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Sentence processing in first language attrition: the interplay of language, experience and cognitive load

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Abstract

In a bilingual mind, two languages frequently interact with each other during language comprehension and production. Both languages stay active, and bilingual speakers must resolve interferences from the unwanted language, to understand and produce speech in the target language (Linck, Hoshino, & Kroll, 2008; Linck, Kroll, & Sunderman, 2009). Inhibiting a language is cognitively demanding, and this kind of mental practice is carried out by bilingual speakers daily (Green, 1998). The bilingual experience not only interacts with speakers’ general cognitive functions, such as attention control and working memory, it also affected their linguistic performance in both of their languages (Bialystok, 2009; Kroll & Bialystok, 2013). Immersion in the second language (L2) environment with limited contact with the first language (L1) can gradually lead to change in the L1 system in terms of knowledge, processing and use; for example, slower and less efficient access to the L1 compared to the L2, even after the L1 has been fully acquired (Levy, McVeigh, Marful, & Anderson, 2007). This non-pathological, post-puberty change in the L1 due to the interaction between two languages is what we called L1 attrition in adulthood (Köpke & Schmid, 2004).

Given the state of literature at the moment, bilingual processing at the lexical level has been investigated more often than bilingual processing at the sentence level (Kroll, Dussias, Bice, & Perrott, 2015; Schmid & Köpke, 2017a). Granted that bilingual lexical retrieval can bring us valuable insights into bilingual processing in general, but sentence-level processing involves not only word recognition and lexical retrieval, but it also involves semantic processing, syntactic processing, as well as discourse processing. During this process, the interplay between language and cognition is quite different from what we have found on the lexical level. The current study aims to fill this gap by investigating sentence processing in L1 attrition, among Mandarin-English late bilingual speakers with different bilingual profiles (passive vs.
active bilinguals) and varying lengths of residence (LoR) in the L2 environment. I investigated two structures in this dissertation, *wh*-topicalization and reflexive *ziji* (‘self’) in Mandarin. Processing said structures requires integrating information from different domains, including syntax, semantics and discourse. In addition, Mandarin and English differs in terms of syntactic, semantic and discourse constraints to those structures, making them the ideal testing ground for cross-language influence.

The first study (Chapter 4) examined the acceptability judgments of sentences with *wh*-topicalization in a speeded paradigm. Different from *wh*-movement in English, *wh*-phrases in Mandarin *wh*-questions usually stay in situ, or they can be topicalized in specific contexts. Native mandarin speakers must use both syntactic and discourse information to decide whether it is grammatical to topicalize the *wh*-phrase in the current context. Using a Speeded Acceptability Judgment Task, I found that sensitivity to the discourse information decreased as bilingual speakers spent more time in the L2 environment: as LoR increased, their judgments became more neutral; and it became increasingly difficult for them to reject ungrammatical or less-preferred *wh*-topicalizations. Also, their linguistic performance was associated with their performance in cognitive tasks, suggesting certain aspects of general cognitive functions affected the attrition process.

The second study (Chapter 5) used a Speeded Comprehension Task with two-alternative forced-choice to investigate how bilinguals interpret the Mandarin reflexive pronoun *ziji* under time pressure. Different from its English counterpart *self*, *ziji* allows both long-distance and local binding; besides, the pronoun-resolution is highly context-dependent: native speakers use either semantics or discourse information to resolve ambiguities when there is more than one potential antecedent in the context. Results show that despite long-term immersion in the L2 environment, active bilingual speakers outperformed their passive bilingual peers in both reaction time and response accuracy. All participants, however, showed the same preference for local binding, and were more accurate when they used the semantic rather than the discourse information to determine the antecedent. A significant correlation between cognitive tasks and the speeded comprehension task suggests that general cognitive abilities, such as working memory and attention control, play a role during pronoun-resolution in L1 attrition.

Through these studies, this thesis contributes to the understanding of bilingual processing and L1 attrition at the sentence level. Although much more work
is required to fully understand the interplay of language, experience and cognitive factors, this thesis provides evidence that the effect of L1 attrition manifests itself differently with different linguistic structures, and the degree of L1 attrition is influenced by both bilingual experience and cognitive demands of the task.
Lay Summary

When bilingual speakers produce or comprehend speech in one language, the other language in their mind does not shut down. Thus, bilinguals must use control mechanisms to regulate the traffic between two languages so that the language not-in-use does not interfere with the ongoing communication. Controlling the activation levels of two languages posts an extra challenge to bilinguals’ communication systems. Researchers believe this experience has consequences for both the linguistic and cognitive domains. This thesis focuses on one of the linguistic consequences of bilingualism, namely first language attrition.

First language attrition describes changes to the first language of any kind, whether they are word-finding difficulties, foreign accents, or modifications of grammatical rules. It is often seen among immigrants who moved to a foreign country where the dominant language is not their first language. As a result, their L2 input and use inevitably increases, and it is often accompanied by a decrease of L1 use. However, studies do not always observe attrition effects among immigrants: it depends on the linguistic structure involved and the speakers’ language experience.

Few studies investigated how sentence processing is affected by language attrition. This thesis aims to fill the gap and reports two studies of syntactic L1 attrition among Mandarin-English late bilingual speakers. The primary goal is to understand the effects of linguistic properties and bilingual experience on L1 syntactic attrition. I also consider the possible influence of other mental abilities like attention.

The first study examined how bilinguals process *wh*-questions (Chapter 4) and the second study investigated how they understand pronouns (Chapter 5). These two structures are of interest because English and Mandarin differ in said structures, creating a conflict that must be solved during sentence processing. Also,
processing the two structures require speakers to integrate information from different sources, which could be more challenging for bilingual speakers with reduced L1 use and increased interference from the L2.

Both studies showed that bilingual experience plays a role in how people process sentences. However, *wh*-sentences and pronouns showed different attrition patterns. Furthermore, as bilingual speakers spent more time in the L2 environment, their linguistic performance concerning the two target structures continued to change. I also found correlations between bilinguals’ mental abilities and their linguistic performance. It seems that bilinguals with better mental abilities can perform language tasks more accurately and more quickly.

Through these studies, this thesis contributes to the understanding of bilingual processing and L1 syntactic attrition. It showed that L1 attrition selectively affects different sentence structures. Also, the degree of L1 attrition is influenced by bilinguals’ language experience and mental abilities.
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 acknowledgment 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.

Wenjia Cai
30/12/2020
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Introduction

This thesis investigates sentence processing among bilingual speakers in the process of first language attrition. The term ‘bilingual speaker’ usually refers to people who are functional in two languages (Kroll et al., 2015). Whether they are early bilingual speakers who acquire two languages simultaneously, or have acquired the first (L1) and the second language (L2) sequentially before adolescence, or they are late bilinguals whose onset of bilingualism starts in adulthood– bilinguals generally go through multiple changes of the language environment in their lifespan. From switching among speakers to migrating abroad, constant changes in the language environment require bilinguals to be flexible and adaptive. Accommodating their communication systems to new challenges is one of the main characteristics that sets bilingual speakers apart from monolinguals.

Recently, an increasing number of studies in bilingualism have focused on the first language attrition. When bilingual speakers move to an L2 dominant environment, their L2 input and use inevitably increases, and it is often accompanied by a decrease of L1 use. Furthermore, they face additional demands in monitoring their language choices in different contexts, reducing interferences from the non-target language, and switching between languages to achieve communication goals. As a result of L2 immersion, decreasing L1 use and increasing cognitive demands, there can be changes in the L1 system in terms of knowledge, processing and use, for example, slower and less efficient access to the L1 compared to the L2 (e.g., Levy et al., 2007). We refer to this process as the first language attrition (hereafter L1 attrition).

In the last three decades, our understanding of L1 attrition has progressed through approximately three stages (see Köpke & Schmid, 2004; Schmid & Köpke, 2017a, for a review). Initially, L1 attrition was studied as a form of language loss that only takes place in extreme conditions among a minimal subset of bilinguals (e.g.,
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R. W. Anderson (1982). It was then studied as a form of structural change in the L1 grammar that goes beyond online transfer, under the influence of L2 rules and constraints (e.g., Pavlenko, 2000, 2004; Seliger, 1991). Recently, it has been argued that effects of the second language on the first (Cook, 2003; henceforth EotSLotF) – both at the level of representation and processing – fall within the scope L1 attrition (Schmid & Köpke, 2017a). Despite the on-going representation vs. processing debate (see Schmid & Köpke, 2017b, for a review), more and more researchers in the field have come to view L1 attrition less as a loss, and more as a change in our linguistic and cognitive system (Sorace, 2011, 2016); less as a deficit, and more as a natural result of “juggling two languages in one mind” (Kroll, Dussias, Bogulski, & Krofl, 2012, p. 229). Nevertheless, there are still quite a few gaps to fill to understand the underlying mechanisms of L1 attrition as well as bilingual development in general.

First, most studies to date, both empirical studies and theoretical frameworks, focus on the lexical level, while the investigation into L1 attrition on the sentence level is still limited (Kroll et al., 2015; Schmid & Köpke, 2017a). Compared to the bilingual lexicons, the grammars of bilinguals’ two languages rarely converge, which makes crosslinguistic interactions on the sentence level more challenging to detect, compared to those on the lexical level (Schmid, 2011b). Second, not all linguistic structures are sensitive to changes in the language environment, and research has shown that some structures are more resilient than others despite long-term exposure to the L2 (Chamorro, Sturt, & Sorace, 2015; Tsimpli, Sorace, Heycock, & Filiaci, 2004). It is still an open question what conditions generate such resilience in some cases, and vulnerability in others. Third, the interplay of individual factors that influences the L1 attrition process remains underexplored. Even with similar age at onset of L2 acquisition and L1 attrition, some late bilingual speakers appear to be better at maintaining their native language than others. What are the characteristics that distinguish “good language maintainers” from others? Relevant work has focused on the quantity and quality of language exposure in both languages, and length of residence in the L2 environment (see Schmid, 2011a, for a review); while cognitive factors, such as working memory and attention, have not been studied in the context of L1 attrition (cf. Köpke, 2007; Sorace, 2016). As I will further discuss in Chapter 2 and 3, both working memory and attention control are actively engaged in monolingual sentence processing and L2 learning. In light of recent discoveries on the mutual effects of bilingualism and cognition (Bialystok, 2009; Kroll & Bi...
lystok, 2013), individual differences in working memory and attention control may affect the degree of L1 attrition in sentence processing among late bilinguals. This thesis aims to contribute to the field, not only by exploring the linguistic factors that drive L1 attrition, but also investigating the role of general cognition, and how it modulates the attrition process.

I address these questions in two empirical studies (Chapter 4 and 5), which investigate how sentence processing in the first language, especially those involving complex syntactic structures, changes over time in the second language environment. To set the background of these studies, I begin by reviewing the relevant literature in Chapter 1, 2 and 3.

