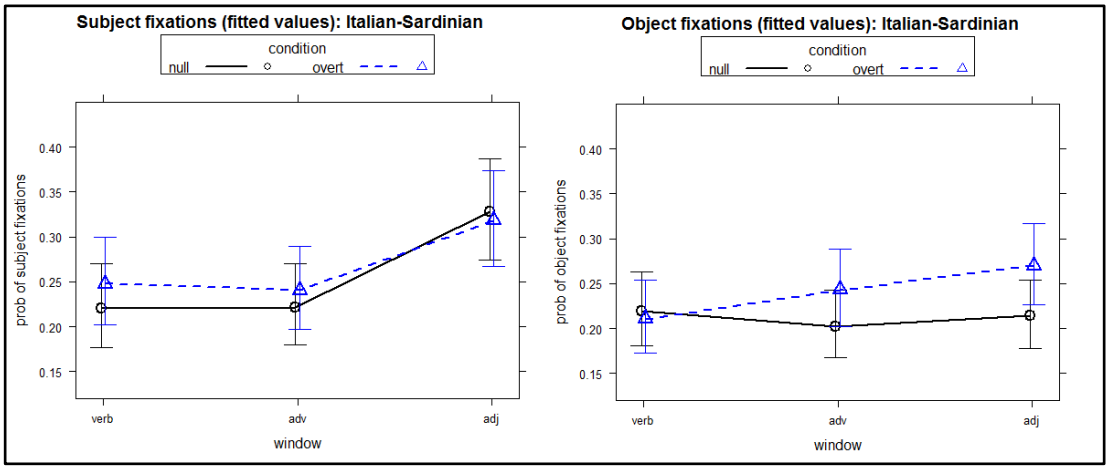



Figure 7.7 - Subject and Object fixations during time windows (fitted values) in Italian-Sardinian bilinguals. Time windows: verb, adverb, adjective. Bars = 95% C.I.

windows ($p < .001$), as there were more looks to the subject during the adjective than during the verb (ß = 0.548, SE = 0.052, z = 10.534). The interaction between condition and time window was significant ($p = .003$), as Italian-Sardinian bilinguals looked less at the subject during the adjective in the 'overt' condition, than in the 'null' condition (ß = -0.198, SE = 0.073, z = -2.70)

In object fixations, the difference between 'null' and 'overt' trials did not reach significance ($p = .092$). We found a significant main effect of time window ($p < .001$), as there were significantly more looks to the object during the adjective than during the verb (ß = 0.147, SE = 0.037, z = 3.882), and a significant interaction between condition and time window ($p < .001$), as in 'overt' trials looks to the object antecedent increased during the adverb (ß = 0.285, SE = 0.083, z = 3.409) and during the adjective (ß = 0.356, SE = 0.075, z = 4.688), but they did not increase in 'null' trials.

### *7.4.5 Discussion*

Italian-Sardinian bilinguals interpreted null pronouns differently from overt pronouns, as reflected by their key-press responses in which they chose the object antecedent more often for overt pronouns than for null pronouns. Nonetheless, we did not find a main effect of pronoun type in their eye movements to either antecedent, nor in their RT in the forced-choice task. Consistent with the difference in off-line measures, however, we found an interaction between time window and condition on object fixations, suggesting that by the end of the sentence, the two pronouns were associated with different antecedents. These findings suggest that our Italian-Sardinian bilinguals differentiated between null and overt pronouns in their explicit interpretation, but this difference between pronouns, in processing, was minimal and emerged late (i.e. while participants were listening to the end of the sentence).

## 7.5 Experiment 4: Italian-Sardinian Passive Bilinguals

In experiment 3 we found variability in pronominal resolution in bilingual speakers independently of relevant differences in null subject properties and pronoun inventories between their languages. To evaluate the hypothesis that the relevant aspect of their experience affecting pronoun processing is active and sustained language control, we tested Italian-Sardinian Passive bilinguals. As in the case of Italian-Sardinian full bilinguals, we assume no cross-linguistic difference between Italian and Sardinian from the point of view of the properties associated with the null subject grammar, therefore, we expected more object responses after an overt pronoun in off-line measures. Assuming that Italian-Sardinian Passive bilinguals lack the critical factor of active language control experience, we predicted on-line measures to also show a distinction in eye movements toward the subject and the object antecedents after an overt pronoun. Finally, we expected RT to questions after sentences containing an overt pronoun to be faster than RT to questions after sentences containing a null pronoun.

### *7.5.1 Experimental design and materials, data pre-processing and data analysis*

Experimental design and materials, data pre-processing and data analysis were identical to experiment 1.

### *7.5.2 Procedure*

The procedure was identical to experiment 1.

### *7.5.3 Participants*

38 Italian-Sardinian Passive bilinguals (29 females, mean age 28.39, range 19 – 42) were tested in various locations in Sardinia. A further selection requirement in addition to those for participants to experiment 1 was to not being fluent in Sardinian. 10 other participants were

tested but excluded from the analysis for high percentage of discarded eye-tracking data (N = 6) or for equipment failure (N = 4).

### *7.5.4 Results*

The analysis of key-press responses showed a main effect of condition (p = .013), as Italian-Sardinian Passive bilinguals chose the subject antecedent significantly less often after an overt pronoun than after a null pronoun (ß = -0.405, SE = 0.157, z = -2.580). RT also differed significantly in the two conditions (p = .026), as RT after overt pronouns were shorter than after null pronouns (ß = -168.56, SE = 75.94, t = -2.22).

The analysis of subject fixations showed no difference between conditions (p = .983). However, there was a significant main effect of time window (p < .001), as fixations to the subject decreased while participants were hearing the adverb, with respect to the beginning of the sentence (ß = -0.278, SE = 0.057, z = -4.857). We also found a significant interaction between condition and time window (p <. 001), as there were more fixations to the subject antecedent at the end of the sentence in 'overt' trials than in 'null' trials (ß = 0.329, SE = 0.074, z = 4.443).

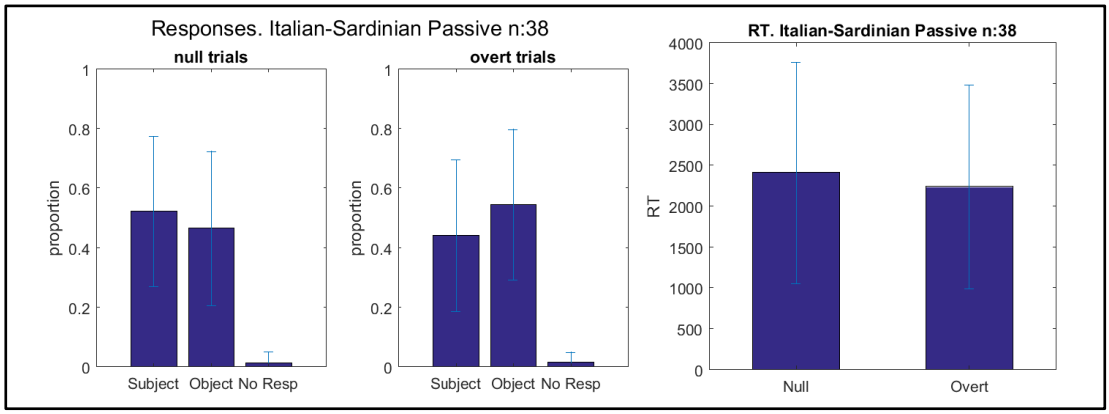



Figure 7.8 - Responses and RT in Italian-Sardinian Passive bilinguals. Bars = ±1 SD

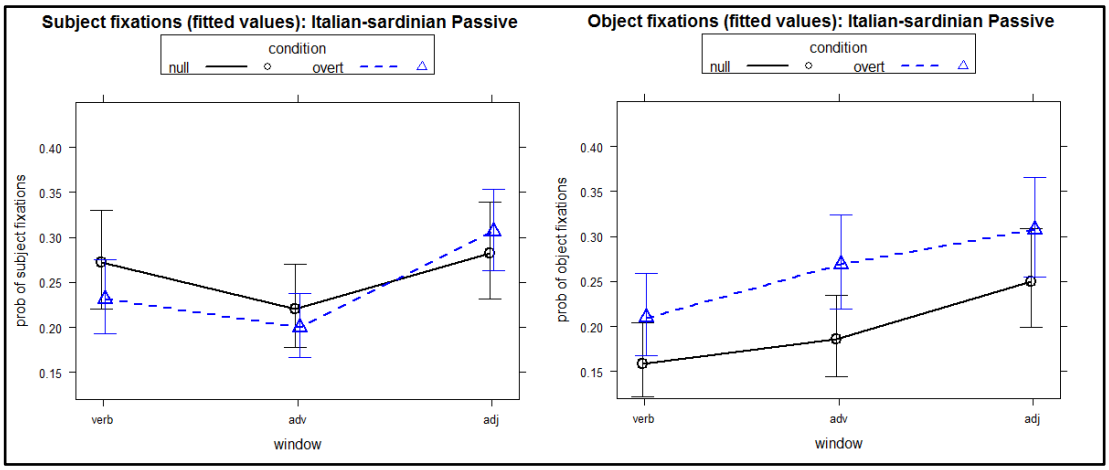



Figure 7.9 - Subject and Object fixations during time windows (fitted values) in Italian-Sardinian Passive bilinguals. Time windows: verb, adverb, adjective. Bars = 95% C.I.

The analysis of object fixations revealed that the difference between 'null' and 'overt' trials was significant ($p = .036$), reflecting the fact that participants looked more at the object in 'overt' trials than in 'null' trials ($ß = 0.339$, $SE = 0.175$, $z = 1.938$), We found a significant main effect of time window ($p < .001$), as looks to the object increased during the adverb ($ß = 0.188$, $SE = 0.063$, $z = 2.988$) and during the adjective ($ß = 0.568$, $SE = 0.056$, $z = 10.054$). We also found a significant interaction between time windows and condition ($p = .005$), although pairwise comparisons showed no significant difference between conditions across individual time windows.

### *7.5.5 Discussion*

Italian-Sardinian Passive bilinguals showed a pattern of results reflecting their distinction between null and overt pronouns (more object responses after an overt pronoun, more eye movements toward the object antecedent after an overt pronoun, shorter RT to questions after sentences containing an overt pronoun). While they markedly associated the overt pronoun to the object antecedent in both their explicit responses and in on-line measures, they did not show a marked antecedent preference for the null pronoun, in line with the results of experiments 1 and 2.

## 7.6 Comparison across groups

Finally, we present a comparative analysis, to summarise our findings and capture similarities and differences between our groups.

### *7.6.1 Forced-choice task responses across groups*

Across groups, the analysis of key-press responses showed a main effect of condition ($p < .001$), reflecting the fact that participants gave fewer subject responses after an overt pronoun than after a null pronoun (ß = -0.554, SE = 0.075, z = -7.357). We also found a main effect of group ($p = .001$), in that Italian-Sardinian bilinguals gave more subject responses than the other groups, in particular of the Italian-dominant (ß = 1.036, SE = 0.271, z = 3.820). The interaction between group and condition was not significant ($p = .560$).

| | **Italian-dominant** | | **Italian-English** | | **Italian-Sardinian** | | **Italian-Sardinian Passive** | |
|---|---|---|---|---|---|---|---|---|
| | subject | object | subject | object | subject | object | subject | object |
| **null** | 0.48 (0.27) | 0.51 (0.27) | 0.48 (0.24) | 0.50 (0.23) | 0.64 (0.25) | 0.34 (0.26) | 0.52 (0.25) | 0.46 (0.26) |
| **overt** | 0.35 (0.26) | 0.64 (0.27) | 0.37 (0.21) | 0.62 (0.22) | 0.55 (0.26) | 0.44 (0.26) | 0.44 (0.25) | 0.54 (0.25) |

Table 7.3 - Forced-choice task: mean proportions of responses and SD in brackets for the subject and object antecedents across conditions and groups.

| | **Italian-dominant** | **Italian-English** | **Italian-Sardinian** | **Italian-Sardinian Passive** |
|---|---|---|---|---|
| **null** | 2048 (1106) | 2289 (1208) | 2330 (1201) | 2409 (1354) |
| **overt** | 1824 (978) | 2125 (1193) | 2276 (1253) | 2238 (1250) |

Table 7.4 - Forced-choice task: mean RT and SD in brackets for responses across conditions and groups.

The analysis of RT also showed a main effect of condition ($p < .001$) and a main effect of group ($p < .004$). The difference between conditions reflects the fact that overall, there was a tendency to give faster responses in 'overt' trials than in 'null' trials (ß = -218.17, SE = 64.71, z = -3.371). The group difference reflects the fact that Italian-dominant participants responded faster than all other participants, irrespectively of the type of trial. The interaction between group and condition was not significant ($p = .414$)

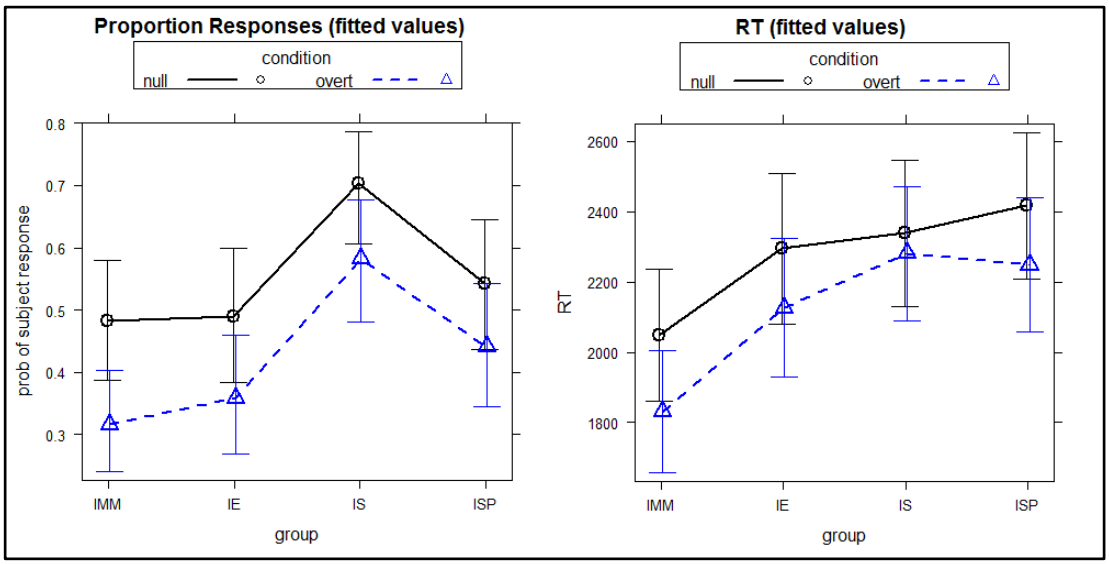



Figure 7.10 - Responses and RT (fitted values) across groups and conditions. Groups from left to right: Italian-dominant (IMM), Italian-English bilinguals (IE), Italian-Sardinian bilinguals (IS), Italian-Sardinian Passive bilinguals (ISP). Bars = 95% C.I.