In Chapter 1, I review research that investigated three influential factors in L1 attrition: linguistic properties, language exposure, and cognitive load. The first two aspects have been studied extensively in the field of L1 attrition, while the effect of general cognitive abilities has been largely overlooked. In terms of linguistic structures that are susceptible to crosslinguistic influence, converging evidence indicates that L1 attrition usually takes place where two languages have a structural overlap (Müller & Hulk, 2001; Schmid & Köpke, 2017a). I first discuss linguistic theories that capture the characteristics of syntactic structures that undergo L1 attrition, and argue that structures which involve complex computing, i.e., integrating multi-layered information, are more vulnerable to language attrition (Section 1.1). Section 1.2 focuses on how language exposure influences the process of L1 attrition. I review a series of studies by Schmid and colleagues, which highlighted the significance of the context of language use. They argued for a more fine-grained approach to language exposure both in definition and in measurement. Finally, I discuss the effect of general cognitive abilities and task demands in bilingual sentence processing (Section 1.3). I argue it is essential to consider cognitive factors when studying L1 attrition. Section 1.3 also foreshadows the more in-depth discussion about bilingual cognitive control in Chapter 3.

L1 attrition can be viewed as a result of interactions between the two languages: language co-activation puts extra demands on the linguistic and cognitive system, and it can change the way bilinguals process and use L1. Chapter 2 reviews the literature of language co-activation on multiple levels, with an emphasis on the sentence level. There are abundant studies on bilingual visual word recognition and lexical access (Dijkstra, 2005; Kroll & Dijkstra, 2012), while the dynamic of bilin-
gual sentence processing has received little attention (Kroll & Dussias, 2013). The primary purpose of this chapter is to demonstrate the openness between bilinguals’ two language systems not only on the lexical level but also on the sentence level. I first review relevant computational models on bilingual lexical access (Section 2.1). These models summarize our current understanding of bilingual lexical processing and lay the foundation for studies in bilingual sentence processing. Then I move to review research on language co-activation during bilingual sentence processing (Section 2.2), which showed that semantic and syntactic knowledge of the two languages is largely shared.

The co-activation of languages puts extra demands on bilingual speakers’ language and cognitive systems. Compared to monolingual speakers, bilinguals experience interferences from more than one language; additionally, they need to flexibly switch between the two languages based on the current context. “How do bilingual speakers produce the correct form in the intended language” is a question vital to our understanding of bilingualism. It has been proposed that different processing demands underly the monolingual/bilingual divergence (Sorace, 2016). Studies in bilingual language processing have shown that cognitive control mechanisms, such as attention control and working memory, are actively engaged in bilingual language processing (Bialystok, Craik, & Luk, 2008). I begin this chapter by reviewing behavior and neural studies that show bilinguals engaging control mechanisms while performing linguistic tasks (Section 3.1). Then I introduce models of cognitive control (Section 3.2), especially those that can be or already have been applied to the bilingualism research; for instance, the Inhibition Control model (Green, 1998), the Unity and Diversity model (Miyake et al., 2000; Friedman & Miyake, 2017), and the Adaptive Control Hypothesis (Green & Abutalebi, 2013). Finally, I briefly introduce research in cognitive consequences of bilingualism (Section 3.3).

To sum up, Chapters 1 to 3 aim to bring together studies of language attrition, processing and bilingual cognition, to provide a context of the empirical research described in Chapters 4 and 5. Chapter ?? connects the previous and the current research and introduces four research questions that are addressed jointly in two studies. The research questions are:

1. Will bilingual sentence processing undergo L1 attrition after long-term immersion in the L2 environment?
2. What syntactic structures are vulnerable to the attrition process, and why?

3. If the attrition process does affect L1 sentence processing, will speakers’ language experience, such as length of exposure to the L2 environment, affect the degree of attrition?

4. If the attrition process does affect L1 sentence processing, will speakers’ general cognitive abilities, such as attention control and working memory, affect the degree of attrition?

The two studies presented in Chapter 4 and 5 used the same pool of participants: 115 late Mandarin-English bilingual speakers. Among them, 76 participants were residing in the U.K. (i.e., active bilingual speakers), and 39 participants were residing in China (i.e., passive bilingual speakers) during the time of the experiment. The distinction between early and late bilinguals was based on whether the onset of bilingualism occurred before puberty. Early bilinguals (either simultaneous or sequential) begin acquiring their L2 (or community language) before their L1 (or heritage language) is fully acquired and stabilized, and they usually exhibit “incomplete acquisition” when they reach adulthood (Montrul, 2005). In this thesis, I focus on L1 attrition in adulthood (henceforth late L1 attriters), which envelopes all non-pathological change to a mature L1 system in terms of knowledge, processing and use. Limiting the scope of this investigation allows us to separate effects of acquisition from effects of subsequent language attrition (Flores, Santos, Jesus, & Marques, 2017), thus ensures the absence of the influence of (possible) “incomplete acquisition”. In addition, investigating changes to the L1 among late bilingual speakers can shed light on the plasticity of the L1: whether acquiring the second language at a later stage of life can change the way we process our native language.

The first study (Chapter 4) examines the grammaticality judgment of wh-topicalization in a speeded paradigm. Different from wh-movement in English, Wh-phrases in Mandarin wh-questions usually stay in situ, or it can be topicalized in specific contexts: native speakers must use both syntactic and discourse information to decide whether it is grammatical to topicalize the wh-phrase in the current context.

<sup>2</sup> Initially, acquisition of the L1, especially in the heritage language context was coined as incomplete acquisition (Montrul, 2002; Montrul, Davidson, De La Fuente, & Foote, 2014); in recent years, however, researchers (e.g., Kupisch & Rothman, 2018) have been suggesting to regard this acquisition process as “differential acquisition”.

Chapter 0 5 Wenjia Cai
The partial overlap between English *wh*-movement and Mandarin *wh*-topicalization created a “launchpad” for language attrition (Schmid & Köpke, 2017a, p. 645). Using a Speeded Grammaticality Judgment Task, I found that sensitivity to the discourse information decreased as bilingual speakers spent more time in the L2 environment: as LoR increased, it became more difficult for them to reject ungrammatical or less-preferred *wh*-topicalizations. In addition, their performance was influenced by their general cognitive abilities, such as attention control and working memory.

The second study (Chapter 5) used a Speeded Comprehension Task with two-alternative forced-choice to investigate the comprehension of Mandarin reflexive pronoun *ziji* (‘self’) under time pressure. In contrast to its English counterpart *self*, *ziji* allows both long-distance and local binding, and the pronoun resolution is highly context-dependent: native speakers use either semantics or discourse information to resolve ambiguities when there is more than one potential antecedent in the sentence. The difference in pronoun resolution between Mandarin and English is very likely to create a conflict during processing, leading to a non-native-like linguistic outcome. Results show that despite long-term immersion in the L2 environment, active bilingual speakers outperformed their passive bilingual peers in both reaction time and response accuracy. All participants, however, showed the same preference for local binding; they were also more accurate when they use semantics rather than discourse information to determine the antecedent. The significant correlation between the cognitive tasks and the speeded comprehension task suggests that general cognitive abilities, such as working memory and attention control, play a role during pronoun resolution in L1 attrition.

In sum, this thesis investigates how sentence processing in the first language, especially with respect to complex syntactic structures, changes over time in the second language environment. The main purpose is to determine some of the main factors, both linguistic and extralinguistic, that influence the performance of bilingual speakers. This thesis looks at language attrition from both the linguistic and the cognitive perspective and hopes to integrate the two strands of research in the context of L1 attrition.
Chapter 1

The selectivity of first language attrition

I define L1 attrition as changes in the L1 system in terms of knowledge, processing and use, due to L2 immersion accompanied by decreasing L1 use. The changes need not be representational nor permanent to be recognized as L1 attrition. L1 attrition is a selective, “role-governed” process (Seliger, 1991, p. 28). Not all linguistic structures are equally susceptible, and it does not affect all bilingual speakers in the same manner (Schmid & Köpke, 2007; Tsimpli, 2007). Identifying the influential factors of L1 attrition is crucial to understanding its cause and mechanisms.

This chapter reviews research that focuses on three influential factors: linguistic properties (Section 1.1), language exposure (Section 1.2) and cognitive load (Section 1.3). The type of linguistic property is a language-internal, within-speaker variable. The amount of language exposure (in both L1 and L2) is a language-external factor that changes over time and varies among speakers and contexts. Cognitive load refers to the amount of computation required to process various linguistic structures and to achieve communication goals. It depends not only on the complexity of the linguistic structure under investigation but also on the nature of the current task. Despite their different focuses, these factors do not exist in isolation; instead, they interact with each other and work in concert to determine the outcomes of L1 attrition.
1.1 Linguistic properties

It is well-documented that L1 attrition affects the lexical and the syntactic domain differently (see Kroll et al., 2015, for a review). Lexical attrition usually manifests as low verbal fluency, lexical retrieval difficulties, and disfluencies in the free speech (Gollan, Montoya, Fennema-notestine, & Morris, 2005; Gollan, Montoya, & Werner, 2002; Schmid & Jarvis, 2014). Furthermore, it can take place in as short as a few months after the migration (Baus, Costa, & Carreiras, 2013; Linck et al., 2009). In comparison, syntactic features have been considered as relatively stable, especially among late bilingual speakers whose onset of bilingualism occurs after adolescence. In studies that investigated both the lexical and the syntactic domain, many found significant lexical attrition and hardly any attrition to syntactic features (Ammerlaan, 1996; de Bot, Gommans, & Rossing, 1991; Köpke, 2002; Schmid & Dusseldorp, 2010). Noticeably, these studies used an untimed grammaticality judgment task (GJT) to detect syntactic attrition, which is not ideal for capturing the on-going, transient changes of L1 syntactic use, and more suited to evaluate the underlying representation of L1 syntactic knowledge (Altenberg & Vago, 2004; Schütze, 2016). That notwithstanding, it is evident that at least some syntactic features are more resilient to L1 attrition than lexical features.

The differential effect on the lexical and the syntactic domain is only one aspect of the selectivity of L1 attrition; structures pertaining to the syntactic domain showed different levels of attrition as well. Recently, attrition studies that investigated the vulnerability of the pronominal system have yielded fruitful results. Pronominal subjects, for example, have shown L1 attrition effects among different bilingual populations with various language combinations (Chamorro, Sturt, & Sorce, 2013; Gürel, 2004; Kaltsa, Tsimpli, & Rothman, 2014; Kim, Montrul, & Yoon, 2010; Montrul, 2004; Tsimpli et al., 2004; Wilson, 2009). Studies also found attrition effects in relative-clause attachments (Dussias, 2004; Dussias & Sagarna, 2007), realizations of tense and aspect (Montrul, 2002), as well as unaccusatives verbs (Montrul, 2005). The inconsistency between recent and previous findings with regards to L1

1 The difference in L1 attrition between early and late bilinguals is beyond the scope of this thesis. Nevertheless, the current consensus is that an entrenched, mature L1 system is less likely to experience structural change, compared to a developing L1 system. That is, early bilingual speakers are more likely to undergo a drastic change in their L1 grammar than their late bilingual peers (Flores et al., 2017; Schmid, 2014).
syntactic attrition can be partly attributed to different methodologies: recent studies used timed, online measures like eye-tracking, which are more sensitive to nuances in the L1 performance compared to offline measures such as untimed GJT. On the other hand, most structures that exhibited L1 attrition effects require integrating information from multiple linguistic and cognitive domains, let it be syntax, semantics, pragmatics, and discourse. The processing demand of these structures may also contribute to their vulnerability to L1 attrition (see Sorace, 2016, for discussions of cognitive load, see Section 1.3).

Consider the use of null and overt subject pronouns in null-subject languages, such as Italian and Spanish. Different from non-null subject languages like English, they allow null subject pronouns depending on the context. Generally speaking, null pronouns signal the continuation of a topic (i.e., old information), while overt pronouns signal a topic-shift (i.e., new information). The distribution of null and overt pronouns is governed by both syntactic rules and discourse information, and the processing involves retrieving and integrating the syntactic and discourse information. In Tsimpli et al. (2004), results from the picture verification task (PVT) in the forward anaphora condition showed that compared to their monolingual peers, Italian-English bilingual speakers overextended the use of overt-pronouns, while their interpretation of null pronouns remained native-like.

Moreover, Chamorro and colleagues found a similar pattern with Spanish-English bilinguals in L1 attrition (hereafter attriters; Chamorro, Sorace, & Sturt, 2015), using both online and offline measures. In the eye-tracking study, monolingual Spanish speakers showed a strong preference for overt pronouns to co-refer with object antecedents; in contrast, attriters did not exhibit sensitivity to one antecedent over another. However, in the offline acceptability judgment task with the same stimuli, attriters displayed intact knowledge of the use of null versus overt pronouns, and their performance did not diverge from the monolingual norm. A notable feature of their findings is that the use of overt pronouns was susceptible to L1 attrition after being exposed to the L2 environment for a relatively short period—5 years, compared to a minimum of 10 years in the Tsimpli et al. (2004) study. The short time-span during which optionalities emerge in bilingual speakers’ native grammar

2 Until recently, researchers generally use “10-year-stay in the L2 country” as a recruitment criterion for participants in L1 attrition studies (Gürel, 2004, p. 60). The tacit assumption was that L1 syntactic attrition took a long time and prolonged L2 immersion to manifest (if at all) (de Bot & Glyne, 1994, p. 27).
demonstrated the vulnerability of pronoun resolution to language attrition.

In terms of difficulties at integrating syntactic and discourse information, Dussias and colleagues found L1 attrition effects in relative-clause attachments among Spanish-English bilingual speakers, after they had been exposed to L2 English for an average of 3.7 years (Dussias, 2004; Dussias & Sagarra, 2007). Spanish and English speakers have different preferences when they attach a relative clause to a complex noun phrase (NP). For example, in the structurally ambiguous sentence “Someone shot the daughter of the actor who went to a private clinic” (Dussias, 2004, p. 358), English speakers would attach the relative clause to the local noun phrase “the actor” (i.e., low attachment), when Spanish speakers prefer attachment to the non-local NP “the daughter” (i.e., high attachment). Results from the eye-tracking study revealed that attriters switched to low attachment, the preferred option of monolingual English speakers, when they were parsing in their native language Spanish. After immersion in the L2 environment, they were “parsing a first language like a second” (Dussias, 2004, p. 355).

To summarize findings from these studies, it appears that integrating information from different domains, especially syntax-discourse and syntax-pragmatics, is a locus of difficulty for bilingual speakers. The selectivity of L1 attrition in some linguistic and cognitive domains is one of the problems that linguistics and psycholinguistic theories of language development attempt to answer. Before introducing theories regarding the acquisition and attrition of interface-conditioned linguistic properties, it is compulsory to discuss what is an interface and consequently what are the linguistic properties that fit within the interfaces.

1.1.1 Interface-conditioned linguistic properties

Within the generative framework, interfaces are where the core computational system (i.e., syntax in a broad sense) interacts with other domains, more specifically, the conceptional-intentional system and the articulatory-perceptual system, forming the syntax, logical form (LF) and phonetics form (PF) interfaces (Chomsky, 1995, 2007). Reinhart (2006) extended Chomsky’s original proposal by further dividing the conceptual-intentional system to three independent mental systems: concept, context and inference (Reinhart, 2006, see Figure 1.1).
In Reinhart’s proposal (2006), the basic requirement of the computational system is that it should enable the interface, thus mediating information among the independent mental systems (i.e., concept, context, inference and sensorimotor systems). In an optimally designed system, the bare minimum needed for syntactic convergence should be sufficient to satisfy the interface conditions. However, this is not always the case.

When the output of the computational system failed to meet an interface requirement, the need arises to apply an illicit (inefficient) operation to adjust a derivation to the interface needs and this process is called “reference-set computation” (Reinhart, 2006, p. 44). The reference-set consists of pairs of derivation and interpretation (i.e., \(d, i\)). A given \(d, i\) is blocked if the same interface could be obtained more economically— in other words, if there is a better \(d, i\) competitor in the reference set (Reinhart, 2006, p. 36). It has been repeatedly stressed in Reinhart (2006) that reference-set computation is invoked in very limited, special conditions, such as scope-shift, focus, and anaphora resolution. A common feature that these structures share is the competition among alternative derivations.

Considering that reference-set computation is a kind of repair mechanism, a ‘last resort’ strategy to make up for imperfections of the computational system, Reinhart (2006) argued that it should come with a cost; reference-set computation
Sentence processing in first language attrition imposes a greater load on working memory than local computation does, because the computation must be kept open until a global comparison of different derivations (which are constructed and held in the working memory) can be made. Reinhart (2006) also made clear predictions about the acquisition and learning of interface structures, arguing that the processing complexity can account for children’s guess performance in acquisition studies (see also Grodzinsky & Reinhart, 1993). The idea that overburdened learners will perform less efficiently in tasks where they must compare competing derivations is further developed by Sorace and colleagues in the Interface hypothesis, which I will discuss in details in Section 1.1.2.

More recently, interface structures have attracted a lot of attention in language acquisition and bilingualism research, and they are sometimes presented as the loci of difficulty for acquisition and retention. The term “interface” used in those situations deviates from its original definition as levels of representations (i.e., LF and PF), and is taken to be points of mapping between levels of representations (e.g., syntax-semantics or syntax-discourse interface). Taking Chomsky’s original proposal and the recent development of interface studies together (for a review of interface studies in bilingualism, see Montrul, 2011; White, 2011), a working definition of interface is “Interfaces describe the interaction and integration of information between the core computational system and other linguistic or non-linguistic cognitive domains”.

Figure 1.2: A working model of interfaces from White (2009)

The interactions and integrations across the linguistic modules are often referred to as ‘internal interfaces’, in contrast to the ‘external interfaces’ which refers to interactions between linguistic modules and other areas of general cognition (Sorace & Filiaci, 2006; Sorace & Serratrice, 2009; White, 2011). The distinction
between internal and external interfaces will be discussed further in Section 1.1.2. The synthesized model from White (2009) easily visualized the distinction between internal and external interfaces (Figure 1.2).

In the current thesis, I use syntax-pragmatics and syntax-discourse interface interchangeably, unless stated otherwise. However, it is worth noting that pragmatics is not only discourse and the two are very different constructs. One of the structures of interest, reflexive pronoun (see Chapter 3 for the study), should be more strictly categorized as a syntax-discourse structure, as it involves meaning computation based on information from the previous discourse context.

1.1.2 Interface Hypothesis and L1 attrition

When researchers try to capture developmental characteristics of bilingual speakers and learners, the influence from the other language, namely cross-linguistic influence (CLI), has been the centre of attention for a long time. The underlying reasoning is that, if a learner deviates from the monolingual norm, chances are the other language that co-exists in their language system plays a role.

In the field of child bilingual language development, Müller and Hulk (2001) was the first to propose that CLI is likely to occur under two conditions. First, two languages have a partial overlap of the same syntactic structure. For example, one language has two alternative forms, while the other language only has one. Second, processing said structure requires mapping pragmatic into syntactic principles. In other words, Müller and Hulk (2001) claimed that CLI takes place when two languages have different pragmatic realizations of the same syntactic structure, and the influence is unidirectional from the language that has more options or more relaxed rules to the language that has fewer options or stricter rules.

Müller and Hulk (2001) supported their account with object omissions among German-French bilingual children. German has the option to omit objects in specific contexts (2 options), while French does not (1 option). As a consequence, German-French bilingual children omit objects for a longer time than monolingual French children. That is to say, influence from L1 German causes a developmental delay in French (Müller & Hulk, 2001, p. 19). This account later received supports from other studies investigating language attrition at the syntax-pragmatics inter-
face, with different language combinations (Paradis & Navarro, 2003; Serratrice, Sorace, & Paoli, 2004; Sorace, Serratrice, Filiaci, & Baldo, 2009; Sorace & Serratrice, 2009).

Along the same vein but focusing on the adult bilingual development, the Interface Hypothesis also identifies the syntax-pragmatics and syntax-discourse interfaces as loci of difficulty in L1 attrition. First proposed to account for the residual optionality of end-state L2 acquisition (Sorace & Filiaci, 2006), it was later extended to account for the emerging optionality in bilingual first language acquisition (Sorace & Serratrice, 2009) and in L1 attrition among late bilingual speakers with near-native proficiency in their L2 (Sorace, 2011). The theory evolved from a dichotomy of “narrow syntax” and “interface” (Tsimpli et al., 2004; Sorace & Filiaci, 2006) to a more fine-grained distinction between “internal interfaces” (e.g., syntax-semantics interface) and “external interfaces” (e.g., syntax-discourse interface) (Tsimpli & Sorace, 2006; Sorace, 2011).

The current hypothesis postulates that structures that involve syntax and other cognitive domains, such as discourse and pragmatics, are more difficult to acquire fully in advanced L2 acquisition; they are also more vulnerable to early L1 attrition compared to structures without such interfaces. Furthermore, it argues that the effect of L1 attrition among late bilinguals does not involve the underlying knowledge, but rather the ability to integrate said knowledge in real-time processing. One of the reasons that “interface structures” behave differently from others, is that integrating information from different linguistic and cognitive domains is taxing on bilinguals’ cognitive resources which would otherwise be used to resolve competition from the non-target language (Green, 1998), leaving bilinguals performing inconsistently (Sorace, 2011, 2016). Interface Hypothesis attributes the selectivity in L1 attrition not only to the influence from the second language, but also to the computation complexity of interface structures and to the limited cognitive resources of overburdened speakers.