### *7.6.2 Eye movements across groups*

The comparison of subject fixations between groups showed no effect of condition ($p = .750$) and a very marginal effect of group ($p = .068$), as the Italian-Sardinian bilinguals tended to look more at the subject antecedent than the Italian-dominant group (ß = 0.221, SE = 0.123, z = 1.794). We also found a main effect of time window ($p < .001$) reflecting the fact that fixations to the subject increased significantly during the adjective time window (ß = 0.350, SE = 0.018, z = 18.900), and a significant interaction between condition and window ($p <$

.001), although the pairwise comparison did not show relevant differences between conditions and windows.

| | Subject Fixations (null) | Object Fixations (null) | Subject Fixations (overt) | Object Fixations (overt) |
|---|---|---|---|---|
| **Italian-dominant** | | | | |
| verb | 0.24 (0.4) | 0.18 (0.35) | 0.22 (0.39) | 0.21 (0.38) |
| adverb | 0.21 (0.35) | 0.18 (0.33) | 0.21 (0.35) | 0.25 (0.38) |
| adjective | 0.27 (0.33) | 0.25 (0.32) | 0.3 (0.35) | 0.34 (0.37) |
| **Italian-English** | | | | |
| verb | 0.20 (0.38) | 0.18 (0.37) | 0.22 (0.38) | 0.18 (0.36) |
| adverb | 0.19 (0.34) | 0.19 (0.34) | 0.18 (0.32) | 0.23 (0.37) |
| adjective | 0.26 (0.32) | 0.23 (0.32) | 0.27 (0.33) | 0.33 (0.35) |
| **Italian-Sardinian** | | | | |
| verb | 0.25 (0.4) | 0.24 (0.39) | 0.28 (0.43) | 0.22 (0.39) |
| adverb | 0.24 (0.38) | 0.22 (0.36) | 0.26 (0.39) | 0.26 (0.39) |
| adjective | 0.33 (0.37) | 0.23 (0.32) | 0.32 (0.36) | 0.29 (0.36) |
| **Italian-Sardinian Passive** | | | | |
| verb | 0.29 (0.43) | 0.17 (0.35) | 0.26 (0.42) | 0.23 (0.39) |
| adverb | 0.24 (0.37) | 0.21 (0.33) | 0.22 (0.35) | 0.28 (0.38) |
| adjective | 0.29 (0.33) | 0.27 (0.33) | 0.31 (0.36) | 0.33 (0.36) |

Table 7.5 - Eye-movements: mean proportions of fixations (SD in brackets) to the subject and object antecedents across conditions, groups and time windows.

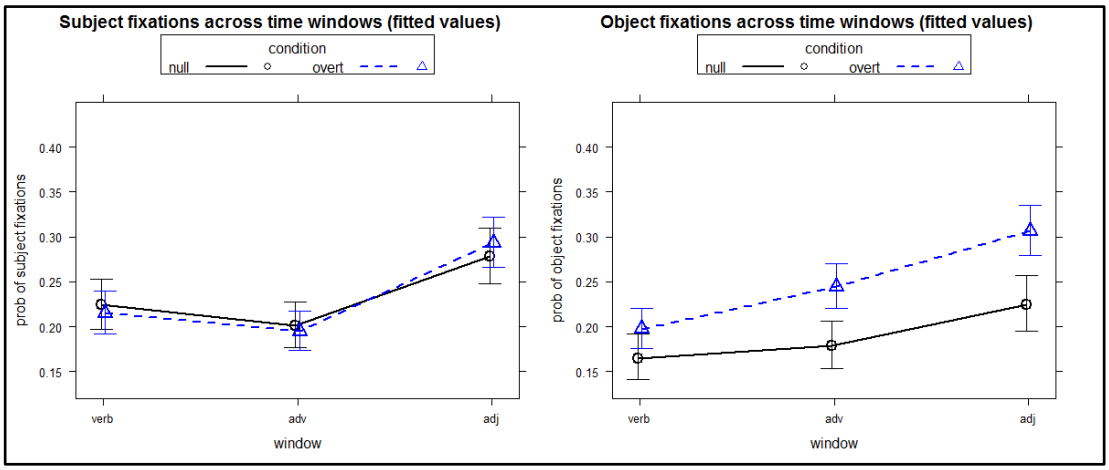



Figure 7.11 - Fitted values of fixations to the subject antecedent (left) and to the object antecedent (right) across time windows, averaged across groups. Time windows: verb, adverb, adjective. Bars = 95% C.I.

The comparative analysis of object fixations showed a main effect of condition ($p < .001$), as participants were more likely to look at the object antecedent after hearing an overt pronoun ($\beta = 0.389$ SE = 0.095 z = 4.053). The main effect of group was not significant ($p = .776$), and there was no interaction between group and condition ($p = .293$). We found a main effect of time windows ($p < .001$), as fixations to the object antecedent increased during the adverb (ß = 0.190, SE = 0.021, z = 8.897) and during the adjective (ß = 0.490, SE = 0.019, z = 25.425). We also found a significant interaction between time window and condition ($p < .001$), reflecting the fact that object fixations did not differ by condition while participants listened to the verb, but increased significantly more in the 'overt' condition already during the adverb than in the 'null' condition (adjusted $p < .001$).

## 7.7 General discussion

Our first experiment showed that the processing of null and overt pronouns in native Italian speakers is not symmetric: overt pronouns are associated with an antecedent more strongly and earlier than null pronouns. The difference in the strength of the antecedent preference is indicated by higher proportions of looks towards the object antecedent and of object responses

after an overt pronoun, and no difference between looks nor responses after a null pronoun. The difference in time-course is reflected by shorter RT for questions relating to the interpretation of overt pronouns, and by the fact that eye movements to the object antecedent increased significantly while participants were listening to the adverb, whereas eye movements to the subject antecedent only increased later in the sentence (during the adjective). Note that, even if we varied the combinations of antecedents and adjectives across experimental lists to avoid potential semantic associations, participants could still 'wait' for the semantic information provided by the adjective to resolve the pronoun, albeit arbitrarily. Therefore, the processing strategies for null and overt pronouns seem to differ not only quantitatively (i.e. magnitude of antecedent preference) but also qualitatively (i.e. time course and possibly type of information retrieved). These results are consistent with previous studies (Tsimpli et al., 2004; Belletti et al., 2007; Sorace & Filiaci, 2009); at the same time, they add crucial information to Carminati's PAS, which only analyses anaphora resolution in Italian from a syntactic point of view.

Experiments 2 supports this asymmetric processing in another group of Italian speakers: Italian-English bilinguals showed a strong difference between null and overt pronouns in their off-line and on-line measures, comparably to Italian-dominant speakers. This was unexpected, following research on cross-linguistic interference, as well as the IH. A possible explanation for the lack of cross-linguistic interference in our data is the relatively short duration of linguistic immersion and recent onset of bilingualism in our Italian-English sample (3.7 years, SD = 3.5). Linguistic attrition at the sentence level has been attested in cases of more prolonged linguistic immersion (10 years in Köpke & Schmid 2004; Schmid 2007; 5 years in Chamorro, Sorace & Sturt, 2016), and previous studies presenting variability in anaphora resolution in Italian-English bilinguals tested near-native L2 speakers, with considerable immersion experience (e.g. Belletti et al., 2007; Sorace & Filiaci, 2006; Tsimpli et al., 2004). While our participants were highly proficient in English, they were not near-native bilinguals. Hence the extent of cross-linguistic effects may have been reduced in our population. Speculatively, we suggest that behavioural effects of the bilingual experience on

pronoun processing may be restricted to highly proficient bilinguals, with an early onset of bilingualism or immersion of long duration.

In experiment 3, Italian-Sardinian bilinguals interpreted the overt pronoun as referring to the object antecedent more often than the null pronoun, in the forced-choice task – i.e., they interpreted the two pronouns like Italian-dominant speakers. However, the analysis of their eye movements did not show antecedent preferences for the overt pronouns. Moreover, the comparative analysis shows that these participants gave on average more subject responses than the other groups, and also tended to look more to the subject antecedent with respect to the other groups. Taken together, these results show that these participants not only displayed a reduced and delayed difference between the two pronouns during real-time processing in comparison to the other groups, but also chose the subject antecedent more often than Italian-dominant participants. These results are thus qualitatively and quantitatively different from those of Italian-dominant participants (and of our other participants too). We interpret these findings as evidence in support of a different pronoun processing strategy connected to the specific bilingual experience of these participants.

We identified the critical aspect of the bilingual experience affecting pronoun processing in experiment 4, where we tested Italian-Sardinian Passive bilinguals. These participants interpreted and processed null and overt pronouns comparably to Italian-dominant speakers. The linguistic experience of Italian-Sardinian Passive bilinguals only differed from the group tested in experiment 3 from the point of view of active vs passive bilingualism, i.e. the participants in experiment 3, but not those in experiment 4, had an extensive experience in actively managing two languages, while age of acquisition, patterns of use, and linguistic distance were the same in the two groups. Taken together, experiment 3 and 4 support the idea that the active and prolonged management of two languages may draw on the resources required to resolve pronominal co-references, as suggested by the Interface Hypothesis (Sorace & Filiaci, 2006; Sorace 2011, 2016).

## 7.8 Conclusion

Our four experiments shed light on real time processing of pronouns in Italian: firstly, by showing an asymmetry between how null and overt pronouns are processed, secondly, by showing similarities and differences in pronoun processing between four groups of Italian speakers with different linguistic experiences, and lastly by identifying the effect of active bilingual experience on pronoun processing.

Regarding the limitations of our study, the lack of an interaction in our comparative analysis of eye movements between type of pronoun and group shows that the differences between the groups (in particular, between Italian-Sardinian bilinguals and Italian-dominant speakers) are indeed minimal. This fact may relate to discrepancies between the results of previous studies (e.g., small effect sizes). Secondly, in our by-group analyses we found different patterns of interactions between type of pronoun and time course of the sentence. Specifically, we found an interaction between type of pronoun and time window in the analysis of subject fixations in Italian-dominant speakers and in Italian Sardinian bilinguals, showing that eye movements towards the subject antecedent increased during the adjective after a null pronoun. This interaction was not present in Italian-English bilinguals, and we found a different pattern of interactions in Italian-Sardinian Passive bilinguals. Similarly, we found an interaction in object fixations in Italian-English and Italian-Sardinian bilinguals (showing that looks to the object antecedent increase more after an overt pronoun than after a null pronoun), but no interaction in Italian-dominant, and an unclear pattern in Italian-Sardinian bilinguals. These different interactions may reflect more subtle differences in the processing strategies of the groups examined here, that our design or our analyses were not able to capture. They could also be the result of the limited sampling rate of our portable eye-tracker.

Future research is needed to explore these different patterns of interactions. Moreover, the unexpected similarity between Italian-English bilinguals and Italian-dominant speakers suggests that future research should also aim to clarify further aspects of the bilingual experience that may contribute to variations in anaphora resolution, from both the linguistic and the cognitive perspectives, such as length of immersion and amount of language exposure.

# 8. Conclusion

## 8.1 Summary

In this thesis I investigated the role of specific aspects of the bilingual experience on language processing, language control and cognitive control. This research was aimed at understanding the bilingual experience as a continuum characterised by several dimensions, and at considering together linguistic and cognitive aspects in bilinguals.

I discussed these motivations in the first three chapters. In chapter 1, I examined existing literature on the development of the bilinguals' two languages as distinct and yet intertwined systems. Specifically, I focused on the role of both language exposure and age of acquisition on linguistic performance, and I questioned the operationalisation of language dominance in terms of proficiency only. I also discussed how language development is further characterised by the interaction between these aspects of language experience and language-specific properties – such as those of structures at the interface between syntax and pragmatics. Together, language experience and linguistic properties explain patterns of variability in bilingual linguistic performance, which are particularly visible in on-line processing.

In chapter 2, I then considered the cognitive aspects of language processing in bilinguals, that is, the circumstances and the mechanisms involved in managing the co-activation of the two languages. The two languages compete for selection: existing studies show effects of competition both at the local level (e.g., retrieval time for a specific word) and at the global level (e.g. overall naming times in the two languages). The available literature explains these effects in terms of mechanisms to control this competition (specifically, inhibition, as posited by the Inhibitory Control model, Green, 1998) and of factors such as word frequency across languages. However, as I pointed out, the correspondence between accounts of bilingual language access and the reported effects is elusive, and it is modulated

by various aspects of language experience beyond proficiency, such as exposure and age of acquisition.

In chapter 3, I examined existing research exploring the relationship between bilingualism and cognitive control. The relationship between language and executive functions is generally well-established in research on language, and both behavioural and neuroimaging studies show that language control and cognitive control partially overlap. The degree of overlap appears to depend on the speakers' experience, suggesting that bilingualism may have cognitive effects such as the modulation of cognitive control mechanisms. However, research aimed at clarifying this issue has proved inconclusive, and I identified three main reasons: lack of a theoretically explicit formulation of control mechanisms, lack of consideration of individual differences in executive control, and lack of consideration of differences in bilingual experience.

On the basis of this discussion, I formulated three research questions (chapter 4), relative to the effects of the bilingual experience on executive control, to how the ability to handle the competition between the two languages is modulated by various aspects of the bilingual experience, beyond proficiency, and to whether the bilingual experience affects language processing independently of cross-linguistic differences. I addressed these questions in three experimental studies, in which I studied four bilingual groups with different experiences: dominant Italian speakers with a low, late acquired proficiency in English, highly proficient late bilinguals of Italian (native language) and English, early, balanced bilinguals of Italian and Sardinian, and passive early bilinguals of Italian and Sardinian.

In my first study (chapter 5), I examined the effects of bilingualism on cognitive control using a task (AX-CPT) motivated by the dual mechanisms framework (Braver et al., 2007; Braver 2012). I evaluated group differences using two analyses: one on aggregated measures of accuracy, equivalent to a mixed-effects ANOVA, widely used in existing research, and one on non-aggregated accuracy, using binomial regression and a full random effects structure. The first analysis revealed that Italian-Sardinian bilinguals performed better than Italian dominant bilinguals on the critical condition ("AY"), which measures the ability to adjust

proactive and reactive control mechanisms; the Italian-English bilingual group also performed marginally better on this condition with respect to the Italian-dominant group. This result suggests that high proficiency in both active and passive modalities is related to better performance in cognitive control, so that both early age of acquisition and high proficiency may result in cognitive effects, but that each of these variable, individually examined, does not relate to better performance on cognitive control. The second analysis, however, did not confirm this group difference. Mixed-model regression, which allows the inclusion of individual variability between subjects as well as individual variability across conditions, supported the pattern and direction of data found in the analysis over aggregated accuracy, but it did not show a significant difference between groups on the critical condition. The comparison between these two analyses highlights the importance of individual variability in the relationship between language and cognitive control. This is the first important result of this thesis: this study shows that the exclusion of individual variability inflates the effect of group averaging and can result in a spurious link between individual aspects of the bilingual experience (e.g. age of acquisition, language proficiency) and cognitive control performance.