With regards to the prediction of vulnerability at the syntax-pragmatics and syntax-discourse interface, Interface Hypothesis received support from Italian-English bilinguals (Belletti, Bennati, & Sorace, 2007; Sorace & Filiaci, 2006), German-English bilinguals (Wilson, 2009; Wilson, Sorace, & Keller, 2009) and Greek-Spanish bilinguals (Lozano, 2006; Margaza & Bel, 2006) in the field of L2 acquisition; Italian-English and Greek-English bilinguals (Tsimpli et al., 2004), Spanish-English bilinguals...
guals (Chamorro, Sorace, & Sturt, 2015; Chamorro, Sturt, & Sorace, 2015), Turkish-English bilinguals (Gürel, 2004) as well as German-English bilinguals (Wilson, 2009) in the context of L1 attrition. Even though Interface Hypothesis was intended for near-native speakers in both L2 acquisition and L1 attrition (Sorace, 2011), it was also tested against other types of bilingual populations: heritage speakers (Cuza, 2013; Kaltsa et al., 2014; Montrul, 2004), and bilingual children (Serratrice et al., 2004; Serratrice, Sorace, & Filiaci, 2012; Sorace et al., 2009; Sorace & Serratrice, 2009). Meanwhile, the prediction that L1 attrition affects the ability to process interface structures but not the underlying knowledge was only tested in the Chamorro et al. (2015) study, to the best of my knowledge.

To sum up, L1 attrition selectively affects different domains and structures. Within the syntactic domain, it appears that structures that interface with pragmatics and discourse are more vulnerable to L1 attrition. Their vulnerability could be partly attributed to the amount of computing it requires to integrate syntactic rules and contextual information in real-time language use. In the bilingual mind where knowledge and information from both languages are simultaneously activated (see Chapter 2), tracking discourse information and rapidly integrating it with other linguistic knowledge is not an easy task.

### 1.1.3 Controversies of IH and alternative approaches

Among the studies testing against the Interface Hypothesis, there has been a tendency to treat interfaces in a sweeping, holistic manner, assuming that “external interfaces” are inherently problematic, while “internal interfaces” do not pose lasting challenges to language acquisition or retention. Some researchers cautioned against such across-the-board presumptions, rightfully arguing that interface structures should be examined in a case-by-case manner (see Rothman & Slabakova, 2011; White, 2011 for a review). Studies have shown that even structures pertaining to the same interface, for example, clitic doubling and overt pronouns at the syntax-discourse interface, do not necessarily behave alike (e.g., Ivanov, 2012; Valenzuela, 2006). In this section, I intend to address three important issues with the application and the testing of Interface Hypothesis.

First and foremost, it is not always easy to pinpoint what interfaces a specific structure implicates. Some syntax-discourse interface structures involve the
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semantics domain as well (for example, clitic doubling), and many syntax-semantic interface structures also taps onto the morphology domain (such as wh-expressions in wh-in situ languages). In Hopp (2007, 2010), he investigated scrambling in L2 German, which involves multiple interfaces such as syntax-morphology (case and word order), syntax-semantics (interpretive constraints on the scrambling of indefinites), and syntax-discourse (information structural conditions on scrambling). When multiple interfaces are involved, it becomes more difficult to localize the source of difficulties.

In her reply to commentaries, Sorace (2012) acknowledged the danger of circularity when accounting for difficulties pertaining to interface structures, and she agreed that we cannot let speakers’ behaviours decide what counts as an interface phenomenon. Instead of using interface as an explanatory device, Sorace suggested that we use interface to “capture different conditions on syntactic realization” (2012, p. 210). For example, if the syntactic computation of a certain structure is constrained by semantic conditions, this structure lies at the syntax-semantics interfaces (without excluding other interfaces that could also be involved). This updated proposal allows us to move away from neat dichotomies of ‘internal vs. external interfaces’ and to focus on computational complexity instead (for discussions of computational complexity, see Section 1.3). By doing so, the explanatory and predicative power of the hypothesis inevitably decreases. However, if we can, as Sorace (2012) suggested, determine a computational difficulty hierarchy of interface structures in highly-proficient bilinguals, ultimately we will have a stronger and more explanatory theory, as long as we are careful and very specific when describing interface structures and the relevant interfaces.

The Features Reassembly Hypothesis put forward by Lardiere (2008, 2009) provides an alternative approach to the Interface Hypothesis. Virtually any grammatical constructs can be characterized as assembling features into lexical items and determining the appropriate conditioning environment for their expressions. Unlike earlier theories on the variation of L2 acquisition, it rejects on-and-off switch-like notions of parameter-setting and focuses on reconfiguring features represented in the L1 to new reconfigurations on (possibly different types of) lexical items in the L2 (Lardiere, 2009, p. 175). If applied to the context of L1 attrition, the Features Reassembly Hypothesis could potentially account for more localized and subtle linguistic changes as often observed in L1 attrition among late bilinguals.
Secondly, syntax-pragmatics and syntax-discourse interfaces have been the centre of discussion in the Interface Hypothesis, with the concentration mainly being on syntactic and discourse properties of null subject languages (Sorace, 2011, 2016). Other structures pertaining to the syntax-pragmatics and syntax discourse interfaces and other external interfaces have been overlooked. As White (2011) accurately pointed out, it remains unclear whether syntax-pragmatics and syntax-discourse interface are inherently problematic or are the difficulties reported so far consequences of particular phenomena (from particular language pairs) which have been chosen for investigation (p. 580-81).

 Scalar implicatures, for example, can be categorized as semantic-pragmatics interface, since the interpretation of sentences with quantifiers like some and all goes beyond strict semantics and is subjected to conversational maxims (Grice, 1989). It has been shown that L2 learners have no problem computing the scalar implicatures with or without supporting contexts, providing evidence against the proposal that external interfaces are not completely acquirable and lead to lasting indeterminacy in L2 grammars (Slabakova, 2010; Snape & Hosoi, 2018).

 Thirdly, the discussion of internal interface structure has been limited to the syntax-semantics interface, while other internal interfaces such as semantics-morphology, phonology-morphology have been left out of the conversation. In fact, L2 learners often show variability in their production of inflectional morphology or functional words (see Slabakova, 2008, for a review).

 The Bottleneck Hypothesis proposed by Slabakova (2008, 2010) highlighted the difficulties of functional morphology in L2 acquisition and has been extended to L1 attrition to account for persistent challenges in the syntax-morphology or semantics-morphology interfaces (Slabakova, 2019). It is predicted on the generative linguistic notion that functional morphology are more difficult for L2 learners compared to syntax or semantics, not only because grammatical and semantic features are encoded and expressed through functional morphology, also because functional morphemes are the main loci of linguistic variation. Slabakova argued that grammatical and semantic meanings, such as TENSE, ASPECT, SPECIFICITY or DEFINITENESS, are universal in the sense that almost all languages have to express them in one way or another, but language differs in the ways those meanings are represented through functional morphology (2019, p. 37). In other words, acquiring new mappings between meanings and forms are what presents great challenge to
L2 learners, especially when their L1 differs in the ways those meanings and functions are realized. These predictions has been (partially) supported by Ribbert and Kuiken’s (2010) study of German infinitival complementizers among late L1 attriters and Montrul’s (2014) study in Spanish differential object markings among child and adult heritage speakers.

Despite the controversies of the Interface Hypothesis, it is a commendable attempt to capture the non-convergence in end-state L2 acquisition and early stages of L1 attrition. Additionally, the cognitive component in the latest version of Interface Hypothesis has encouraged interdisciplinary approaches in bilingualism research (for example Chamorro, Sorace, & Sturt, 2015). Research so far does suggest that incorporating information from different linguistics and cognitive domain can be particularly challenging for L2 learners and L1 attriters; however, those challenges are not insurmountable, nor are they limited to external interfaces.

1.2 Language exposure

In the last section, I discussed how L1 attrition selectively affects different linguistic domains and structures. Similarly, L1 attrition manifests itself differently among bilingual speakers: some bilinguals appear to be better at maintaining their native language than others, despite the similar age at onset of bilingualism. What are the characteristics that distinguish “good language maintainers” from others?

Recall that in both Chamorro et al. (2015) and Dussias & Sagarra (2007), the recency and the length of exposure played a role in L1 attrition. Re-exposure to L1 Spanish for a couple of weeks reversed the attrition effects of overt-pronouns (Chamorro, Sorace, & Sturt, 2013); and only Spanish-English bilinguals with extended exposure to L2 English (compared to those with limited L2 exposure) parsed relative clauses differently from the monolinguals (Dussias & Sagarra, 2007).

A large body of work focused on the amount of L1 use, and the length of residence in the migrant environment (LoR). Intuitively, less L1 use and longer LoR should be associated with more L1 attrition, as in “use it or lose it”. However, previous research on this matter yielded mixed findings: while some studies found that both the amount of L1 use and the length of residence (LoR) in the L2 environ-

In the de Bot, Gommans and Rossing (1991) study, 30 Dutch immigrants were tested for their L1 proficiency in terms of pronunciation, grammar, vocabulary, fluency, and comprehension. Participants were divided into two groups—many contacts versus few contacts, based on the number of Dutch contacts they have in daily life. Both groups included participants with various LoR ranging from 11 to 36+ years. Initial analysis showed significant effects for both contact and time, as well as a significant interaction between contact and time. However, further analysis revealed that time was only significant when there were few contacts. In other words, Dutch language proficiency decreased linearly through time only when speakers had few L1 contacts. Similar patterns were found in Soesman (1997) with Dutch immigrants in Israel.

The early findings with regards to the influence of language exposure on L1 attrition were not replicated in later studies, probably due to differences in methodology (i.e., methods to evaluate the amount of L1 use and to measure language proficiency) as well as limitations in statistical analyses (Köpke & Schmid, 2004; Schmid & Yılmaz, 2018). More importantly, language exposure does not work in isolation: it may interact with other sociolinguistic variables such as education level and language attitudes.

Schmid & Dusseldorp (2010) was the first large-scale, quantitative study that investigated a wide variety of sociolinguistic variables concerning L1 attrition. They collected information on a broad range of language exposure and use, using an extensive sociolinguistic questionnaire consisted of 76 questions. To measure the language proficiency, they used both controlled (i.e., a C-TEST, two verbal fluency tasks, and a grammaticality judgment task) and naturalistic tasks (i.e., a film-retelling task). Participants displayed attrition effects in their performance of C-TEST, verbal fluency tasks and the film-retelling task. However, the impact of language use on the degree of L1 attrition was minimal. The only variable that consistently predicted L1 proficiency was L1 professional use: participants who used L1 German at work were indistinguishable from native German speakers in all measures, except that they made more errors in free speech. In comparison, L1 use with family and friends had
Sentence processing in first language attrition. In terms of the role of LoR in L1 attrition, Schmid and Dusseldorp only found an impact of LoR on lexical diversities and errors of free speech: bilinguals’ lexical diversity diminished, and they made more errors in free speech when they lived in the L2 environment for a long time. The minimal impact of LoR was corroborated in de Leeuw et al. (2010), Hopp & Schmid (2013) and Schmid & Javis (2014).

Another notable find from Schmid & Dusseldorp (2010) was that principal component analysis (PCA) revealed clear distinctions of L1 use according to language modes (Grosjean, 2001): items pertaining to the bilingual and intermediate mode of language use were grouped separately and had different loadings on the L1 proficiency measured by controlled and naturalistic tasks. The results provided empirical evidence for the bilinguals’ language modes (Grosjean, 2001; Schmid, 2007).

![Figure 1.3: Types of bilingual language use (Schmid, 2007: Fig 2)](image)

Different language modes entail distinct levels of activation of the L1 and the L2. Schmid extended the language mode continuum proposed by Grosjean (2001) and established 5 types of everyday language use for bilingual speakers in the attrition context ((Schmid, 2007; see Figure 1.3)). Type I and Type V are monolingual language modes in either the L1 or the L2; potential attriters would find themselves in monolingual modes when they visit the home country (Type I), or when they converse with monolingual speakers in their L2 (Type V). Type III is the bilingual...
mode, which refers to informal language use among bilingual speakers, usually with family and friends, when code-switching and code-mixing are allowed. Type II and Type IV are intermediate language modes, where both language are active to some degree, but one of them (L1 in Type II and L2 in Type IV) is used predominantly; code-mixing is discouraged if not forbidden in those contexts. Schmid claimed that potential attriters would experience more inhibition in their L2 in Type II intermediate mode. Relating to the result that more L1 professional use (Type II) predicted a higher L1 proficiency, the authors argued that the ability to inhibit L2 is crucial for maintaining L1 proficiency in the L2 environment. The protective effect of L1 use in professional settings was also found in de Leeuw et al. (2010) and Schmid & Javis (2014) (cf. Schmid & Yılmaz, 2018).

In short, results from Schmid & Dusseldorp (2010) and others highlighted the significance of the context of language use. In comparison, the amount of language use in general and the length of residence alone did not have much impact on L1 proficiency; both variables are confounded with many other influential factors (e.g., age, education level, language attitudes), and they shouldn’t be investigated separately. It’s worth noting that participants from most of these studies had lived in the L2 environment well above a decade (see also Ammerlaan, 1996; de Bot & Glyne, 1994; Gürel, 2002). It has been proposed that most of the language development happened within the first decade after migration (de Bot & Glyne, 1994; Hopp & Schmid, 2013), which can potentially account for the minimal impact of LoR in those studies. It remains a possibility that LoR plays a role within the first decade before L1 attrition is “fossilized”; further investigation on this matter is still needed.

In summary, the role of language exposure in L1 attrition is more complicated than had been predicted previously. Under the “umbrella term” of language use is a collective of inter-related factors waiting to be disentangled: frequency, recency, length of residence and more importantly, the contexts of language use. Future research should take a more fine-grained approach and measure language exposure from different aspects in order to capture the full picture.
1.3 Cognitive load

From discussions in Section 1.1 and 1.2, we see that L1 syntactic attrition is a selective and subtle process, especially among late bilingual speakers whose onset of bilingualism occurs after puberty. It is unlikely for them to completely “lose” or “forget” the L1 grammars which have already been established and entrenched during early adolescence. Instead, they appear to be less efficient in accessing or integrating information from different domains in real-time language use. And during real-time language use, processing factors such as cognitive load can affect the outcome.

I define cognitive load as the amount of computation required to process various linguistic structures and to achieve communication goals. It depends not only on the computational complexity of the linguistic structure under investigation but also on the nature of the current task (e.g., comprehension vs. production tasks, audio vs. visual modalities). When the cognitive load exceeds the cognitive resources allocated for the current task, processing breakdown may happen. For bilingual speakers affected by L1 attrition, it is particularly crucial to monitor cognitive load for two reasons: decreased L1 activation (see Chapter 3 Section 1.1) and increased cognitive demands in maintaining two languages (Bialystok, 2009, see Section 3.1 for further discussions).

In the bilingual mind, both languages are simultaneously activated and interact with each other in lexical access and sentence processing (see Kroll et al., 2012, for a review). Compared to their monolingual peers, bilingual speakers have additional needs to keep the two languages separate and to minimize interferences from the unwanted language. This ability is called bilingual language control (bLC, Calabria, Hernández, Branzi, & Costa, 2012). The exact nature of the cognitive mechanisms involved in bilingual processing remains controversial. Nevertheless, it has been suggested that bLC overlaps with the domain-general executive functions, and their share some of the neural networks (see Chapter 3 Section 3.1). Assuming that language processing partially draws on the same pool of cognitive resources used for bLC, this creates a competition (Green, 1986). The competition for resources may underly the divergence and the inconsistency in bilingual language performance, especially when processing demands are high (for instance, in production tasks, or in dual-tasks settings). In other words, we are more likely to observe L1 attrition effects when bilingual speakers’ processors are overloaded with complex structures.
or demanding tasks (see also Sorace, 2011, 2016).

Some structures are more cognitively demanding than others. In Section 1.1, I discussed the vulnerability of syntax-discourse and syntax-pragmatic interface structures in L1 attrition, which could be partly attributed to the amount of computation required to integrate syntactic rules and contextual information as it unfolds in real-time (Sorace, 2011, 2016). For example, pronoun resolution requires rapid retrieval and integration of syntactic and discourse information, while excluding inappropriate pronoun-antecedent mappings based on syntactic, semantic constraints and perspective information (Brown-Schmidt, 2009).

Studies showed that even monolingual speakers sometimes struggle with syntax-discourse interface structures, such as pronoun resolution. Hendriks and colleagues found that both children and elderly adults were less efficient than young adults in pronoun resolution (Hendriks, Koster, & Hoeks, 2014). They investigated the production of reflexive pronouns at different discourse positions (introducing, maintaining, and re-introducing the referent) and the comprehension of reflexives in sentences with or without topic-shifts. Results showed that compared to young adults, who were highly sensitive to the informational needs of hypothetical conversation partners in both production and comprehension, children and elderly adults performed inconsistently. Children failed to consider the other person’s perspective in both tasks: they tended to produce ambiguous pronouns that were unrecoverable by listeners; they were also insensitive to topic-shift markers made by speakers. Elderly adults, on the other hand, considered the perspective of hypothetical conversation partners in both tasks, but they produced many more full NPs than necessary, which showed they lacked the cognitive capacity to keep track of the discourse prominence of referents. The authors concluded that referential choice depends on perspective-taking abilities as well as cognitive capacities, both of which fluctuate across the lifespan.

Along the similar vein but with a focus on working memory capacity (measured by the reading span task), Nieuwland and Van Berkum (2006) conducted an EEG/ERP study to measure the response to referential ambiguities among participants with varying working memory capacities. They found that readers with high reading span scores were more sensitive to referential ambiguity than the low-span group. The result suggested that working memory is taxed by referential ambiguities.
To investigate the role of domain-general executive functions during bilingual language processing, Linck and colleagues (2008) examined the consequences of individual differences in inhibitory control and working memory capacities for language processing tasks. Highly proficient bilinguals performed a picture-naming task with cognates and non-cognates; their inhibitory control was measured by the Simon task, and their working memory was measured by the operation span task (Study 2, Linck et al., 2008). Results showed that 15.8% and 3.1% the magnitude of variances in cognate facilitation was accounted for by the Simon effect ($F(1, 58) = 10.89, p < .01$) and by operation span scores $F(1, 58) = 1.85, p > .10$), respectively. Cognate facilitation signals activation of the non-target language during target-language processing. On the one hand, the significant correlation between the Simon effect and the cognate effect indicated that bilinguals’ inhibitory control affects their linguistic performance by modulating the activation level of the non-target language. On the other hand, working memory resources did not show a reliable correlation to the cross-language activation among highly proficient bilinguals (cf. Linck, Osthus, Koeth, & Bunting, 2014).

Apart from the individual difference approach in Linck et al. (Linck et al., 2008), extra-load or dual-task conditions are alternative approaches to evaluate the effect of cognitive factors during language processing. Kilborn (1992) tested the word recognition performance of advanced non-native of and native speakers of English. The native speakers were given the same auditory stimuli except under “noisy conditions” (a partial auditory mask). The non-native and the L1-under-noise performance showed striking similarity, which indicates that the performance differences between native and advanced non-native speakers can be (partially) accounted for in terms of cognitive factors affecting temporal integration of different types of information during the online comprehension.

In the context of L1 attrition, Wilson (2009, Experiment 9) used a dual-task visual-world paradigm to investigate the effect of processing load on pronoun resolution among German-English bilingual speakers (who were probably undergoing L1 attrition). In the extra-load condition, participants completed two-alternative forced-choice questions after reading sentences with personal pronouns; at the same time, they retained a list of digits in the working memory for later recall. Participants’ eye-tracking data and antecedent preferences were recorded and compared to the no-load condition. Results showed that additional processing load significantly
affected bilinguals’ pronoun resolutions, especially for those with average to high levels of L1 use and average to high levels of length of residence (LoR) in the L2 environment. They showed a very dramatic post-verbal object (NP2) to pre-verbal object (NP1) switch, with a strong initial preference for NP2 followed by a very strong preference for NP1. The fact that the processing load factor interacts with other factors, such as LoR and language use, highlights the significance of processing load when investigating language change phenomena like the L1 attrition.

Another notable finding in Wilson (2009, Experiment 9) is that anaphoric demonstratives were not as sensitive to the processing load as anaphoric pronouns. The author accounted for the difference with the Form-specific Multiple Constraint Approach (Kaiser & Trueswell, 2008), which claimed that different types of anaphors are sensitive to different types of constraints. Wilson argued that pronouns formed a syntactic dependency (which is also regulated by discourse constraints) with their antecedents. A syntactic dependency is especially vulnerable to resource limitation because “if the parser is unable to form the syntactic dependency, there would be a catastrophic processing failure” (Wilson, 2009, p. 209). Forming syntactic dependency requires speakers to retain possible antecedents in the working memory while considering both representations before integrating the felicitous candidate in the current structure. Thus, the ability to do so would be compromised under extra processing load.

So far, I discussed the influence of cognitive load on bilingual language processing, especially that involves complex structures and demanding tasks. However, the relationship between cognitive factors and language processing is not a one-way street: bilingual speakers may become adept to the sustained demands of controlling activation levels of the two languages, thus altering the way they recruit and allocate cognitive resources to accommodate their communication needs (Abutalebi & Green, 2008; Green & Abutalebi, 2013). Chapter 3 will further explore the bi-directional interaction between bilingual speakers’ language use and their cognitive functions.
1.4 Interim summary

In this Chapter, I demonstrated that L1 attrition is a highly selective, role-governed process, where influential factors, such as linguistic properties, language exposure, and cognitive load, contribute to the change in the L1 system. The interplay among those factors determines when (i.e., task demands) and where (i.e., linguistic structures) we can detect attrition effects, and among which group of bilinguals (i.e., language experience).