The second study (chapter 6) examined language switching in highly proficient Italian-English and Italian-Sardinian bilinguals. First, I analysed switch and mix costs in the two groups: the switch cost in Italian-English bilinguals was asymmetric and surprisingly larger in L2 than in L1. In the Italian-Sardinian group, in contrast, we found a symmetric switch cost, in line with previous findings on highly proficient, balanced bilinguals. Mix costs were asymmetric in both groups: mix costs into Italian were larger than into English and into Sardinian. To understand these patterns of performance in relation to the experience of the participants, I then analysed their naming latencies introducing continuous measures of their linguistic history: proficiency (widely studied in previous research on language switching) but also language exposure, age of acquisition and daily frequency of language switching. The results show that active (but not passive) L2 proficiency predicted faster switch trials in both languages, L2 daily exposure predicted reduced switch and mix costs in L1, and later age of acquisition predicted faster naming in L2. Last, daily frequency of language switching did not have an effect on the modulation of either naming times or mix/switch costs. These results

show that different aspects of the bilingual experience have different effects on the ability to access the two languages. This is the second relevant contribution of this thesis: it indicates that language dominance is more than proficiency; it also shows that these different dimensions modulate local and global effects of language competition differently, supporting the plausibility of distinct but inter-dependent mechanisms of language control at the local and at the global level.

Finally, the third study (chapter 7) addressed the effects of bilingualism on linguistic processing. I examined how four different groups of Italian bilingual speakers process null and overt pronouns using a Visual World paradigm combined with a forced-choice task. My first experiment, on Italian-dominant speakers, showed that the processing of null and overt pronouns is not symmetric: overt pronouns were associated with an antecedent more strongly and earlier than null pronouns, as reflected by differences in proportions of eye-movements and in responses. I also found a difference in the time-course of null and overt pronouns processing, in that questions relating to the interpretation of overt pronouns yielded shorter RT than questions relating to sentences with null pronouns; in addition, participants looked faster at the object antecedent, after an overt pronoun (i.e. earlier while listening to the sentence) than at the subject antecedent, after a null pronoun. This pattern suggests quantitative and qualitative differences between the processing of null and overt pronouns.

In experiment 2, I found a remarkably comparable pattern in Italian-English bilinguals. This was surprising, following the prediction that the cross-linguistic difference between Italian and English (Italian allows both null and overt pronouns while English only has overt pronouns) would lead to an overextension of the overt pronoun (i.e. allowing it to refer to both the subject and the object antecedent) in highly proficient, immersed bilinguals. I interpreted this finding in relation to the participants' experience: although highly proficient, these participants had only been immersed in an English-speaking environment on average for three years, which, compared to previous research, may represent too short a time to affect the processing of native structures such as null and overt pronouns.

In experiment 3, Italian-Sardinian bilinguals interpreted the overt pronoun more often than the null pronoun as referring to the object antecedent, in the forced-choice task; however, the analysis of their eye movements did not show antecedent preferences for the overt pronoun. Moreover, these participants gave on average more subject responses and tended to look more to the subject antecedent than the other groups. Together, these results show a reduced and delayed difference between the two pronouns during real-time processing, but also a baseline preference for pronoun resolution towards the subject antecedent: a qualitative and quantitative difference in the way these bilinguals process null and overt pronouns, compared to the other groups. In experiment 4, in contrast, Italian-Sardinian Passive bilinguals showed a pattern of responses and eye-movements comparable to the participants in experiments 1 and 2. Therefore, this study suggests that prolonged active bilingualism can indeed represent a circumstance for variability in linguistic processing independent of cross-linguistic differences. This is the third important contribution of this thesis: these results indicate the importance of examining different types of bilingual experience to understand the mutual influence of language and cognition in bilinguals.

## 8.2 Discussion and implications

This thesis brings together the study of language processing and cognitive aspects in bilinguals by identifying three dimensions of the bilingual experience and their effects on language processing, language control and cognitive control.

Specifically, high active proficiency and early age of acquisition, together, represent beneficial circumstances for the ability to optimally modulate proactive and reactive components of cognitive control; however, their effects are not strong enough to override individual variability stemming from other developmental, genetic and environmental factors. Active proficiency, age of acquisition and daily language exposure affect the ability to access the two languages separately, overcoming the competition between them: proficiency affects competition at the local level, age of acquisition modulates global competition, whereas

exposure regulates competition at both the local and the global level. Finally, these variables together define circumstances in which processing particularly demanding linguistic structures, such as pronouns, may vary between individuals, independently of structural differences between their languages. This suggests that bilinguals with a long experience of constant exposure to more than one language and high active proficiency may use some linguistic structures in the same way as individuals with different linguistic backgrounds, i.e. explicitly interpret them in similar ways, but process them in marginally different ways. These differences in processing may represent the adoption of alternative, equifinal solutions for these linguistic computations, that is, processing strategies that lead to the same outcome but may be cognitively less expensive or complex than others.

These effects, taken together, confirm that there are more dimensions to bilingualism than just dominance or proficiency. While this may seem an intuitive idea, it bears profound implications for the interpretation of existing research on bilingualism as well as for future research. Specifically, the current findings demonstrate the limits of operationalising dominance in terms of proficiency only, as often done in previous research on language development (see chapter 1) and language switching (see chapter 6), in that this may lead to conflating the effects of different aspects of the bilingual experience. These results also show the importance of examining multiple components of the bilingual experience, and explain, at least in part, why studies comparing heterogeneous populations of bilinguals may yield divergent results. An example related to the study of linguistic phenomena is the difference between the results of experiment 2 in my third study and previous research on pronoun processing in Italian-English bilinguals (see chapter 7): the difference in length of immersion of the participants may very well be responsible for the different results. Another example is the divergent results found using the same tests of executive functions between different studies concerned with the cognitive effects of bilingualism (see chapter 3 section 4).

One further reason for taking into account differences between the linguistic experience of groups and individuals is the way these may interact with individual differences in cognitive abilities, as for instance in executive functions. From this point of view, there are three crucial

implications for future research. First, future research should find empirical ways to account for individual differences and disentangle them from differences between the participants' linguistic background, as demonstrated by my first study (chapter 5). Secondly, individual differences in cognitive abilities and bilingual experience may be related to group differences such as higher or lower intelligence scores and socio-economic status, as in the case of immigrant samples (see Paap, Johnson & Sawi, 2016). This problem ("self-selection", i.e. individual experience such as immigration leading to different linguistic experience) requires future research to address the study of immigrant bilinguals cautiously. Third, the relationship between individual differences in executive functions and individual differences in bilingual experiences is important for the study of learning abilities and the development of learning strategies, because differences in learning abilities and outcomes correlate to both individual differences in cognitive abilities, such as shifting, updating, inhibition, and working memory (St Clair-Thompson & Gathercole, 2006) and to bilingual experience, as shown by studies reporting a higher learning flexibility in bilingual children (Kovács & Mehler, 2009) as well as a modulation of statistical learning biases (Onnis & Thiessen, 2013). The understanding of the contribution of different dimensions of the bilingual experience on both linguistic and cognitive abilities has outstanding applications beyond the study of bilingualism *per se*.

In addition, my results show the theoretical and empirical limitations of a dichotomous distinction between bilinguals and monolinguals. From a theoretical point of view, the analysis of the effects of the bilingual experience examined as a continuum sheds light on how specific components of the linguistic experience have different – albeit combined – effects on linguistic and cognitive abilities, as demonstrated in my three studies. From an empirical point of view, this thesis shows the risks and the disadvantages of classifying individuals as 'monolingual'. First, as different components of the linguistic experience have distinct effects on linguistic and cognitive abilities, future researchers not only should check their participants' proficiency in any additional language, but also their linguistic experience as a whole, as some aspects of this experience may represent confounding factors. Many studies tested 'monolingual' participants with knowledge of an L2 (see 3.4.3 for references), and it is possible that in some

cases those participants did not qualify as ‘monolingual’. This implies further limitations to the generalisability of existing results on linguistic and cognitive abilities in bilinguals.

Secondly, truly ‘monolingual’ speakers are virtually absent in many linguistic communities, as In Italy, for instance, and in many other countries in Europe, due to the pervasive and increasing presence of English, atop the widespread use of local linguistic varieties, and the multilingual composition of the population. Among 200 Italian speakers who participated to the studies presented here, none could be considered a monolingual. The Italian-dominant participants tested in my studies had only a low to moderate proficiency in English, however they all reported a significant passive exposure to it. Had I recruited participants from a non-academic, non-urban environment, I would have most likely tested individuals with perhaps a smaller exposure to English, but a greater exposure to and proficiency in a regional language – that is, individuals with an experience comparable to the Italian-Sardinian Passive bilingual participants. This fact bears important implications on the methodological choices of future research, but also on the scope and motivation of research on language. It raises the following question: what does it mean to study how Italian (or any other language in a similar situation) is processed and used, if this language is almost uniquely spoken by bilingual individuals, whose linguistic experience varies and who – as suggested by my third study – may be processing language in different ways? This question highlights the dynamic nature of language, and it links the study of bilingualism to the study of language change, from both a structural and a socio-linguistic perspective.

Before discussing the limitations of the studies presented here, I conclude this section relative to the implications for future research with a note on the importance of bringing together the study of language processing and cognitive control in bilinguals. Extensive research on language processing has used the expression “bilingual disadvantage” to refer to the interference effects discussed in chapter 2, such as delayed word retrieval (e.g., Runnqvist, Strijkers, Sadat & Costa, 2011); similarly, the body of research on the cognitive effects of bilingualism reviewed in 3.4 is notoriously referred to as research on the “bilingual advantage” (e.g., Costa et al., 2009). However, as I discussed and showed experimentally, it can be argued

that both the “bilingual disadvantage” and the “bilingual advantage” do not exist as such, but are rather the result of how specific, measurable, circumstances affect language processing and control mechanisms that can be modelled and identified. The discussion and the results I presented suggest that future venues of research should fruitfully explore these modulatory and mutual effects of language and cognition, and link them for instance to developmental, communicative and learning issues. In other words, my work indicates ways to empirically operationalise bilingualism as a magnifying glass on the human mind, rather than focusing on it as as a protected category in dated academic debates.

## 8.3 Limitations

In the studies presented, I focused on specific aspects of the bilingual experience of my participants: proficiency, age of acquisition, and daily language exposure of their second language. However, the four groups of participants I tested also differed in terms of language distance, contexts of use, as well as in other ways unrelated to their bilingual experience. I will first address the linguistic differences and then the non-linguistic ones.

With regards to language distance, Italian and Sardinian are of course more closely related than Italian and English, in that they are both Romance languages, and they display numerous similarities in lexicon, phonology, morphology and syntax. In addition, Italian, Sardinian and English do not have the same status. Sardinian is a minority language in Sardinia, and it only became an official language (alongside Italian) in the 1990s. In terms of contexts of use, Italian and Sardinian are used in a diglossic way: both languages are used in everyday life, but not in overlapping contexts. Typically, Sardinian is more used at home and with friends, while Italian is the language used at work or study and to access the media. Moreover, Italian is formally taught in school and it is the medium of education, while Sardinian is acquired informally and it is not often used in written form.

Participants in the Italian-English highly proficient bilingual group, in contrast, reported that Italian was the main language in both formal and informal contexts before their arrival to Scotland, and then English became the main language in all contexts (although participants also reported some use of Italian in informal contexts). For these participants, as well as for the participants in the Italian-dominant group, English proficiency is the result of formal education, which typically begins in primary school and entails a one-hour class a week. The majority of Italian university degrees require basic or intermediate English proficiency, usually assessed through the First Certificate in English (FCE, Cambridge English Language Assessment), or equivalent test. The university students tested in the Italian-dominant group reported using English on a daily basis to read academic materials such as peer-reviewed papers; however, the language used in courses and assessments is Italian. Finally, media are primarily dubbed in Italy, for historical reasons dating back to the Second World War, although they present several English words. Therefore, exposure to English, although significant, was limited in range and predominantly passive for the Italian-dominant participants, and for the Italian-English bilinguals until their arrival in Scotland. For all these reasons, the language experience of the participants examined in my three studies does not only vary in terms of proficiency, age of acquisition and exposure.

Language distance for sure represents an important factor for bilingual language processing: while I considered this aspect in my third study on pronoun processing (chapter 7), I did not operationalise this difference in my second study, on language control (chapter 6), nor in my first study, on cognitive control (chapter 5). In the second study (chapter 6) I controlled for language distance at the local level by checking for cognate status, and matching words across languages using the same criteria in both the Italian-English and the Italian-Sardinian version of the task. I believe that language distance effects on language control at the global level have not been previously reported, however, my regression analysis could not have detected them. In that analysis, I excluded the group predictor (the only binary predictor that could be used to include language distance) because it was collinear with the individual variables I examined. With regards to the first study (chapter 5), I believe that effects of language distance on cognitive control are also undocumented. The original aim of that study

was to present a typical comparison by group, in order to examine the effects of the inclusion of individual variability on group differences. However, an analysis of performance on the AX-CPT including individual differences and continuous predictors of language experience is certainly a venue for future research.

As far as contexts of use are concerned, their effects are instead documented on language control (e.g. Hartanto & Yang, 2016) and linked to the engagement of cognitive control components (Green & Abutalebi, 2013), and various studies addressed the effect of frequency of language switching (e.g., Prior & Gollan, 2011; Soveri et al., 2011; Verreyt et al., 2016), which is the aspect closer to contexts of use, according to Green and Abutalebi's definition. In contrast, to the best of my knowledge, this aspect has not been investigated with respect to syntactic processing. The language history questionnaire I developed did not present a quantitative measure of contexts of use that could be included in my regression analysis; however, in my study on language control (chapter 6), I examined differences in patterns of language use by using measures of both active and passive proficiency as well as of age of acquisition (i.e. age of first exposure vs. age of acquired fluency), and daily frequency of language switching. Developing a quantitative measure of this aspect of the bilingual experience would undoubtedly be useful for future research.

Finally, with respect to the differences in non-linguistic experience among my groups, it is worthy commenting on differences in age, level of education, context of recruitment and immigrant status. With respect to age, while all participants included in my analyses were aged between 18 and 40, the participants tested in Sardinia were on average older than the participants tested in Scotland (Italian-English group) and in Italy (Italian-dominant group, for exact figures, see the participants' table in each study). With respect to the level of education, the participants in the Italian-English group and in the Italian-dominant group were university students, primarily at postgraduate level in the former group, and at the graduate level in the latter group. Student status is linked to the context of recruitment, which happened through word of mouth in Sardinia, and primarily through university recruitment channels in Scotland and in Italy. Finally, all the participants in the Italian-English group were immigrants. Age,

student status and immigrant status may obviously have important effects on measures of executive functions, language processing and general intelligence, while context of recruitment may relate to attitudes and motivations towards participation in the experiments (e.g. participants in Sardinia may have been more intrinsically motivated while participants recruited through university channels may have been more extrinsically motivated).