In the next chapter, I take a step back and discuss the parallel-activation of the two languages among bilingual speakers, which is one of the most important characters that set bilinguals apart from their monolingual peers. Investigating the organization and control of two languages in the bilingual mind is essential to understanding the mechanisms of language change.
Chapter 2

Language co-activation and processing

In the previous chapter, I reviewed key literature on first language attrition among late bilingual speakers. I also discussed the effect of language properties, experience, and cognitive load on the attrition process. In this chapter, I take a step back and focus on the phenomenon of language co-activation, that is the activation of the non-target language when communicating in the target language. It is believed that pervasive parallel activation of the bilinguals’ two languages is a primary mechanism contributing to language change (Kroll et al., 2015, p. 381).

First, I briefly review relevant computational models on bilingual lexical access (Section 2.1); which, despite their different structures and focuses, agree that bilingual word recognition is primarily a language non-selective process. I then move to reviewing research on language co-activation during bilingual sentence processing (Section 2.2), which extended the language non-selective access from lexical processing to syntactic processing. The main purpose of this chapter is to demonstrate the openness between bilinguals’ two language systems not only at the lexical level but also at the sentence level.

2.1 Bilingual lexical access

There is little argument that lexical representations of bilinguals’ two languages are intimately linked. When bilingual speakers are presented with words in either of their languages, words from the other language that share the semantic, phonological or orthographic features are inevitably activated as well (see Dijkstra, 2005, for a
review). Furthermore, when reading sentences where contextual information (e.g., semantic constraints) are provided to bias the selection in one specific language, the other language receives activation nevertheless (see Lauro & Schwartz, 2017, for a review). Even during word production, where speakers should have more anatomy than word recognition, parallel activation still exists in the non-target language (Costa, 2005; Kroll & Gollan, 2015). The crucial question is no longer whether the non-target language is activated during bilingual language processing, rather when and how the non-target language gets activated, and what does the pattern of language co-activation tell us about the organization of the two languages in the bilingual mind.

This section discusses the structures of and the empirical evidence for computational models of bilingual lexical access, which can be divided into two types: localist and distributed models. Localist models assign discrete identities and functions to individual units, while distributed models start with randomized connections and go through training to learn the relevant mappings. Consequently, localist models have been used to investigate features of stable word recognition systems often seen among adult bilinguals; distributed models tend to focus on experience-driven change, and are usually used to explain issues concerning language development (acquisition or attrition) (Thomas & van Heuven, 2005, p. 204). This section will focus only on localist models, because they are relatively comprehensible and have been widely applied to the bilingualism research. That notwithstanding, distributed models are not any less applicable to bilingualism; in fact, ultimately characteristics of the two types of models should be combined “to reflect different different stages of bilingual development as well as processing in the adult state” (Thomas & van Heuven, 2005, p. 205).

2.1.1 Bilingual Interactive Activation Model (BIA)

To account for the orthographic processing in visual word recognition, Dijkstra and colleagues established the Bilingual Interactive Activation (BIA) model (Dijkstra & van Heuven, 1998; Dijkstra, van Heuven, & Grainger, 1998), building on the monolingual, Interactive Activation model (McClelland & Rumelhart, 1981). The structure of the BIA model is depicted in Figure 2.1 (Dijkstra & van Heuven, 2002, p. 177).
The BIA model consists of four levels of linguistic representations: letter features, letter, word, and language nodes. In the process of word recognition, activation flows in a bottom-up manner through four levels. Letter features are activated first. The activation then spreads to the letter level, where letter features activate each letter they are part of on each position of the presented word. Since the model implements language non-selective access and an integrated lexicon, these activated letters activate words they are part of in either language. Afterwards, the activated words activate their corresponding language nodes, which can exert top-down inhibition to word candidates that belong to the other language (cf. Dijkstra & van Heuven, 2002, for a different assumption about the top-down inhibition). Meanwhile, word candidates feed activation back to the letter level. There is also
lateral inhibition where word candidates and letters inhibit the activation of other word candidates and letters, respectively. Lateral inhibition is not limited to one language. Finally, through several cycles of activation and inhibition (both top-down and lateral inhibition), the target word becomes activated the most, and it is recognized when it surpasses the recognition threshold. The resting level activation reflects the frequency and recency of language activation, and language proficiency (Dijkstra & van Heuven, 1998; Dijkstra, 2005).

The BIA model made three theoretical assumptions regarding bilingual lexical access: parallel activation, lateral inhibition and top-down inhibition from the language node. Parallel activation and lateral inhibition jointly predict that lexical access in one language is likely to be affected by the presence of the other language. This prediction has been tested and supported by a series of studies using cognates, interlingual homographs, and orthographic neighbors (see Dijkstra, 2005, for a review). Cognates are words from two languages that are identical in orthographic form and largely overlap in meaning. Interlingual homographs, or false friends, are words from two languages that are identical in orthographic form but differ in meaning (and phonology, in most cases). Orthographic neighbors are words that differ in a single letter in terms of length and letter position, such as *pit* and *pig*. If bilingual lexical access is language non-selective in nature, then the semantic or orthographic overlap in cognates, interlingual homographs and orthographic neighbors would lead to different activation level and retrieval speed compared to their matched controls; otherwise, it would not be affected.

Cognates and interlingual homographs showed different processing patterns, depending on language intermixing and task demands. In an exclusive English lexical decision task with Dutch-English bilinguals, Dijkstra, van Jaarsveld, & Ten Brinkle (1998, Experiment 1) found a significant facilitation effect with cognates compared to noncognate controls. They attributed the faster decision time of cognates to joint activation of semantic readings from both languages; that is, semantic readings in Dutch was activated although no Dutch words were presented in the stimuli, which supports language non-selective access. The facilitation effect of cognates was later extended to nonidentical cognates (e.g., *baker* and *bakker*) in the van Hell and Dijkstra (2002) study; they found faster lexical decision time for both Dutch-English and Dutch-French cognates for Dutch-English-French trilinguals with high French proficiency. On the other hand, interlingual homographs did not show
any cross-language effect, which appeared to contradict the language non-selective account.

To understand the contradictory results between cognates and homographs, Dijkstra and colleagues adjusted the stimuli list composition in Experiment 2. Dutch fillers were added to the stimuli list, and participants were instructed to answer “yes” to English words, and “no” to Dutch fillers and nonwords. Results showed strong inhibition effect with interlingual homographs. The authors argued that due to presence of the Dutch fillers, participants found it more difficult to suppress the Dutch readings, which significantly slowed down the English readings of the homographs. Moreover, the inhibition effect was directly affected by the frequency of the Dutch reading: when the homograph has a high frequency in Dutch but a low frequency in English, the inhibition effect was the largest. These results were later replicated in the go/no-go paradigm in Dijkstra, Timmermans and Schriefers (2000), where participants would overlook interlingual homographs in lexical decisions when the non-target language reading of the homograph has higher frequency than the target language reading.

Building on the results of Experiment 2, Dijkstra and colleagues changed from an specific lexical decision to a general lexical decision task, where participants responded “yes” to either Dutch or English words, and “no” to nonwords. The authors predicted that if bilinguals cannot ignore the non-target language reading of an interlingual homograph, then a general lexical decision task would show a different pattern because participants can react as soon as reading from either language becomes available for the interlingual homograph. The results confirmed their prediction: a strong facilitation effect was found in Dutch-English homographs compared to monolingual English controls. It appears that participants did react to the first available reading in either language because there was also an effect of word frequency: the Dutch high-frequency English low-frequency homographs that suffered the most inhibition in Experiment 2 received the most facilitation in this experiment.

Different results in Experiment 1 and Experiment 2 regarding homographs indicated that bilinguals are sensitive to language context, and can somehow adjust the overall level of activation based on the presence or absence of other languages. It also indicated that bilingual lexical access is language non-selective (at least at the initial stage) because the instruction to respond “no” to Dutch words was in-
sufficient to inhibit Dutch readings completely in Experiment 2. In addition, due to the presence of Dutch fillers, the non-target Dutch language node was more active (compared to Experiment 1) and can exert inhibition to word candidates from the target language English, especially when the Dutch reading of the homograph was highly-frequent. Furthermore, results from Experiment 3 suggested that bilinguals are sensitive and adaptive to task demands, as they were able to exploit the non-selective nature of a general lexical decision task and speed up their decision based on either reading of the homograph rather than just one. Consequently, the authors proposed an extension to the original BIA model with an decision mechanism, so that the processing model can be made context-sensitive (Dijkstra, van Jaarsveld, & Ten Brinke, 1998, p. 64).

Dijkstra, Grainger, and van Heuven (1999) provided an alternative explanation for the null results with interlingual homographs in Dijkstra, van Jaarsveld et al. (1998, Experiment 1). They asked Dutch-English bilinguals to perform a progressive demasking task and a visual lexical decision task with English words that varied in their degree of orthographic (O), semantic (S) and phonological (P) overlap with Dutch words. Both tasks showed that lexical decision was facilitated by orthographic and semantic overlap, but inhibited by phonological overlap. Since Dutch-English homographs mostly consist of O and OP items, the null effect obtained in the previous experiment (Dijkstra, van Jaarsveld, & Ten Brinke, 1998, Experiment 1) may have been caused by a mixing of two types of items, leading to a cancellation of orthographic facilitation effects by phonological inhibition effects. The results also suggested that phonology, in addition to the semantic meaning and orthographic form, plays a role during visual word recognition. Bilingual lexical processing system is highly interactive: similarities in all three dimensions affected the reactions of Dutch-English bilinguals in an exclusive English task context. Based on these results, Dijkstra and colleagues suggested a further extension to the BIA model to address distinct contributions of different codes (e.g., phonological and orthographic codes) to bilingual word recognition (Dijkstra et al., 1999, p. 511).

Before moving on to the BIA+ model, which incorporates a decision mechanism and added semantic and phonological lexical representations to the available orthographic ones, I want to address another study that supported the language non-selective access using neighborhood density effects. As mentioned above, orthographic neighbors are words that differ in a single letter in terms of length and letter
position, and previous monolingual studies showed that target word identification is sensitive to the number and the frequency of such neighbors. Through a series of progressive demasking and lexical decision tasks with Dutch-English bilinguals, van Heuven and colleagues found that orthographic neighbors in the non-target language affected word recognition in the target language, and the magnitude of the effect was influenced by task demands, stimuli list composition, and second language proficiency. By manipulating the number of orthographic neighbors in the target and non-target languages, they found that reaction latencies to English target words systematically increased as the number of Dutch orthographic neighbors increased. The authors also tested monolingual English speakers with the same stimuli, and their performance was not affected by the number of Dutch neighbor words (van Heuven & Dijkstra, 1998). These results provided strong support for language non-selective access and an integrated lexicon.

2.1.2 The BIA+ model for bilingual word recognition

From the discussions in Section 2.1.1, we can see that bilingual lexical access is language non-selective in nature, but it can be affected by context information such as stimuli list composition and task demands (Dijkstra, van Jaarsveld, & Ten Brinke, 1998). In addition to orthographic similarities, semantic and phonological overlap also influence the visual word recognition (Dijkstra et al., 1999). On the other hand, participant expectations and instructions do not affect the activation levels of the two languages (Dijkstra, van Jaarsveld, & Ten Brinke, 1998; Dijkstra et al., 2000).

In the original BIA model, there are no phonological or semantic representations, and there is a limited account of how linguistic (e.g., semantic and syntactic constraints) and nonlinguistic context (e.g., instructions and task demands) can affect bilingual word recognition (Dijkstra & van Heuven, 2002, p. 181). These limitations greatly affect the model’s capacity to account for bilingual word recognition in different contexts. Consequently, Dijkstra and van Heuven proposed the BIA+ model, which is depicted in Figure 2.2.

According to the BIA+ model, once sublexical and lexical orthographic representations become active, they spread the activation to associated phonological and semantic representations. The activated word candidates from either language also send activations to corresponding language nodes; however, in contrast to the
Figure 2.2: The BIA+ model for bilingual word recognition. Arrows indicate activation flows between representational pools. Inhibitory connections within pools are omitted. Language nodes could instead be attached to lemma representations between word form and meaning representations. Non-linguistic context only affects the task schema level.

original BIA model, there is no feedback from the language node to word candidates, indicating a minimal influence of language membership on word recognition. Another distinctive feature of the BIA+ model is a separate task/decision system from the word identification system. The task/decision system handles the output of the word identification system to complete the task at hand, for example, lexical decision. The model also makes a distinction between linguistic context, which arises from lexical, syntactic or semantic resources, and nonlinguistic contexts, such as instructions, task demands and participant expectations (see Task schema in Figure 2.2). It is assumed that linguistic context can directly interact with the word identification process. In contrast, nonlinguistic context can only affect the task/decision system.
On one hand, results from Dijkstra, van Jaarsveld and Brinkle (1998) indicated that participants were sensitive and adaptive to stimuli list composition and different task demands; results from Dijkstra, Timmermans and Schriefers (2000, Experiment 2, 3), on the other hand, showed that instructions and task demands do not directly attenuate the activation of non-target language during word recognition. Using the same set of stimuli consisting of Dutch-English homographs, Dutch controls and English controls, strikingly similar patterns were obtained in the English go/no-go task (Experiment 2) and the Dutch go/no-go task (Experiment 3). Despite the different instructions and task demands (in the English go/no-go task, participants only react when presented with an English word, and vice versa in the Dutch go/no-go task), significantly slower reaction latencies and higher error rates were observed with interlingual homographs. Moreover, response latencies were dependent on the relative frequency of their readings in the non-target language. In some cases, recognition of the non-target reading even “blocked” the target reading, suggesting language non-selective access and minimal impact of nonlinguistic context.

In terms of the influence of linguistic contexts, evidence supporting the BIA+ model primarily came from word recognition studies in the sentence context. Lexical processing in real-life settings rarely takes the form of isolated word lists, so it is essential to find out whether sentence contexts provides sufficient information to confine activation to the target language. Empirical studies on bilingual lexical access in sentence context also supported the prediction regarding linguistic context effects by the BIA+ model.

Converging evidence indicates that sentence context do not completely “turn off” activation of the non-target language, as participants still experience substantial cross-language effects (e.g., cognate facilitation) in low-constraint sentences (see Lauro & Schwartz, 2017, for a review). In high-constraint sentences, however, activation of the non-target language appear to be attenuated significantly in some studies (Schwartz & Kroll, 2006; Duyck, Van Assche, Drieghe, & Hartsuiker, 2007; Van Assche, Duyck, Hartsuiker, & Diependaele, 2009; Van Assche, Drieghe, Duyck, Welvaert, & Hartsuiker, 2011). Meanwhile, studies found an early cognate facilitation effect even in high-constraint sentences, which was later overridden by top-down semantic factors (Libben & Titone, 2009; Titone, Libben, Mercier, Whitford, & Pivneva, 2011). It is noteworthy that the cognate facilitation effect was observed
in L2 processing and L1 processing (see Schwartz & Van Hell, 2012 for a review), indicating a bidirectional, cross-language effect during bilingual word recognition in sentence context.

As for the word-recognition system, the inclusion of semantic and phonological representations was supported by studies of same-script languages such as French-English (Jared & Kroll, 2001) and Dutch-English (Dijkstra et al., 1999), as well as studies of different-script languages such as Japanese-English (Hoshino & Kroll, 2008) and Chinese-English (Thierry & Wu, 2007). It appears that bilingual word recognition is a highly interactive and dynamic process, where semantic and phonological information from both languages would affect the processing outcome.

The computational models discussed so far have focused on lexical access in the written modality, while speech perception takes up a larger portion of bilinguals’ daily communication. Before I move on to discussing language co-activation at the sentence level, I will introduce a bilingual lexical access model that handles acoustic rather than visual input.

### 2.1.3 Bilingual Model of Lexical Access (BIMOLA)

Grosjean and colleague developed the bilingual speech recognition and processing model to fill two gaps in the literature. The first is the focus on written language rather than spoken language, which arguably takes up most bilingual language use; the second is the lack of attention to code-switching and code-mixing contexts, where both languages are used in the same conversation. Similar to the BIA and BIA+ model discussed above (Section 2.1.1 and 2.1.2), the Bilingual Model of Lexical Access (here and after, BIMOLA) is also a bilingual extension on the Interactive Activation model (McClelland & Rumelhart, 1981). Grosjean and colleagues argued that a bilingual language processing model should explain how bilinguals process both monolingual and bilingual utterances. It should also account for speech recognition in various language modes (for details of language modes see Chapter 1, Section 1.2), which is critical since mixed language perception and production are frequent for bilingual speakers.

First proposed in Grosjean (1988), BIMOLA consists of three layers of representations: features, phonemes, and words, as depicted in Figure 2.3. The feature-
level nodes are shared between two languages, while nodes in both the phoneme and the word level are organized independently in their language subsets (in contrast to the integrated lexicon in BIA and BIA+ model). Furthermore, the two language subsets form one large system, which allows cross-language interactions during speech recognition. Besides, language units on the phoneme and the word level can have close and distant neighbours within a language and between languages, depicted by spatial proximity and darkness of the units correspondingly. Darker units have more neighbours in the other language. At the word level, word frequency is represented by the size of the units. Also, the more frequent the word, the higher the pre-activation it receives (Grosjean, 1997; Léwy & Grosjean, 2008).

Figure 2.3: The Bilingual Model of Lexical Access (BIMOLA) model (Grosjean, 1997; Léwy & Grosjean, 2008. A model of bilingual speech perception)

The BIMOLA model allows for both bottom-up and top-down spreading
activation between different levels. When encountering acoustic waves, activation spreads from the feature level to the phoneme level, where features activate phoneme candidates that contain those features in both languages (language non-selective access). These mechanisms can account for the unit similarity effect found in bilingual speech recognition \cite{Grosjean1988}. Between the phoneme and the word levels, activation flows bidirectionally: not only can phonemes activate words, word candidate feed activation back to the phoneme level. In contrast to the BIA and BIA+ model, BIMOLA does not have language nodes. Instead, information about base language, language mode and other higher linguistic-level information, such as semantic and syntactic constraints, would adjust the language activation level globally and supply top-down pre-activation to the word level. For example, if a speaker is in the monolingual mode where language A is spoken, words in the language A subset would receive significantly more pre-activation than those in the language B subset \cite{Grosjean1997, LéwyGrosjean2008}. The top-down pre-activation, combined with bottom-up activation, is responsible for the base-language effect found in Grosjean \cite{Grosjean1988}.

Meanwhile, there are two types of within-level activation: subset activation and phonotactic activation. Subset activation functions on both the phoneme and the word level, and it boosts activation level within the language subset. Take English-French bilinguals as an example. If an English word is activated as a possible candidate for speech recognition, the activation spread through the English language subset, raising all English words’ activation level. Phonotactic activation is present on the phoneme level only and is based on “distributional properties of word-initial segments” \cite[LéwyGrosjean2008, p. 204]{LéwyGrosjean2008}. For instance, English favours consonant clusters more than French; so acoustic input with consonant clusters would more strongly activate the English language subset. This is also called the language phonotactic effect \cite{Grosjean1988}.

In addition to the excitation mechanisms, the BIMOLA model also has build-in inhibition mechanisms that only functions within-level. Recall that both phonemes and words have close or distant neighbours within and across languages. Grosjean and colleagues predicted that, in the bilingual mode, guest words that have close neighbours in the base language would be more challenging to process compared to those without; they call it the base-language homophone effect. In a gating study \cite{Grosjean1988}, Grosjean studied the impact of interlanguage neighbour density
on speech recognition. Participants were asked to process French sentences with English guest words, and their performance indicated that guest words that had close neighbours in the base language were more difficult to process than other guest words. The inhibitory effect of phonological overlap in speech recognition echoed with the finding of Dijkstra, Grainger and van Heuven (1999) in written words recognition. Grosjean (1988) also found that the frequency of base-language homophone affects the speed and accuracy of guest-word recognition: homophones that are more frequent in the base language than in the guest language are more difficult to recognise. This phenomenon is called the cross-language homophones frequency pull effect.

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<th>BIMOLA (Grosjean 1997; Léwy &amp; Grosjean 2008)</th>
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<td>• Separated lexicons, phonemes and words only compete within a language</td>
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<td>• Allows top-down pre-activation from higher-linguistic information</td>
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<td>• Resting activation level of words reflects language mode and frequency</td>
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<td>• Language mode is continuous and sensitive to many factors</td>
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<td>• Stimuli list composition affects language activation state</td>
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<td>• Participant expectations affect language activation state through top-down pre-activation</td>
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<td>• Identification and decision levels interact</td>
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<th>BIA (Dijkstra &amp; van Heuven 1998)</th>
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<td>• Integrated lexicon, activated words inhibit other words from both languages</td>
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<td>• Allows top-down inhibition from language nodes</td>
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<td>• Stimuli list composition affects language activation state</td>
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<td>• Participant expectations do not exert strong effects on the activation state of words</td>
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<td>• Resting activation level reflects frequency and proficiency</td>
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<tr>
<td>• Stimuli list composition affects language activation state</td>
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<tr>
<td>• Participant expectations may affect task/decision system</td>
</tr>
<tr>
<td>• Distinction between linguistic and non-linguistic context information. Linguistic information can affect language activation state, but non-linguistic context information only affects task/decision system</td>
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**Table 2.1:** Characteristics of current bilingual word recognition models, modified from Dijkstra (2005, p. 188)

The BIMOLA model differs from BIA and BIA+ models in several ways.
Sentence processing in first language attrition

(see Table 2.1). First, BIMOLA does not have language nodes. Instead, it uses language modes to adjust language (pre)activation states globally. Second, BIMOLA has different predictions regarding participant expectations from BIA and BIA+. Third, BIMOLA assumes separated lexicons while BIA and BIA+ assume integrated ones. However, the language subsets in BIMOLA form one large system that allows interaction between languages.