While controlling for these differences at the recruitment stage would have been ideal, it was not entirely possible mainly due to practical limitations, such as time limits on the field-work data collection in Sardinia and in Italy. Therefore, to control for the possible effects of differences in age and in level of education, I analysed the correlation within responses to the language history questionnaire across groups, and regressed out these predictors from the analysis of the first and the second study (chapters 5 and 6). I did not do so in my third study (chapter 7): first, I did not predict age and years of education to result in group differences in the performance of the task, as the task was timed but not speeded (participants had 7 seconds to answer). However, a difference in RT can be seen in the comparative analysis, as the Italian-dominant group (i.e. the youngest) answered faster than the other groups; crucially, though, this difference does not interact with the experimental condition (see 7.6). Secondly, even if the average age differs, all the participants are young adults in the same age range, so I did not expect effects of diachronic change in the interpretation of null and overt pronouns.

In my studies, however, I have not controlled for immigrant status nor recruitment differences. One partial solution to control for the possible effects of these non-linguistic differences would have been to administer tasks measuring for instance general intelligence and working memory. However, this would have entailed longer experimental sessions, which were already 90 minutes long for the highly proficient bilinguals.

## 8.4 Conclusion

This thesis examined the effects of bilingualism on cognitive control, language control and language processing. I investigated cognitive control as the combination of a proactive and a reactive mechanism, as proposed by the dual mechanisms framework (Braver et al., 2007; Braver, 2012), and I found a tendency, among highly proficient early bilinguals, to perform better than bilinguals on a lower point of the bilingual continuum; however, the effect of the bilingual experience did not override individual differences in cognitive control, suggesting a direction for future research.

With respect to language control, I examined the ability to select the target language in a cued-language switching task analysing both mix and switch costs, which I related to a global and a local level of language control, respectively, and to proactive and reactive components of this ability. I showed that this ability is modulated by active proficiency, age of acquisition and language exposure: while proficiency affects switch costs (local level), age of acquisition has an effect on overall naming latencies (global level), while exposure affects both switch and mix costs, thereby modulating both local and global control mechanisms.

Finally, I studied the processing of a particular type of syntactic structure: null and overt pronouns, the resolution of which has been discussed in relation to both cognitive and linguistic factors, and which has been previously shown to vary across individuals and across groups. Specifically, I wanted to understand whether bilinguals may differ in the way they process pronouns, independently of differences between their two languages, that is to say, because of processing and cognitive aspects related to their experience. Among my four groups of participants, Italian-Sardinian participants (whose languages both display null and overt pronouns, and have isomorphic pronominal inventories) interpreted pronouns like the participants in the other groups, but processed them differently.

Taken together, these studies identify three dimensions of the bilingual experience and their effects on cognitive control, language control and language processing, thereby advancing our understanding of the multifaceted nature of bilingualism, and suggesting links

between these three domains that can shed light onto the mutual influence of language and cognition.

# Appendices

## A.1 Language History Questionnaire

The questionnaire was computerised and presented in OpenSesame 3.0 (Mathôt et al., 2012). It was presented in Italian to all participants. For the Italian-dominant participants and the Italian-English bilingual participants, the questions relative to the second language made reference to English, for the remaining participants they made reference to Sardinian.

- Age
- Place of Birth
- Gender
- Years of Education (please count how many years you spent in school/university)

- At what age did you begin learning Italian?
- Do you speak Italian fluently?
- If yes, at what age did you begin speaking Italian fluently?
- On a scale from 1 to 7, how would you describe your knowledge of Italian: oral production? (1 = minimal or null; 7 = excellent)
- On a scale from 1 to 7, how would you describe your knowledge of Italian: oral comprehension? (1 = minimal or null; 7 = excellent)
- On a scale from 1 to 7, how would you describe your knowledge of Italian: written production? (1 = minimal or null; 7 = excellent)
- On a scale from 1 to 7, how would you describe your knowledge of Italian: written comprehension? (1 = minimal or null; 7 = excellent)
- In what situations do you use Italian? (You can pick more than one option)
    - At home/with family
    - With friends
    - In formal contexts/at work
    - On the media
- How much is Italian used by people around you?
    - Almost never
    - 25%
    - 50%
    - 75%
    - Almost always
- How frequently were you using Italian at home as a child? (1 = rarely or never; 7 almost always)
- How frequently were you using Italian at school as a child? (1 = rarely or never; 7 almost always)
- How frequently are you using Italian at home now? (1 = rarely or never; 7 almost always)
- How frequently are you using Italian at work/university now? (1 = rarely or never; 7

almost always)

- Do you know any other language?

  (if yes):

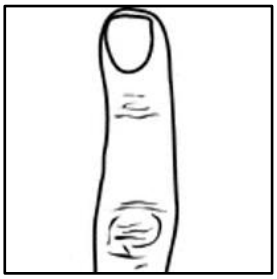
  - Which ones (write the one that you know better first, and the other in descending order)
  - On a scale from 1 to 7, how would you define your knowledge of language 1? (1 = minimal or null; 7 = excellent; leave blank if does not apply)
  - On a scale from 1 to 7, how would you define your knowledge of language 2? (1 = minimal or null; 7 = excellent; leave blank if does not apply)
  - On a scale from 1 to 7, how would you define your knowledge of language 3? (1 = minimal or null; 7 = excellent; leave blank if does not apply)
  - How frequently do you switch from one language to another? (1 = rarely or never; 7 = almost always)
  - Do you switch language more often...
    - Across different situations
    - Between different conversations
    - Within the same sentence
  - Do you consistently use more than one language in your everyday life? (1 = definitely no; 2 = usually not; 3 = I would not know; 4 = usually yes; 5 = definitely yes)
  - If you answered positively to the previous question, or if people around you consistently use other languages other than yours, since how long has this been the case?

- At what age did you begin learning English/Sardinian?
- Do you speak English/Sardinian fluently?
- If yes, at what age did you begin speaking English/Sardinian fluently?
- On a scale from 1 to 7, how would you describe your knowledge of English/Sardinian: oral production? (1 = minimal or null; 7 = excellent)
- On a scale from 1 to 7, how would you describe your knowledge of English/Sardinian: oral comprehension? (1 = minimal or null; 7 = excellent)
- On a scale from 1 to 7, how would you describe your knowledge of English/Sardinian: written production? (1 = minimal or null; 7 = excellent)
- On a scale from 1 to 7, how would you describe your knowledge of English/Sardinian: written comprehension? (1 = minimal or null; 7 = excellent)
- In what situations do you use English/Sardinian? (You can pick more than one option)
  - At home/with family
  - With friends
  - In formal contexts/at work
  - On the media
- How much is English/Sardinian used by people around you?
  - Almost never
  - 25%
  - 50%
  - 75%
  - Almost always
- How frequently were you using English/Sardinian at home as a child? (1 = rarely or never; 7 almost always)

- How frequently were you using English/Sardinian at school as a child? (1 = rarely or never; 7 almost always)
- How frequently are you using English/Sardinian at home now? (1 = rarely or never; 7 almost always)
- How frequently are you using English/Sardinian at work/university now? (1 = rarely or never; 7 almost always)
- How frequently are you using English/Sardinian at work/university now? (1 = rarely or never; 7 almost always)

## A.2 Pictures for the Language Switching task (chapter 6)

A.2.1 Italian-English list: butterfly, “farfalla”

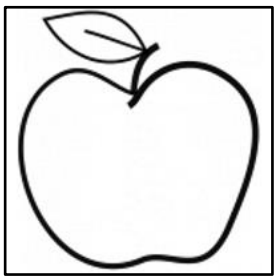


A.2.2 Italian-English list: finger, “dito”

A.2.3 Italian-English list: elbow, “gomito”

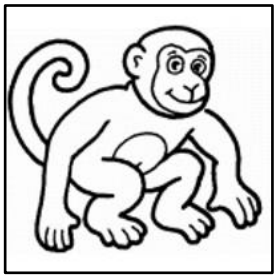
A.2.4 Italian-English list: glasses, “occhiali”

A.2.5 Italian-English list: curtain, “tenda”



A.2.6 Italian-English list: apple, “mela”

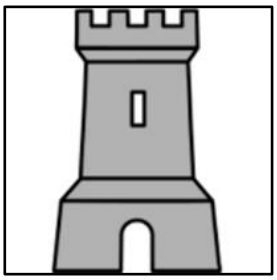
A.2.7 Italian-English list: flower, “fiore”



A.2.8 Italian-English list: monkey, “scimmia”

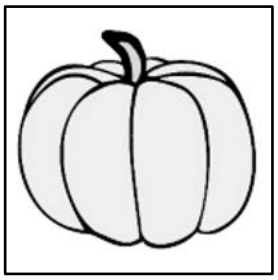
A.2.9 Italian-English list: mushroom, “fungo”

A.2.10 Italian-English list: shower, “doccia”



A.2.11 Italian-English list: tower, “torre”

A.2.12 Italian-English list: pencil, “matita”



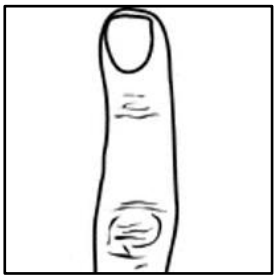
A.2.13 Italian-English list: pumpkin, “zucca”

A.2.14 Italian-English list: river, “fiume”

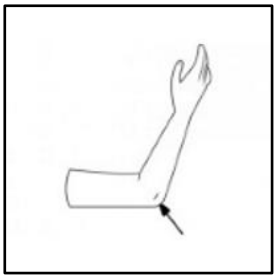
A.2.15 Italian-English list: ladder, “scala”

A.2.16 Italian-English list: king, “re”

A.2.17 Italian-Sardinian list: butterfly, “farfalla”, “mariposa”



A.2.18 Italian-Sardinian list: finger, “dito”, “poddighe”

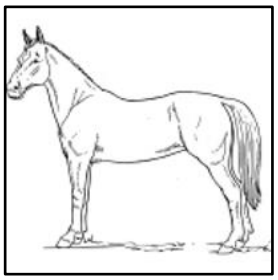


A.2.19 Italian-Sardinian list: elbow, “gomito”, “cuidu”

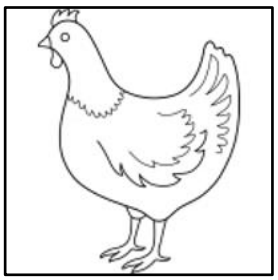
A.2.20 Italian-Sardinian list: glasses, “occhiali”, “ulleras”

A.2.21 Italian-Sardinian list: key, “chiave”, “giae”

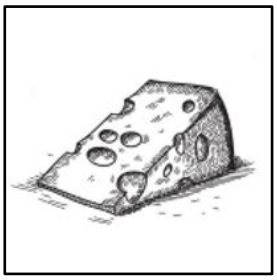
A.2.22 Italian-Sardinian list: cherry, “ciliegia”, “cariasa”



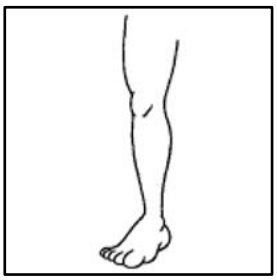
A.2.23 Italian-Sardinian list: horse, “cavallo”, “caddu”



A.2.24 Italian-Sardinian list: hen, “gallina”, “pudda”



A.2.25 Italian-Sardinian list: cheese, “formaggio”, “casu”

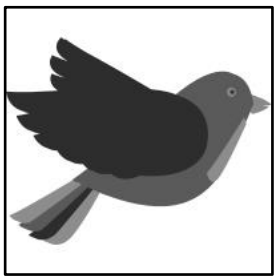


A.2.26 Italian-Sardinian list: leg, “gamba”, “anca”

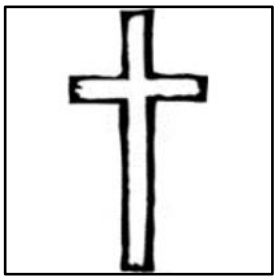
A.2.27 Italian-Sardinian list: skirt, “gonna”, “munnedda”

A.2.28 Italian-Sardinian list: door, “porta”, “ghenna”

A.2.29 Italian-Sardinian list: chair, “sedia”, “cadrea”



A.2.30 Italian-Sardinian list: bird, “uccello”, “puzone”



A.2.31 Italian-Sardinian list: cross, “croce”, “rughe”

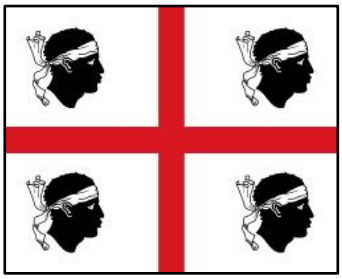
A.2.32 Italian-Sardinian list: house, “casa”, “domo”

A.2.33 Italian flag: cue 1

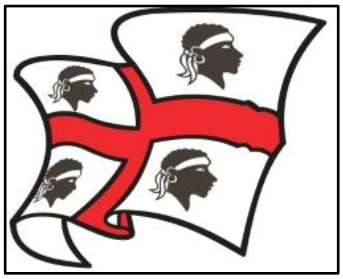
A.2.34 Italian flag: cue 2

A.2.35 English flag: cue 1

A.2.36 English flag: cue 2



A.2.37 Sardinian flag: cue 1



A.2.38 Sardinian flag: cue 2

## A.3 Experimental lists for the Visual World Experiment (chapter 7)

### *A.3.1 Verbs for experimental items (‘null’ and ‘overt’ sentences)*

1. “chiamare”, 'to call'
2. “notare”, 'to notice'
3. “salutare”, 'to greet'
4. “osservare”, 'to observe'
5. “invitare”, 'to invite'
6. “guardare”, 'to look'
7. “riconoscere”, 'to recognize'
8. “vedere”, 'to see'
9. “incontrare”, to meet'
10. “ascoltare”, 'to listen'
11. “visitare”, 'to visit'
12. “raggiungere”, 'to reach'

### *A.3.2 Verbs for lure and filler items*

1. “sbirciare”, 'to peep at'
2. “irritare”, 'to annoy'
3. “rimproverare”, 'to scold'
4. “interrogare”, 'to question'
5. “convocare”, 'to convene'
6. “intrattenere”, 'to entertain'

7. “aspettare”, 'to wait'
8. “intervistare”, 'to interview'
9. “contraddire”, 'to contradict'
10. “abbracciare”, 'to hug'
11. “insultare”, 'to insult'
12. “criticare”, 'to criticize'
13. “chiacchierare”, 'to chat'
14. “litigare”, 'to quarrel'
15. “esercitarsi”, 'to exercise'
16. “conoscersi”, 'to know each other'
17. “partire”, 'to leave'
18. “giocare a scacchi”, 'to play chess'
19. “discutere”, 'to argue'
20. “uscire”, 'to go out'
21. “suonare”, 'to play'
22. “scioperare”, 'to strike'
23. “lamentarsi”, 'to complain”
24. “lavorare”, 'to work'
25. “camminare”, 'to walk'
26. “inciampare”, 'to stumble'
27. “dormire”, 'to sleep'
28. “cantare”, 'to sing'
29. “viaggiare”, 'to travel'
30. “studiare”, 'to study'
31. “riflettere”, 'to think over'

32. “passeggiare”, 'to stroll'
33. “dipingere”, 'to paint'
34. “sorridere”, 'to smile'
35. “fischiettare”, 'to whistle'

### *A.3.3 Adjectives for experimental items*

1. “severo”, 'strict'
2. “amichevole”, 'friendly'
3. “preciso”, 'careful'
4. “sveglio”, 'bright'
5. “vivace”, 'lively'
6. “gentile”, 'kind'
7. “annoiato”, 'bored'
8. “spensierato”, 'carefree'
9. “ordinato” ,'tidy'
10. “prepotente”, 'overbearing'
11. “nervoso”, 'nervous'
12. “stanco”, 'tired'
13. “cortese”, 'polite'
14. “esigente”, 'demanding'
15. “inquieto”, 'anxious'
16. “arrogante”, 'arrogant'
17. “agitato”, 'upset'
18. “garbato”, 'well-behaved'

19. “beneducato”, 'well-mannered'
20. “irrequieto”, 'restless'
21. “cordiale”, 'warm'
22. “simpatico”, 'nice'
23. “allegro”, 'cheerful'
24. “divertito”, 'amused'

### *A.3.4 Experimental Lists: List 1*

L1_Pro. La cameriera chiama la ricercatrice mentre i messicani mangiano. E' molto severa

Chi è severo?

*The waitress calls the researcher while the Mexicans eat. She is very strict.*

*Who is strict?*

L1_Pro. La fioraia nota la strega quando le candele si accendono. Sembra davvero amichevole

Chi è amichevole?

*The florist notices the witch when the candles light on. She seems really friendly.*

*Who is friendly?*

L1_Pro. La laureata saluta la panettiera mentre i bagnini riposano. Sembra molto precisa

Chi è preciso?

*The graduate greets the baker while the lifeguards rest. She seems very accurate.*

*Who is accurate?*

L1_Pro. La ricercatrice osserva la hostess mentre i negozi aprono. Sembra molto sveglia

Chi è sveglio?

*The researcher observes the hostess while the shop opens. She seems very smart.*

*Who is smart?*

L1_Pro. La strega invita la sarta quando i reporter arrivano. E' proprio vivace

Chi è vivace?

*The witch invites the tailor when the reporters arrive. She is really lively.*

*Who is lively?*

L1_Pro. la panettiera guarda l'anziana quando i cani abbaiano. E' davvero gentile

Chi è gentile?

*The baker looks at the old lady while the dogs bark. She is very kind.*

*Who is kind?*

L1_Pro. Il bambino riconosce il poliziotto mentre le campane suonano. Sembra molto annoiato

Chi è annoiato?

*The child recognizes the policeman while the bells chime. He seems very bored.*

*Who is bored?*

L1_Pro. Il barbiere vede il postino mentre le modelle si truccano. Sembra proprio spensierato

Chi è spensierato?

*The barber sees the postman while the models make up. He seems really cheerful.*

*Who is cheerful?*

L1_Pro. Il calciatore incontra il professore mentre le pecore pascolano. E' molto ordinato

Chi è ordinato?

*The football player meets the professor while the sheep graze. He is very tidy.*

*Who is tidy?*

L1_Pro. l'investigatore ascolta il bambino mentre i mendicanti si siedono. E' molto prepotente

Chi è prepotente?

*The detective listens (to) the baby while the beggars sit down. He is very overbearing.*

*Who is overbearing?*

L1_Pro. Il ladro visita il barbiere mentre i gatti dormono. E' piuttosto nervoso.

Chi è nervoso?

*The thief visits the barber while the cats sleep. He is rather nervous.*

*Who is nervous?*

L1_Pro. Il meccanico raggiunge il calciatore quando i bicchieri cadono. E' davvero stanco

Chi è stanco?

*The mechanic reaches the football player while the glasses fall. He is really tired.*

*Who is tired?*

L1_Overt. La regina chiama la violinista quando le finestre si spalancano. Lei sembra molto cortese

Chi è cortese?

*The queen calls the violinist as the windows shut open. She seems very polite.*

*Who is polite?*

L1_Overt. La principessa nota l'infermiera mentre i lampioni si accendono. Lei e' davvero esigente

Chi è esigente?

*The princess notices the nurse while the streetlamps turn on. She is really demanding.*

*Who is demanding?*

L1_Overt. La cantante saluta la ballerina mentre le monete rotolano. Lei e' piuttosto inquieta

*Chi è inquieto?*

*The singer greets the dancer while the coins roll. She is rather anxious.*

*Who is anxious?*

L1_Overt. La cuoca osserva la regina mentre i soldati se ne vanno. Lei e' proprio arrogante

Chi è arrogante?

*The cool observes the queen while the soldiers go away. She is really arrogant.*

*Who is arrogant?*

L1_Overt. La segretaria invita la principessa mentre gli operai lavorano. Lei sembra molto agitata

Chi è agitato?

*The secretary invites the princess while the craftmen work. She seems very upset.*

*Who is upset?*

L1_Overt. la dottoressa guarda la cantante quando i taxi arrivano. Lei sembra proprio garbata

Chi è garbato?

*The (female) doctor watches the (female) singer when the cabs arrive. She seems really well-mannered.*

*Who is well-mannered?*

L1_Overt. Il cameriere riconosce lo sciatore mentre i pescatori conversano. Lui e' davvero beneducato

Chi è beneducato?

*The waiter recognizes the skier while the fishermen chat. He is very well-behaved.*

*Who is well-behaved?*

L1_Overt. Il chitarrista vede il tennista mentre i brasiliani festeggiano. Lui e' piuttosto irrequieto

Chi è irrequieto?

*The guitar player sees the tennis players while the Brazilians celebrate. He is rather upset.*

*Who is upset?*

L1_Overt. Il contadino incontra il turista quando i ciclisti arrivano. Lui sembra piuttosto cordiale

Chi è cordiale?

*The farmer meets the tourist as the cyclists arrive. He seems rather warm.*

*Who is warm?*

L1_Overt. Il nonno ascolta il cameriere mentre le posate cadono. Lui e' davvero simpatico

Chi è simpatico?

*The granddad listens to the waiter when the cutlery falls. He is really nice.*

*Who is nice?*

L1_Overt. Il nuotatore visita il chitarrista mentre i manifestanti protestano. Lui sembra proprio allegro

Chi è allegro?

*The swimmer visits the guitar player while the demonstrator protest. He seems really cheerful.*

*Who is cheerful?*

L1_Overt. Il pilota raggiunge il contadino mentre i topi scappano. Lui e' molto divertito

Chi è divertito?

*The pilot reaches the farmer while the mice run away. He seems very amused.*

*Who is amused?*

L1_Lure. L'attrice sbircia la cuoca mentre le suore passeggiano. La ricercatrice osserva la scena pensosa

Chi è pensoso?

*The actress peeps at the cook while the nuns take a stroll. The researcher observes the scene thoughtfully.*

*Who is thoughtful?*

L1_Lure. la strega irrita la infermiera mentre i semafori lampeggiano. la giornalista assiste alla scena divertita

Chi è divertito?

*The witch annoys the nurse while traffic lights flash. The journalist looks at the scene amused.*

*Who is amused?*

L1_Lure. La musicista rimprovera la dottoressa mentre gli sposi si abbracciano. La panettiera interviene nel dialogo

Chi interviene?

*The musician scolds the (female) doctor while the newly weds hug. The baker intervenes in the dialogue.*

*Who intervenes?*

L1_Lure. La cameriera interroga la geisha quando i pompieri arrivano. La regina spia la conversazione

Chi spia?

*The waitress questions the geisha when the firemen arrive. The queen spies on the conversation*

*Who spies?*

L1_Lure. .La Fioraia convoca la pianista mentre i deejay suonano. La principessa vede il fatto dalla finestra

Chi convoca?

*The florist calls the pianist while the dee jays play. The princess sees what happens from the window.*

*Who calls?*

L1_Lure. La laureata intrattiene la fruttivendola quando gli aerei atterrano. La cantante ascolta il dialogo curiosa

Chi intrattiene?

*The graduate entertains the grocer when the airplanes land. The singer listens to the dialogue curiously.*

*Who is curious?*

L1_Lure. Il nonno aspetta il dottore mentre le tazzine si rovesciano. Il bambino controlla ciò che succede

Chi aspetta?

*The granddad waits (for) the doctor when the cups are knocked over. The child checks what is going on.*

*Who waits?*

L1_Lure. Il nuotatore intervista l'egiziano mentre le pentole bollono. Il barbiere segue le domande con attenzione

Chi intervista?

*The swimmer interviews the Egyptian while the pots boil. The barber follows the questions carefully.*

*Who interviews?*

L1_Lure. Il pilota contraddice il fantino mentre le porte sbattono. Il calciatore ascolta il colloquio di nascosto

Chi è contraddetto?

*The pilot contradicts the jokey while the doors slam. The football player listens to the conversation secretly*

*Who is contradicted?*

L1_Lure. il fotografo abbraccia l'investigatore quando gli studenti se ne vanno. il cameriere vede la scena da lontano

Chi è abbracciato?

*The photographer hugs the detective while the students go away. The waiter sees the scene from a distance.*

*Who is hugged?*

L1_Lure. Il francese insulta il ladro quando gli spettatori se ne vanno. Il chitarrista prende nota di quanto succede

Chi è insultato?

*The Frenchman insults the thief when the audience go away. The guitar player takes note of what happens*

*Who is insulted?*

L1_Lure. l'imbianchino critica il meccanico mentre i telefoni squillano. Il contadino assiste a tutto il litigio

Chi è criticato?

*The painter criticized the mechanic while the telephones ring. The farmer sees all the quarrel*

*Who is criticized?*

L1_Filler. L'attrice sbircia lo sciatore tutto il tempo. I messicani se ne accorgono divertiti

Chi viene sbirciato?

*The actress peeps at the skier for the whole time. The Mexicans notice that in amusement.*

*Who is peeped at?*

L1_Filler. La giornalista irrita il tennista per tutta la serata. Intanto le candele si consumano

Chi viene irritato?

*The journalist annoys the tennis player for the whole evening. In the meantime the candles go out.*

*Who is annoyed?*

L1_Filler. La musicista rimprovera il turista ormai da ore. Intanto i bagnini osservano la scena

Chi viene rimproverato?

*The musician has been scolding the tourist since for hours. In the meanwhile the lifeguards observe the scene*

*Who is scolded?*

L1_Filler. La hostess interroga il dottore molto a lungo. Nel frattempo i negozi hanno chiuso da un pezzo.

Chi è interrogato?

*The hostess questions the doctor for a long time. In the meantime the shops have closed*

*Who is questioned?*

L1_Filler. La sarta convoca l'egiziano d'improvviso. Intanto i reporter spiano la scena da lontano

Chi è convocato?

*The tailor calls the Egyptian suddenly. In the meanwhile the reporters spy on the scene from a distance*

*Who is called?*

L1_Filler. L'anziana intrattiene il fantino per tutto il pomeriggio. Nel frattempo i cani dormono tranquilli

Chi viene intrattenuto?

*The old lady entertains the jokey for the whole afternoon. In the meantime the dogs sleep quietly.*

*Who is entertained?*

L1_Filler. Il fotografo aspetta la violinista per altre due ore. Intanto le campane suonano ininterrotte

Chi aspetta?

*The photographer waits (for) the violin player for two more hours. In the meantime the bells chime continuously*

*Who waits?*

L1_Filler. Il francese intervista l'infermiera per tutto il giorno. Nella stanza vicina le modelle si preparano per la sfilata

Chi intervista?

*The Frenchman interviews the nurse for the whole day. In the next room the models get ready for the catwalk*

*Who is interviewed?*

L1_Filler. L'imbianchino contraddice la ballerina per tutta la mattina. Fuori dalla finestra le pecore belano nei campi

Chi contraddice?

*The painter contradicts the dancer for the whole morning. Out of the windows the sheep graze in the fields.*

*Who contraditcs?*

L1_Filler. Il poliziotto abbraccia la geisha alla fine della serata. Intanto i mendicanti si preparano per la notte

Chi abbraccia?

*The policeman hugs the geisha at the end of the evening. In the meantime the beggars get ready for the evening.*

*Who hugs?*

L1_Filler. Il postino insulta la pianista ad alta voce. A quel punto i gatti si svegliano per il rumore

Chi insulta?

*The postman insults the pianist out loud. In that moment the cats wake up for the noise*

*Who insults?*

L1_Filler. Il professore critica la fruttivendola apertamente. Intanto i bicchieri tintinnano sul bancone

Chi critica?

*The professor criticizes the grocer openly. In the meantime the glasses tinkle on the counter.*

*Who criticizes?*

L1_Filler. La cameriera e l'attrice chiacchierano per altre due ore. Nel frattempo le finestre sbattono per il vento

Chi chiacchiera?

*The waitress and the actress chat for two more hours. In the meantime the windows are shut by the wind.*

*Who chat?*

L1_Filler. La fioraia e la giornalista litigano fino a sera. Nel frattempo i lampioni si accendono per le strade

Chi litiga?

*The florist and the journalist argue until night. In the meantime the street lamps turn on in the streets.*

*Who argue?*

L1_Filler. La laureata e la musicista si esibiscono per la strada. Intanto le monete tintinnano nel loro cappello

Chi si esercita?

*The graduate and the musician perform in the street. In the meantime coins tinkle in their hat.*

*Who performs?*

L1_Filler. L'investigatore e la hostess si conoscono già da molti anni. Da allora i soldati hanno costruito una nuova caserma

Chi si conosce?

*The detective and the hostess known each other since many years. Since then the soldiers have built new barracks*

*Who knows each other?*

L1_Filler. Il ladro e la sarta partono di mattina presto. Subito dopo gli operai cominciano i lavori

Chi parte?

*The thief and the tailor leave early in the morning. Right after that the craftmen begin to work*

*Who leaves?*

L1_Filler. Il meccanico e l'anziana giocano a scacchi fino a tardi. Nel frattempo i taxi aspettano sotto la pioggia

Chi gioca a scacchi?

*The mechanic and the old lady play chess until late. In the meantime the cabs wait in the rain.*

*Who plays chess?*

L1_Filler. La cuoca e il fotografo discutono tutta la serata. Nel frattempo i pescatori ascoltano la conversazione assonnati

Chi discute?

*The cook and the photographer argue for the whole evening. In the meantime the sleepy fishermen listens to the conversation*

*Who argues?*

L1_Filler. La segretaria e il francese viaggiano ormai da ore. Intanto i brasiliani dormono nei sedili di fronte

Chi viaggia?

*The secretary and the Frenchman have been traveling for hours. In the meantime the Brazilians sleep in the front seats.*

*Who travels?*

L1_Filler. La dottoressa e l'imbianchino escono velocemente. A quest'ora i ciclisti stanno per arrivare al traguardo

Chi esce?

*The (female) doctor and the painter get out quickly. By now the cyclists are reaching the finishing line.*

*Who gets out?*

L1_Filler. Il nonno e il poliziotto suonano molto a lungo. Nel frattempo le posate vengono lavate ed asciugate

Chi suona?

*The granddad and the policeman play for a long time. In the meantime the cutlery are washed and drained.*

*Who plays?*

L1_Filler. Il nuotatore e il postino scioperano già da molti giorni. Nel frattempo i manifestanti si uniscono alla protesta

Chi sciopera?

*The swimmer and the postman have been on strike for many days. In the meantime the demonstrators have joined the protest.*

*Who is on strike?*

L1_Filler. Il pilota e il professore ore si lamentano tutta la mattina. I topi hanno invaso lo scantinato nottetempo

Chi si lamenta?

*The pilot and the professor complain for the whole morning. The mice have swarmed into the basement overnight*

*Who complains?*

L1_Filler. Lo sciatore lavora intensamente. Le suore guardano ammirate

Chi lavora?

*The skier works intensely. The nuns look in admiration*

*Who works?*

L1_Filler. Il tennista cammina per tutta la serata. Ad un certo punto alcuni semafori si spengono

Chi cammina?

*The tennis player walks for the whole evening. At some point some traffic lights turn off.*

*Who walks?*

L1_Filler. La turista inciampa improvvisamente. Gli sposi se ne accorgono divertiti

Chi inciampa?

*The tourist trips over suddenly. The newlyweds notice that in amusement.*

*Who trips over?*

L1_Filler. Il dottore dorme tutta la mattina. Ad un certo punto i pompieri lo svegliano

Chi dorme?

*The doctor sleeps for the whole morning. At some point the firemen wake him up.*

*Who sleeps?*

L1_Filler. L'egiziano canta allegramente. I deejay hanno suonato canzoni famose tutta la serata

Chi canta?

*The Egyptian sings cheerfully. The dee jays have played famous tunes for whole evening.*

*Who sings*

L1_Filler. Il fantino viaggia frequentemente. Infatti gli aerei non lo spaventano più

Chi viaggia?

*The jokey travels often. Airplanes do not scare him anymore.*

*Who travels?*

L1_Filler. La violinista studia molto a lungo. Ad un certo punto le tazzine si rovesciano sul tavolo

Chi studia?

*The violin player studies for a long time. At some point the cups fall on the table.*

*Who studies?*

L1_Filler. L'infermiera riflette per tutta la mattina. Intanto le pentole si sono quasi bruciate.

Chi riflette?

*The nurse ponders for the whole morning. In the meantime the pots are almost burnt.*

*Who ponders?*

L1_Filler. La ballerina passeggia ormai da ore. Intanto le porte del teatro sono state chiuse.

Chi passeggia?

*The dancer has been walking for hours. In the meantime the theatre doors have been closed.*

*Who walks?*

L1_Filler. La geisha dipinge per tutto il giorno. Gli studenti osservano e prendono appunti

Chi dipinge?

*The geisha paints for the whole day. The students observe and take note.*

*Who paints?*

L1_Filler. La pianista sorride alla fine della serata. Gli spettatori battono le mani entusiasti

Chi sorride?

*The pianist smiles at the end of the evening. The audience clap their hands enthusiastically.*

*Who smiles?*

L1_Filler. La fruttivendola fischietta continuamente. I telefoni intanto continuano a suonare

Chi fischietta?

*The grocer whistles continuously. The telephones in the meantime keep on ringing*

*Who whistles?*

### *A.3.5 Experimental Lists: List 2*

(questions as List 1)

L2_Pro. La regina chiama la violinista mentre i messicani mangiano. E' molto severa

L2_Pro. La principessa nota l'infermiera quando le candele si accendono. Sembra davvero amichevole

L2_Pro. La cantante saluta la ballerina mentre i bagnini riposano. Sembra molto precisa

L2_Pro. La cuoca osserva la regina mentre i negozi aprono. Sembra molto sveglia

L2_Pro. La segretaria invita la principessa quando i reporter arrivano. E' proprio vivace

L2_Pro. La dottoressa guarda la cantante quando i cani abbaiano. E' davvero gentile

L2_Pro. Il cameriere riconosce lo sciatore mentre le campane suonano. Sembra molto annoiato

L2_Pro. Il chitarrista vede il tennista mentre le modelle si truccano. Sembra proprio spensierato

L2_Pro. Il contadino incontra il turista mentre le pecore pascolano. E' molto ordinato

L2_Pro. Il nonno ascolta il cameriere mentre i mendicanti si siedono. E' molto prepotente

L2_Pro. Il nuotatore visita il chitarrista mentre i gatti dormono. E' piuttosto nervoso.

L2_Pro. Il pilota raggiunge il contadino quando i bicchieri cadono. E' davvero stanco

L2_Overt. La hostess chiama l'attrice quando le finestre si spalancano. Lei sembra molto cortese

L2_Overt. La sarta nota la giornalista mentre i lampioni si accendono. Lei e' davvero esigente

L2_Overt. L'anziana saluta la musicista mentre le monete rotolano. Lei e' piuttosto inquieta

L2_Overt. L'attrice osserva la cameriera mentre i soldati se ne vanno. Lei e' proprio arrogante

L2_Overt. La giornalista invita la fioraia mentre gli operai lavorano. Lei sembra molto agitata

L2_Overt. La musicista guarda la laureata quando i taxi arrivano. Lei sembra proprio garbata

L2_Overt. Il dottore riconosce l'investigatore mentre i pescatori conversano. Lui e' davvero beneducato

L2_Overt. I'egiziano vede il ladro mentre i brasiliani festeggiano. Lui e' piuttosto irrequieto

L2_Overt. Il fantino incontra il meccanico quando i ciclisti arrivano. Lui sembra piuttosto cordiale

L2_Overt. Il poliziotto ascolta il dottore mentre le posate cadono. Lui e' davvero simpatico

L2_Overt. Il postino visita l'egiziano mentre i manifestanti protestano. Lui sembra proprio allegro

L2_Overt. il professore raggiunge il fantino mentre i topi scappano. Lui e' molto divertito

L2_Lure.La geisha sbircia la hostess mentre le suore passeggiano. La regina osserva la scena pensosa

L2_Lure. La pianista irrita la sarta mentre i semafori lampeggiano. La principessa assiste alla scena divertita

L2_Lure. La fruttivendola rimprovera l'anziana mentre gli sposi si abbracciano. La cantante interviene nel dialogo

L2_Lure. La ballerina interroga la ricercatrice quando i pompieri arrivano. L'attrice spia la conversazione

L2_Lure. La violinista convoca la strega mentre i deejay suonano. La giornalista vede il fatto dalla finestra

L2_Lure. L'infermiera intrattiene la panettiera quando gli aerei atterrano. La musicista ascolta il dialogo curiosa

L2_Lure. Il bambino aspetta il nuotatore mentre le tazzine si rovesciano. Il cameriere controlla ciò che succede

L2_Lure. Il barbiere intervista il pilota mentre le pentole bollono. il chitarrista segue le domande con attenzione

L2_Lure. il calciatore contraddice il nonno mentre le porte sbattono. il contadino ascolta il colloquio di nascosto

L2_Lure. L'investigatore abbraccia il fotografo quando gli studenti se ne vanno. il dottore vede la scena da lontano

L2_Lure. il ladro insulta il francese quando gli spettatori se ne vanno. L'egiziano prende nota di quanto succede

L2_Lure. Il meccanico critica l'imbianchino mentre i telefoni squillano. il fantino assiste a tutto il litigio

L2_Filler. Il bambino sbircia la laureata tutto il tempo. I messicani se ne accorgono divertiti

L2_Filler. Il barbiere irrita la panettiera per tutta la serata. Intanto le candele si consumano

L2_Filler. Il calciatore rimprovera la pianista ormai da ore. Intanto i bagnini osservano la scena

L2_Filler. La cameriera interroga il poliziotto molto a lungo. Nel frattempo i negozi hanno chiuso da un pezzo.

L2_Filler. La cuoca convoca il postino d'improvviso. Intanto i reporter spiano la scena da lontano

L2_Filler. La dottoressa intrattiene il professore per tutto il pomeriggio. Nel frattempo i cani dormono tranquilli

L2_Filler. La fioraia aspetta lo sciatore per altre due ore. Intanto le campane suonano ininterrotte

L2_Filler. Il fotografo intervista la ricercatrice per tutto il giorno. Nella stanza vicina le modelle si preparano per la sfilata

L2_Filler. Il francese contraddice la segretaria per tutta la mattina. Fuori dalla finestra le pecore belano nei campi

L2_Filler. La fruttivendola abbraccia il turista alla fine della serata. Intanto i mendicanti si preparano per la notte

L2_Filler. La geisha insulta il tennista ad alta voce. A quel punto i gatti si svegliano per il rumore

L2_Filler. L'imbianchino critica la strega apertamente. Intanto i bicchieri tintinnano sul bancone

L2_Filler. L'anziana e il bambino chiacchierano per altre due ore. Nel frattempo le finestre sbattono per il vento

L2_Filler. La ballerina e il barbiere litigano fino a sera. Nel frattempo i lampioni si accendono per le strade

L2_Filler. La hostess e il calciatore si esibiscono per la strada. Intanto le monete tintinnano nel loro cappello

L2_Filler. L'infermiera e la cameriera si conoscono già da molti anni. Da allora i soldati hanno costruito una nuova caserma

L2_Filler. L'investigatore e la cuoca partono di mattina presto. Subito dopo gli operai cominciano i lavori

L2_Filler. Il ladro e la dottoressa giocano a scacchi fino a tardi. Nel frattempo i taxi aspettano sotto la pioggia

L2_Filler. Il meccanico e la fioraia discutono tutta la serata. Nel frattempo i pescatori ascoltano la conversazione assonnati

L2_Filler. Il nonno e il fotografo viaggiano ormai da ore. Intanto i brasiliani dormono nei sedili di fronte

L2_Filler. Il nuotatore e il francese escono velocemente. A quest'ora i ciclisti stanno per arrivare al traguardo

L2_Filler. Il pilota e la fruttivendola suonano molto a lungo. Nel frattempo le posate vengono lavate ed asciugate

L2_Filler. La sarta e la geisha scioperano già da molti giorni. Nel frattempo i manifestanti si uniscono alla protesta

L2_Filler. La violinista e l'imbianchino si lamentano tutta la mattina. I topi hanno invaso lo scantinato nottetempo

L2_Filler. La laureata lavora intensamente. Le suore guardano ammirate

L2_Filler. La panettiera cammina per tutta la serata. Ad un certo punto alcuni semafori si spengono

L2_Filler. La pianista inciampa improvvisamente. Gli sposi se ne accorgono divertiti

L2_Filler. Il poliziotto dorme tutta la mattina. Ad un certo punto i pompieri lo svegliano

L2_Filler. Il postino canta allegramente. I deejay hanno suonato canzoni famose tutta la serata

L2_Filler. Il professore viaggia frequentemente. Infatti gli aerei non lo spaventano più

L2_Filler. La ricercatrice studia molto a lungo. Ad un certo punto le tazzine si rovesciano sul tavolo.

L2_Filler. Lo sciatore riflette per tutta la mattina. Intanto le pentole si sono quasi bruciate.

L2_Filler. La segretaria passeggia ormai da ore. Intanto le porte dell'ufficio sono state chiuse.

L2_Filler. La strega dipinge per tutto il giorno. Gli studenti osservano e prendono appunti

L2_Filler. Il tennista sorride alla fine della serata. Gli spettatori battono le mani entusiasti

L2_Filler. Il turista fischietta continuamente. I telefoni intanto continuano a suonare

### *A.3.6 Experimental Lists: List 3*

(questions as List 1)

L3_Pro. L'attrice chiama la cameriera mentre i messicani mangiano. E' molto severa

L3_Pro. La giornalista nota la fioraia quando le candele si accendono. Sembra davvero amichevole

L3_Pro. La musicista saluta la laureata mentre i bagnini riposano. Sembra molto precisa

L3_Pro. la hostess osserva l'attrice mentre i negozi aprono. Sembra molto sveglia

L3_Pro. La sarta invita la giornalista quando i reporter arrivano. E' proprio vivace

L3_Pro. L'anziana guarda la musicista quando i cani abbaiano. E' davvero gentile

L3_Pro. Il poliziotto riconosce il dottore mentre le campane suonano. Sembra molto annoiato

L3_Pro. Il postino vede l'egiziano mentre le modelle si truccano. Sembra proprio spensierato

L3_Pro. Il professore incontra il fantino mentre le pecore pascolano. E' molto ordinato

L3_Pro. Il dottore ascolta l'investigatore mentre i mendicanti si siedono. E' molto prepotente

L3_Pro. L'egiziano visita il ladro mentre i gatti dormono. E' piuttosto nervoso.

L3_Pro. Il fantino raggiunge il meccanico quando i bicchieri cadono. E' davvero stanco

L3_Overt. La geisha chiama la cuoca quando le finestre si spalancano. Lei sembra molto cortese

L3_Overt. La pianista nota la segretaria mentre i lampioni si accendono. Lei e' davvero esigente

L3_Overt. la fruttivendola saluta la dottoressa mentre le monete rotolano. Lei e' piuttosto inquieta

L3_Overt. La violinista osserva la geisha mentre i soldati se ne vanno. Lei e' proprio arrogante

L3_Overt. L'infermiera invita la pianista mentre gli operai lavorano. Lei sembra molto agitata

L3_Overt. La ballerina guarda la fruttivendola quando i taxi arrivano. Lei sembra proprio garbata

L3_Overt. Il francese riconosce il nonno mentre i pescatori conversano. Lui e' davvero beneducato

L3_Overt. Il fotografo vede il nuotatore mentre i brasiliani festeggiano. Lui e' piuttosto irrequieto

L3_Overt. L'imbianchino incontra il pilota quando i ciclisti arrivano. Lui sembra piuttosto cordiale

L3_Overt. Lo sciatore ascolta il fotografo mentre le posate cadono. Lui e' davvero simpatico

L3_Overt. Il tennista visita il francese mentre i manifestanti protestano. Lui sembra proprio allegro

L3_Overt. Il turista raggiunge l'imbianchino mentre i topi scappano. Lui e' molto divertito

L3_Lure. La ricercatrice sbircia la violinista mentre le suore passeggiano. L'attrice osserva la scena pensosa

L3_Lure. La strega irrita l'infermiera mentre i semafori lampeggiano. La giornalista assiste alla scena divertita

L3_Lure. La panettiera rimprovera la ballerina mentre gli sposi si abbracciano. La musicista interviene nel dialogo

L3_Lure. La regina interroga la hostess quando i pompieri arrivano. La geisha spia la conversazione

L3_Lure. La principessa convoca la sarta mentre i deejay suonano. La pianista vede il fatto dalla finestra

L3_Lure. La cantante intrattiene l'anziana quando gli aerei atterrano. La fruttivendola ascolta il dialogo curiosa

L3_Lure. Il bambino aspetta lo sciatore mentre le tazzine si rovesciano. Il dottore controlla ciò che succede

L3_Lure. Il barbiere intervista il tennista mentre le pentole bollono. L'egiziano segue le domande con attenzione

L3_Lure. il calciatore contraddice il turista mentre le porte sbattono. il fantino ascolta il colloquio di nascosto

L3_Lure. Il cameriere abbraccia il poliziotto quando gli studenti se ne vanno. Il fotografo vede la scena da lontano

L3_Lure. Il chitarrista insulta il postino quando gli spettatori se ne vanno. Il francese prende nota di quanto succede

L3_Lure. Il contadino critica il professore mentre i telefoni squillano. L'imbianchino assiste a tutto il litigio

L3_Filler. La ricercatrice sbircia il nonno tutto il tempo. I messicani se ne accorgono divertiti

L3_Filler. La strega irrita il nuotatore per tutta la serata. Intanto le candele si consumano

L3_Filler.  La panettiera rimprovera il pilota ormai da ore. Intanto i bagnini osservano la scena

L3_Filler. La regina interroga l'investigatore molto a lungo. Nel frattempo i negozi hanno chiuso da un pezzo.

L3_Filler. La principessa convoca il ladro d'improvviso. Intanto i reporter spiano la scena da lontano

L3_Filler. La cantante intrattiene il meccanico per tutto il pomeriggio. Nel frattempo i cani dormono tranquilli

L3_Filler. Il bambino aspetta la cuoca per altre due ore. Intanto le campane suonano ininterrotte

L3_Filler. Il barbiere intervista la segretaria per tutto il giorno. Nella stanza vicina le modelle si preparano per la sfilata

L3_Filler. Il calciatore contraddice la dottoressa per tutta la mattina. Fuori dalla finestra le pecore belano nei campi

L3_Filler. Il cameriere abbraccia la fioraia alla fine della serata. Intanto i mendicanti si preparano per la notte

L3_Filler. Il chitarrista insulta la laureata ad alta voce. A quel punto i gatti si svegliano per il rumore

L3_Filler. Il contadino critica la cameriera apertamente. Intanto i bicchieri tintinnano sul bancone

L3_Filler. La hostess e la ricercatrice chiacchierano per altre due ore. Nel frattempo le finestre sbattono per il vento

L3_Filler. La sarta e la strega litigano fino a sera. Nel frattempo i lampioni si accendono per le strade

L3_Filler. L'anziana e la panettiera si esibiscono per la strada. Intanto le monete tintinnano nel loro cappello

L3_Filler. Il poliziotto e la regina si conoscono già da molti anni. Da allora i soldati hanno costruito una nuova caserma

L3_Filler. Il postino e la principessa partono di mattina presto. Subito dopo gli operai cominciano i lavori

L3_Filler. Il professore e la cantante giocano a scacchi fino a tardi. Nel frattempo i taxi aspettano sotto la pioggia

L3_Filler. La violinista e il bambino discutono tutta la serata. Nel frattempo i pescatori ascoltano la conversazione assonnati

L3_Filler. L'infermiera e il barbiere viaggiano ormai da ore. Intanto i brasiliani dormono nei sedili di fronte

L3_Filler. La ballerina e il calciatore escono velocemente. A quest'ora i ciclisti stanno per arrivare al traguardo

L3_Filler. Lo sciatore e il cameriere suonano molto a lungo. Nel frattempo le posate vengono lavate ed asciugate

L3_Filler. Il tennista e il chitarrista scioperano già da molti giorni. Nel frattempo i manifestanti si uniscono alla protesta

L3_Filler. La turista e il contadino si lamentano tutta la mattina. I topi hanno invaso lo scantinato nottetempo

L3_Filler. La cameriera lavora intensamente. Le suore guardano ammirate

L3_Filler. La fioraia cammina per tutta la serata. Ad un certo punto alcuni semafori si spengono

L3_Filler. La laureata inciampa improvvisamente. Gli sposi se ne accorgono divertiti

L3_Filler. L'investigatore dorme tutta la mattina. Ad un certo punto i pompieri lo svegliano

L3_Filler. Il ladro canta allegramente. I deejay hanno suonato canzoni famose tutta la serata

L3_Filler. Il meccanico viaggia frequentemente. Infatti gli aerei non lo spaventano più

L3_Filler. La cuoca studia molto a lungo. Ad un certo punto le tazzine si rovesciano sul tavolo.

L3_Filler. La segretaria riflette per tutta la mattina. Intanto le pentole si sono quasi bruciate.

L3_Filler. La dottoressa passeggia ormai da ore. Intanto le porte dello studio sono state chiuse.

L3_Filler. Il nonno dipinge per tutto il giorno. Gli studenti osservano e prendono appunti

L3_Filler. Il nuotatore sorride alla fine della serata. Gli spettatori battono le mani entusiasti

L3_Filler. Il pilota fischietta continuamente. I telefoni intanto continuano a suonare

### *A.3.7 Experimental Lists: List 4*

(questions as List 1)

L4_Pro. La geisha chiama la cuoca mentre i messicani mangiano. E' molto severa

L4_Pro. la pianista nota la segretaria quando le candele si accendono. Sembra davvero amichevole

L4_Pro. la fruttivendola saluta la dottoressa mentre i bagnini riposano. Sembra molto precisa

L4_Pro. La violinista osserva la geisha mentre i negozi aprono. Sembra molto sveglia

L4_Pro. L'infermiera invita la pianista quando i reporter arrivano. E' proprio vivace

L4_Pro. La ballerina guarda la fruttivendola quando i cani abbaiano. E' davvero gentile

L4_Pro. Il fotografo riconosce il nonno mentre le campane suonano. Sembra molto annoiato

L4_Pro. Il francese vede il nuotatore mentre le modelle si truccano. Sembra proprio spensierato

L4_Pro. L'imbianchino incontra il pilota mentre le pecore pascolano. E' molto ordinato

L4_Pro. Lo sciatore ascolta il fotografo mentre i mendicanti si siedono. E' molto prepotente

L4_Pro. il tennista visita il francese mentre i gatti dormono. E' piuttosto nervoso.

L4_Pro. Il turista raggiunge l'imbianchino quando i bicchieri cadono. E' davvero stanco

L4_Overt. La cameriera chiama la ricercatrice quando le finestre si spalancano. Lei sembra molto cortese

L4_Overt. La fioraia nota la strega mentre i lampioni si accendono. Lei e' davvero esigente

L4_Overt. La laureata saluta la panettiera mentre le monete rotolano. Lei e' piuttosto inquieta

L4_Overt. la ricercatrice osserva la hostess mentre i soldati se ne vanno. Lei e' proprio arrogante

L4_Overt. La strega invita la sarta mentre gli operai lavorano. Lei sembra molto agitata

L4_Overt. La panettiera guarda l'anziana quando i taxi arrivano. Lei sembra proprio garbata

L4_Overt. Il bambino riconosce il poliziotto mentre i pescatori conversano. Lui e' davvero beneducato

L4_Overt. Il barbiere vede il postino mentre i brasiliani festeggiano. Lui e' piuttosto irrequieto

L4_Overt. il calciatore incontra il professore quando i ciclisti arrivano. Lui sembra piuttosto cordiale

L4_Overt. L'investigatore ascolta il bambino mentre le posate cadono. Lui e' davvero simpatico

L4_Overt. il ladro visita il barbiere mentre i manifestanti protestano. Lui sembra proprio allegro

L4_Overt. Il meccanico raggiunge il calciatore mentre i topi scappano. Lui e' molto divertito

L4_Lure. La sarta sbircia l'attrice mentre le suore passeggiano. La geisha osserva la scena pensosa

L4_Lure. L'anziana irrita la giornalista mentre i semafori lampeggiano. La pianista assiste alla scena divertita

L4_Lure. La hostess rimprovera la musicista mentre gli sposi si abbracciano. La fruttivendola interviene nel dialogo

L4_Lure. La regina interroga la violinista quando i pompieri arrivano. La ricercatrice spia la conversazione

L4_Lure. La principessa convoca l'infermiera mentre i deejay suonano. La strega vede il fatto dalla finestra

L4_Lure. La cantante intrattiene la ballerina quando gli aerei atterrano. La panettiera ascolta il dialogo curiosa

L4_Lure. il cameriere aspetta lo sciatore mentre le tazzine si rovesciano. il bambino controlla ciò che succede

L4_Lure. Il chitarrista intervista il tennista mentre le pentole bollono. Il barbiere segue le domande con attenzione

L4_Lure. il contadino contraddice il turista mentre le porte sbattono. il calciatore ascolta il colloquio di nascosto

L4_Lure. L'investigatore abbraccia il dottore quando gli studenti se ne vanno. Il fotografo vede la scena da lontano

L4_Lure. Il ladro insulta l'egiziano quando gli spettatori se ne vanno. Il francese prende nota di quanto succede

L4_Lure. Il meccanico critica il fantino mentre i telefoni squillano. L'imbianchino assiste a tutto il litigio

L4_Filler. La attrice sbircia il nuotatore tutto il tempo. I messicani se ne accorgono divertiti

L4_Filler. La cameriera irrita il nonno per tutta la serata. Intanto le candele si consumano

L4_Filler. La cameriere rimprovera il giornalista ormai da ore. Intanto i bagnini osservano la scena

L4_Filler. La cantante interroga il professore molto a lungo. Nel frattempo i negozi hanno chiuso da un pezzo.

L4_Filler. Il chitarrista convoca la laureata d'improvviso. Intanto i reporter spiano la scena da lontano

L4_Filler. Il contadino intrattiene la musicista per tutto il pomeriggio. Nel frattempo i cani dormono tranquilli

L4_Filler. La cuoca aspetta il poliziotto per altre due ore. Intanto le campane suonano ininterrotte

L4_Filler. Il dottore intervista la regina per tutto il giorno. Nella stanza vicina le modelle si preparano per la sfilata

L4_Filler. La dottoressa contraddice il pilota per tutta la mattina. Fuori dalla finestra le pecore belano nei campi

L4_Filler. L'egiziano abbraccia la segretaria alla fine della serata. Intanto i mendicanti si preparano per la notte

L4_Filler. Il fantino insulta la principessa ad alta voce. A quel punto i gatti si svegliano per il rumore

L4_Filler. La fioraia critica il postino apertamente. Intanto i bicchieri tintinnano sul bancone

L4_Filler. L'anziana e l'attrice chiacchierano per altre due ore. Nel frattempo le finestre sbattono per il vento

L4_Filler. La ballerina e la cameriera litigano fino a sera. Nel frattempo i lampioni si accendono per le strade

L4_Filler. La hostess e il cameriere si esibiscono per la strada. Intanto le monete tintinnano nel loro cappello

L4_Filler. L'infermiera e la cantante si conoscono già da molti anni. Da allora i soldati hanno costruito una nuova caserma

L4_Filler. L'investigatore e il chitarrista partono di mattina presto. Subito dopo gli operai cominciano i lavori

L4_Filler. Il ladro e il contadino giocano a scacchi fino a tardi. Nel frattempo i taxi aspettano sotto la pioggia

L4_Filler. Il meccanico e la cuoca discutono tutta la serata. Nel frattempo i pescatori ascoltano la conversazione assonnati

L4_Filler. La sarta e il dottore viaggiano ormai da ore. Intanto i brasiliani dormono nei sedili di fronte

L4_Filler. Lo sciatore e la dottoressa escono velocemente. A quest'ora i ciclisti stanno per arrivare al traguardo

L4_Filler. Il tennista e l'egiziano suonano molto a lungo. Nel frattempo le posate vengono lavate ed asciugate

L4_Filler. Il turista e il fantino scioperano già da molti giorni. Nel frattempo i manifestanti si uniscono alla protesta

L4_Filler. La violinista e la fioraia si lamentano tutta la mattina. I topi hanno invaso lo scantinato nottetempo

L4_Filler. La giornalista lavora intensamente. Le suore guardano ammirate

L4_Filler. La laureata cammina per tutta la serata. Ad un certo punto alcuni semafori si spengono

L4_Filler. La musicista inciampa improvvisamente. Gli sposi se ne accorgono divertiti

L4_Filler. Il nonno dorme tutta la mattina. Ad un certo punto i pompieri lo svegliano

L4_Filler. Il nuotatore canta allegramente. I deejay hanno suonato canzoni famose tutta la serata

L4_Filler. Il pilota viaggia frequentemente. Infatti gli aerei non lo spaventano piu'

L4_Filler. Il poliziotto studia molto a lungo. Ad un certo punto le tazzine si rovesciano sul tavolo.

L4_Filler. Il postino riflette per tutta la mattina. Intanto le pentole si sono quasi bruciate.

L4_Filler. La principessa passeggia ormai da ore. Intanto le porte del castello sono state chiuse.

L4_Filler. Il professore dipinge per tutto il giorno. Gli studenti osservano e prendono appunti

L4_Filler. La regina sorride alla fine della serata. Gli spettatori battono le mani entusiasti

L4_Filler. La segretaria fischietta continuamente. I telefoni intanto continuano a suonare

## A.4 Pictures for the Visual World Experiment (chapter 7)

A.4.1 Feminine NP: the baker, “la panettiera”

A.4.2 Feminine NP: the waitress, “la cameriera”

A.4.3 Feminine NP: the grocer, “la fruttivendola”

A.4.4 Feminine NP: the cook, “la cuoca”

A.4.5 Feminine NP: the hostess, “la hostess”

A.4.6 Feminine NP: the pianist, “la pianista”

A.4.7 Feminine NP: the violinist, “la violinista”

A.4.8 Feminine NP: the queen, “la regina”

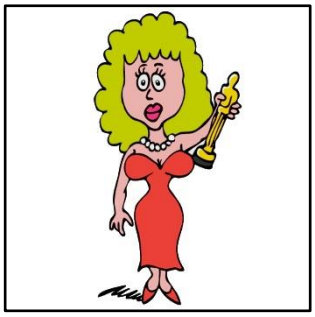
A.4.9 Feminine NP: the journalist, “la giornalista”

A.4.10 Feminine NP: the dancer, “la ballerina”

A.4.11 Feminine NP: the nurse, “l’infermiera”

A.4.12 Feminine NP: the witch, “la strega”

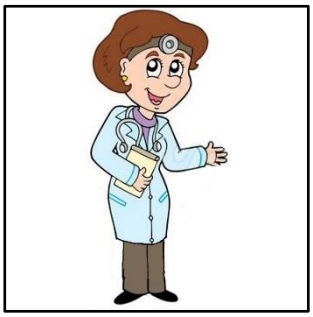
A.4.13 Feminine NP: the old woman, “l’anziana”



A.4.14 Feminine NP: the actress, “l’attrice”

A.4.15 Feminine NP: the princess, “la principessa”

A.4.16 Feminine NP: the singer, “la cantante”



A.4.17 Feminine NP: the doctor, “la dottoressa”

A.4.18 Feminine NP: the researcher, “la ricercatrice”

A.4.19 Feminine NP: the musician, “la musicista”

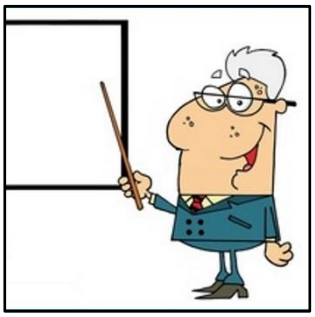
A.4.20 Feminine NP: the graduate, “la laureata”

A.4.21 Feminine NP: the geisha, “la geisha”

A.4.22 Feminine NP: the tailor, “la sarta”

A.4.23 Feminine NP: the florist, “la fioraia”

A.4.24 Feminine NP: the secretary, “la segretaria”



A.4.25 Masculine NP: the professor, “il professore”

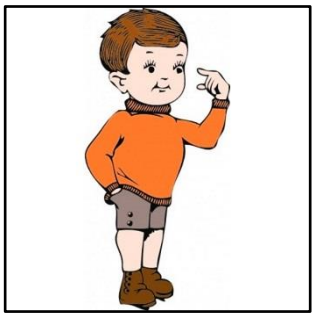
A.4.26 Masculine NP: the mechanic, “il meccanico”

A.4.27 Masculine NP: the detective, “l’investigatore”

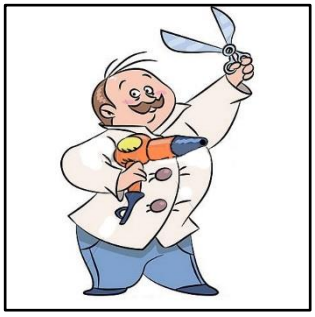
A.4.28 Masculine NP: the guitar player, “il chitarrista”

A.4.29 Masculine NP: the photographer, “il fotografo”


A.4.30 Masculine NP: the jokey, “il fantino”



A.4.31 Masculine NP: the child, “il bambino”



A.4.32 Masculine NP: the barber, “il barbiere”

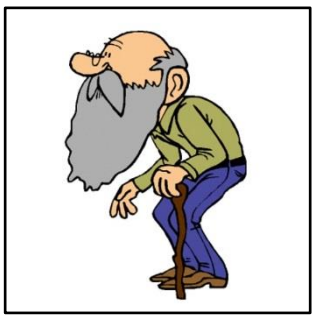
A.4.33 Masculine NP: the thief, “il ladro”

A.4.34 Masculine NP: the doctor, “il dottore”

A.4.35 Masculine NP: the Egyptian, “l’egiziano”

A.4.36 Masculine NP: the farmer, “il contadino”

A.4.37 Masculine NP: the Frenchman, “il francese”



A.4.38 Masculine NP: the grandad, “il nonno”

A.4.39 Masculine NP: the pilot, “il pilota”

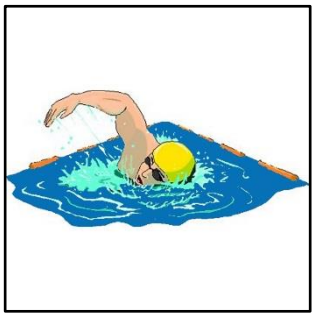
A.4.40 Masculine NP: the painter, “l’imbianchino”

A.4.41 Masculine NP: the policeman, “il poliziotto”

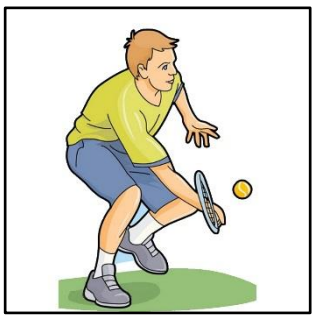
A.4.42 Masculine NP: the postman, “il postino”

A.4.43 Masculine NP: the skier, “lo sciatore”

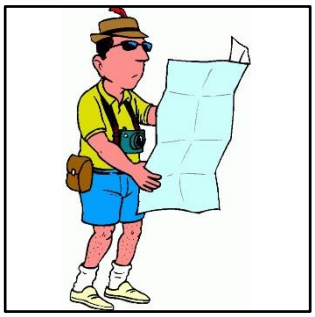
A.4.44 Masculine NP: the football player, “il calciatore”



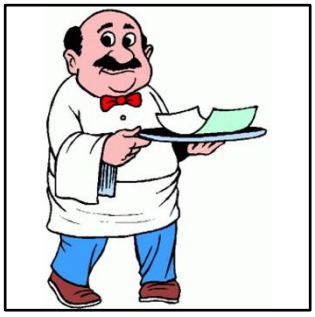
A.4.45 Masculine NP: the swimmer, “il nuotatore”



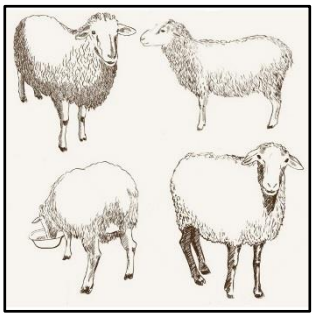
A.4.46 Masculine NP: the tennis player, “il tennista”



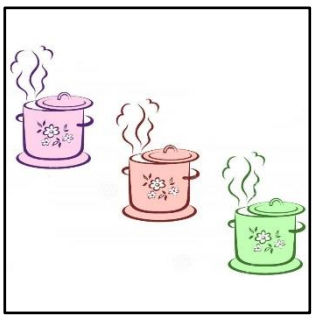
A.4.47 Masculine NP: the tourist, “il turista”



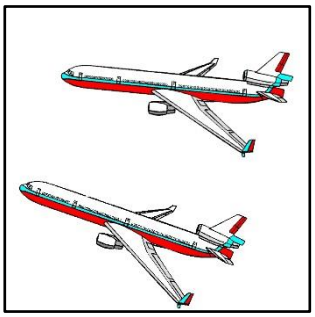
A.4.48 Masculine NP: the waiter, “il cameriere”



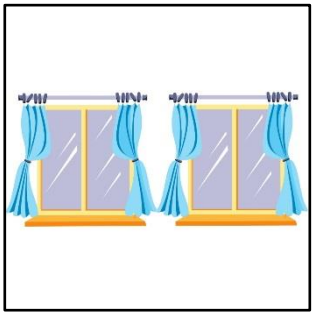
A.4.49 Plural NP: the sheep, “le pecore”



A.4.50 Plural NP: the pots, “le pentole”



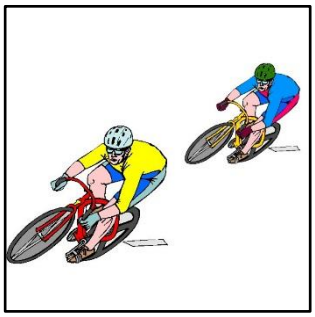
A.4.51 Plural NP: the airplanes, “gli aerei”



A.4.52 Plural NP: the windows, “le finestre”

A.4.53 Plural NP: the deejays, “i deejay”

A.4.54 Plural NP: the Mexicans, “i messicani”

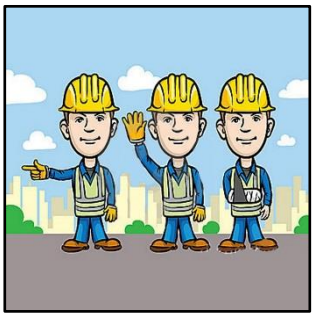


A.4.55 Plural NP: the cyclists, “i ciclisti”

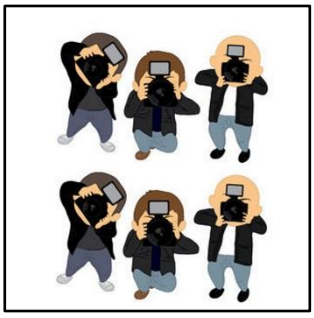
A.4.56 Plural NP: the mice, “i topi”

A.4.57 Plural NP: the beggars, “i mendicanti”

A.4.58 Plural NP: the models, “le modelle”



A.4.59 Plural NP: the builders, “gli operai”



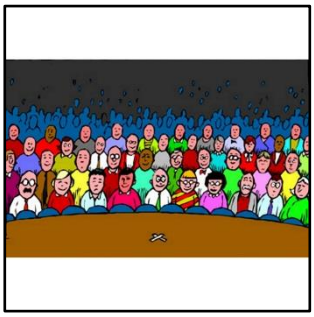
A.4.60 Plural NP: the reporters, “i reporter”

A.4.61 Plural NP: the fishermen, “i pescatori”

A.4.62 Plural NP: the cats, “i gatti”

A.4.63 Plural NP: the dogs, “i cani”

A.4.64 Plural NP: the lifeguards, “i bagnini”



A.4.65 Plural NP: the audience, “gli spettatori”

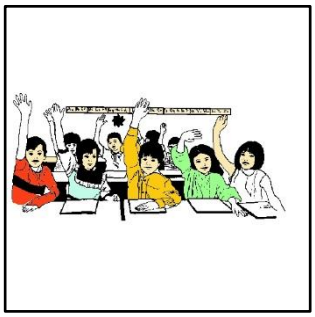
A.4.66 Plural NP: the soldiers, “i soldati”

A.4.67 Plural NP: the newly-weds, “gli sposi”

A.4.68 Plural NP: the nuns, “le suore”

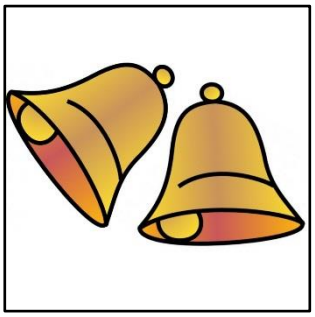

A.4.69 Plural NP: the Brasilians, “i brasiliani”

A.4.70 Plural NP: the protesters, “i manifestanti”



A.4.71 Plural NP: the students, “gli studenti”

A.4.72 Plural NP: the firemen, “i pompieri”

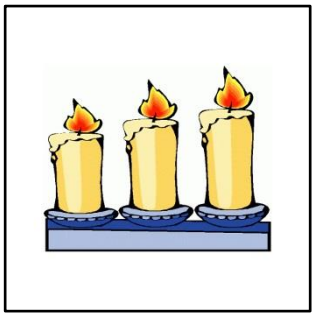


A.4.73 Plural NP: the bells, “le campane”

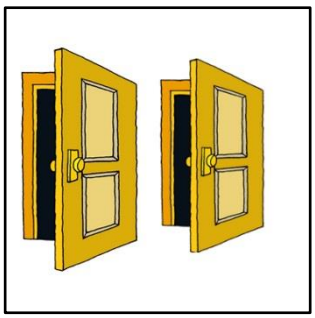
A.4.74 Plural NP: the cutlery, “le posate”

A.4.75 Plural NP: the shops, “i negozi”

A.4.76 Plural NP: the glasses, “i bicchieri”

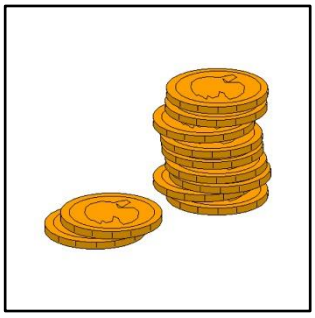


A.4.77 Plural NP: the candles, “le candele”

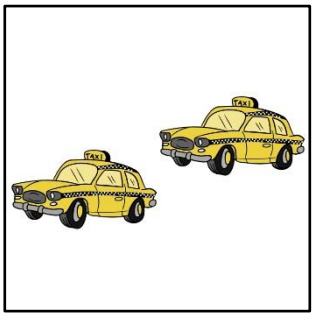


A.4.78 Plural NP: the doors, “le porte”

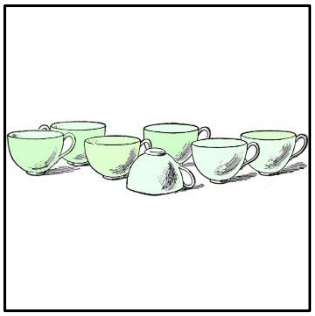
A.4.79 Plural NP: the street lamps, “i lampioni”



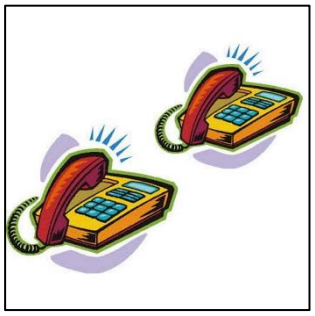
A.4.80 Plural NP: the coins, “le monete”



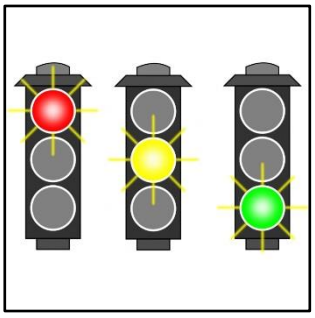
A.4.81 Plural NP: the taxis, “i taxi”



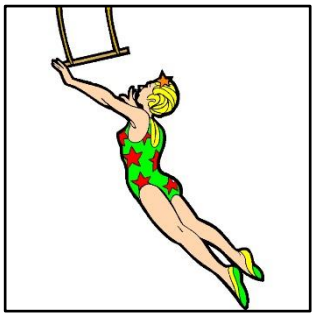
A.4.82 Plural NP: the cups, “le tazzine”



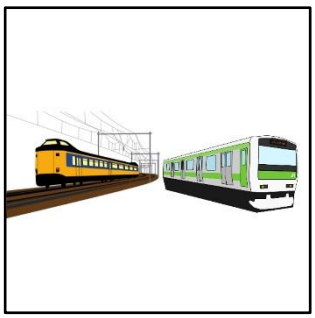
A.4.83 Plural NP: the telephones, “i telefoni”



A.4.84 Plural NP: the street lights, “i semafori”



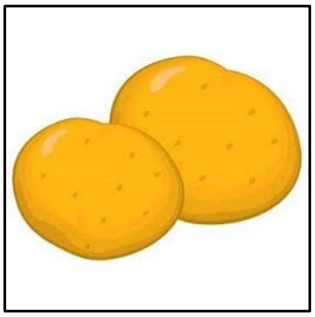
A.4.85 Practice NP: the acrobat, “l’acrobata”



A.4.86 Practice NP: the trains, “i treni”

A.4.87 Practice NP: the bin-men, “i netturbini”

A.4.88 Practice NP: the teacher, “la maestra”



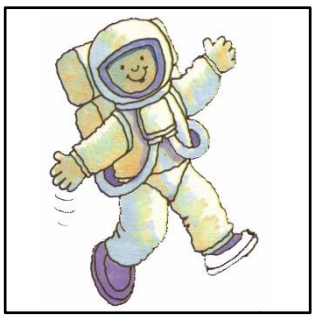
A.4.89 Practice NP: the potatoes, “le patate”

A.4.90 Practice NP: the fortune teller, “la maga”

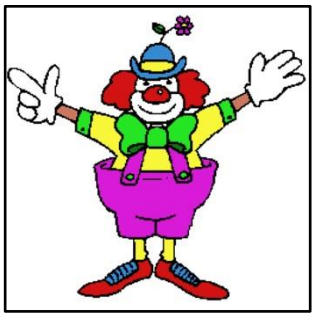
A.4.91 Practice NP: the pirate, “il pirata”

A.4.92 Practice NP: the employees, “gli impiegati”

A.4.93 Practice NP: the cowboy, “il cowboy”



A.4.94 Practice NP: the astronaut, “l’astronauta”



A.4.95 Practice NP: the clown, “il pagliaccio”

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