In sum, bilingual word recognition appears to be primarily language non-selective, automatic (i.e., not under the control of the reader), and– although task-dependent and context-sensitive– its first processing stages might remain unaffected by nonlinguistic contextual factors (Dijkstra, 2005, p. 180).

2.2 Sentence processing

In the last section, I reviewed studies of language co-activation at the lexical level. The consensus is that lexical representations of bilinguals’ two languages are not accessed separately; similarities in phonological, semantic and orthographic features can trigger activation of one language when processing words in the other language (Section 2.1). However, retrieving words from the mental lexicon is only the first step; the second step involves putting words in a sentence structure that conforms to the grammatical rules. This section reviews studies investigating whether language non-selective access extends to the syntactic domain; specially, whether syntactic representations in the non-target language are activated during bilingual sentence processing. The primary purpose is to understand the organisation of two grammatical systems in the bilingual mind.

One way to test whether syntactic information is shared between bilinguals’ two languages is through cross-linguistic syntactic priming. Syntactic priming describes how processing a particular grammatical form affects the subsequent processing of said grammatical form (Hartsuiker, Pickering, & Veltkamp, 2004, p. 410). If syntactic processing in one language is influenced by the presence of a similar structure in the other language, i.e., cross-linguistic priming, it is consistent with the shared-syntax account. In their 2004 study, Hartsuiker and colleagues asked Spanish-English speakers to describe cards to their confederates in a dialogue. Both the participants and the confederates were native Spanish speakers with moderate or
high English proficiency. The prime stimuli consisted of four sentence types: active, passive, active with OVS (object-verb-subject) word order and intransitive; with intransitive sentences functioning as the baseline for comparison. Results showed that participants produced more English passive sentences following Spanish passives than Spanish intransitive or active sentences. The authors interpreted these findings as evidence for the shared-syntax account, because the separate-syntax account predicts no cross-linguistic priming. They also addressed the asymmetry of priming, i.e., no significant priming effects with active sentences, by arguing that intransitives have active morphology and could serve as a prime of actives vs. passives (Hartsuiker et al., 2004, p. 412).

Figure 2.4: Example of lexical entries for “to chase” and “to hit” in an integrated (shared lexicon, shared syntax) account of bilingual lexical representation (Hartsuiker et al., 2004)

Moreover, Hartsuiker and colleagues extended the monolingual, lexical-driven production model by Pickering and Branigan (1998, see Figure 2.4) by adding the language nodes (Dijkstra & van Heuven, 1998, 2002). The model assumes integrated lexicon and integrated syntax, which means that lexical and syntactic information is shared between bilinguals’ two languages when they are sufficiently similar (Hartsuiker & Pickering, 2008). In this model, each lemma directly connects to a language node, a combinatorial node and a category node. Combinatorial nodes represent how a word can combine with other linguistic units to form possible expressions, and categorical nodes represent the word’s syntactic category (Pickering...
More importantly, combinatorial nodes and category nodes are shared between languages, which means activation of the lemma and its associated combinatorial node leads to activation of the corresponding grammatical structure in both languages. This model not only accounts for the cross-linguistic syntactic priming effects found in Hartsuiker et al. (2004), it also explains frequent code-switching and code-mixing in bilingual conversations: the fact that bilingual speakers borrow words and phrases from the non-target language with ease may be due to parallel activation of the grammatical structure in both languages.

Assume that syntactic information is shared whenever the structures are sufficiently similar between the two languages, what level of similarity would warrant shared syntactic representation in the bilingual mind? The same word order has shown to be a necessary condition for cross-linguistic priming of syntactic structures.

Using a picture-description dialogue game, Berlonet and colleagues investigated cross-linguistic syntactic priming of noun phrases, more specifically, whether participants choose adjective-noun (AN) phrases or relative clauses (RC) in their production (Bernolet, Hartsuiker, & Pickering, 2007). Dutch-English (Experiment 3a, 3b, 4) and Dutch-German participants (Experiment 5) describe pictures to their conversation partners. Participants and confederates were seated opposite each other and cannot see the computer screen of their partners. Results displayed different patterns for the two bilingual populations. Dutch-German bilinguals produced significantly more German RC-structures after Dutch RC-primes (L1 to L2 priming effects); however, no syntactic priming effects were found between Dutch and English RC structures (L1 to L2 or vice versa). The primary variable here is the word order: Dutch RC-structures has the identical word order with German, but differs from English. Furthermore, priming effects were found not only when the head nouns were translation equivalents; they also occurred when a different head noun was used.

The restrictive effect of word order was also found in Salamoura and Williams (2007, Experiment 2), where the L1 Greek dative structure primed the L2 dative structure, but the same L1 structure with a shifted word order did not elicit priming effects in the L2. Loebell and Bock (2003) also provides (indirect) evidence for the same word-order priming. Researchers found that German datives primed English datives and vice versa among fluent German-English bilingual speakers in a picture-description task. However, German or English passives did not prime
passive sentences in the other language. German and English passives have different word orders: German participles follow the by-phrase, while English participles precede the by-phrase. Thus, the absence of priming effect in German and English passive sentences indicates that necessity of the same word order in cross-linguistic syntactic priming (see also, Hartsuiker et al., 2004).

Context is another factor that may constrain cross-linguistic syntactic priming. Hatzidaki and colleagues investigated the bilingual production of subject-verb agreement using a sentence completion task in different language contexts (Hatzidaki, Branigan, & Pickering, 2011). Their primary question was whether subject-verb agreement in the target-language production could be affected by syntactic properties of the non-target language. Additionally, they tested one-language and two-language production in both monolingual and bilingual contexts to investigate the circumstances where cross-language interferences are mostly likely to occur (Grosjean, 1988, 1997). They conducted four experiments: Experiment 1 and 2 were conducted in the bilingual contexts; Experiment 3 and 4 replicated the first two experiment but in the monolingual context.

In Experiment 1, Greek-English bilinguals were asked to read aloud a subject noun phrase in Greek or English, and then complete the sentence however they like in either Greek or English (one-language or two-language production). The experimental items were created by crossing four factors: number (singular vs. plural), noun convergence (convergent vs. divergent), source language (Greek vs. English), and language task (one-language vs. two-language production). Results showed that participants never produced incongruent responses following convergent nouns (where the syntactic number of nouns did not differ between the two languages). However, following incongruent subject nouns, participants did produce incongruent responses: singular verbs after plural nouns and vice versa. The result supported the interference account, suggesting that syntactic properties of the non-target language, such as noun number, can affect the target-language production. Furthermore, this effect occurred when participants only need to activate one language (one-language production); however, the interference effect was stronger in two-language production. Additionally, results showed asymmetrical cross-language influence, with stronger interference from the L1 Greek to the L2 English than otherwise.

Experiment 2 replicated Experiment 1 using a different bilingual popula-
tion, English-Greek bilinguals, to investigate whether the effect of non-target lan-
guage during target-language production occurs among a linguistically different pop-
ulation. In terms of the noun divergence effect, Experiment 2 replicated Experiment
1: participants only produce incongruent responses following divergent nouns, thus
extending the results from Experiment 1. However, in contrast to Experiment 1, the
symmetrical cross-language influence was found in Experiment 2; that is, not only
did L1 English affects the subject-verb agreement production in L2 Greek, L2 Greek
affected L1 English as well.

Experiment 3 replicated Experiment 1 but only in monolingual contexts: Greek-English bilinguals completed sentences in their L2 English following conver-
gent or divergent English subject nouns. Experiment 3 intended to investigate pos-
sible effects of non-target language in a monolingual context, where the non-target
language was never spoken. Replicating the results of Experiment 1, participants
only produced incongruent responses following divergent nouns. Also, there was a
numeric tendency to produce more incongruent responses following singular than
plural divergent nouns, although the difference did not reach statistical significance.
Additionally, analysis of the combined results from Experiment 1 and 3 showed that
participants were more likely to produce incongruent responses following divergent
nouns in Experiment 1 than in Experiment 3, indicating that language context plays
a role in the process. Experiments 1 and 3 echoed with the findings from Dijkstra
et al. (1998) concerning parallel-activation of the lexical representations. Different
results in Experiment 1 and Experiment 2 regarding homographs indicated that
bilingual are sensitive to language context, and can somehow adjust the overall ac-
tivation level based on the presence or absence of other languages (Dijkstra, van

Taken together, results from the four experiments showed that: (1) cross-
linguistic syntactic priming effects occurred in the monolingual (Experiment 3, 4)
and the bilingual context (Experiment 1 and 2), even though the priming effects were
stronger in the bilingual context than the monolingual context; (2) cross-linguistic
syntactic priming effects occurred in one-language production and two-language pro-
duction, although the priming effects were stronger in two-language production than
one-language production (Experiment 1, 2); (3) cross-language syntactic priming is
not unidirectional: L1 syntactic properties affected L2 sentence production and vice
versa (Experiment 2). However, L1 exerts a more substantial influence on L2 syn-
tactic processing than otherwise, probably due to differences in the proficiency.

Sanoudaki and Thierry extended the cross-linguistic syntactic priming effects to language comprehension among early bilingual speakers (Sanoudaki & Thierry, 2015). They also found that language proficiency may limit syntactic priming across languages. In an EEG/ERP paradigm, they asked Welsh-English bilinguals to complete a picture verification task in English. During the task, participants read sentences containing adjective-noun phrases and were instructed to respond only when either the adjective or the noun matched the proceeding picture. Initial analysis of the results revealed that only Welsh-English bilinguals displayed response inhibition when the noun was encountered first, indicating that they were ready to process post-nominal adjectives, even though it is ungrammatical in English. The authors further argued that this result provides evidence that syntactic information from Welsh was co-activated and accessible during English sentence comprehension (Thierry and Sanodaki, 2012).

Sanoudaki and colleague divided the Welsh-English bilinguals into two subgroups based on their language proficiency in a later analysis. Reanalysis of the original data showed a different pattern: only Welsh-English bilinguals in the high-proficiency group displayed response inhibition when encountering nouns first, in contrast to the low-proficiency bilinguals and the monolingual speakers (Sanoudaki & Thierry, 2015). In short, the results showed that cross-linguistic syntactic priming is not unconditional: it may depend on the relative proficiency of bilinguals’ two languages.

### 2.3 Interim summary

This chapter demonstrated pervasive parallel-activation of bilinguals’ two languages on multiple levels. Bilingual lexicons has shown to be highly integrated: activation of words in one language sends activation to words in the other language that have similar phonological, semantic or orthographic features. Contextual information, such as syntactic and semantic constraints, cannot completely “turn off” activation of the non-target language. Similarly, at the sentence level, syntactic properties of the non-target language can sometimes affect target-language processing, even when the non-target language is not used. Nevertheless, bilingual speakers seem to be sensitive
to the language context and adjust their overall language activation level based on the presence or absence of other languages. To sum up, activation of the non-target language appeared to be regulated by language proficiency, dominance and contexts.

The discussion of language co-activation brings us a step closer to understanding language attrition as an emerging, dynamic process. On the one hand, parallel-activation of the two languages poses sustained demand on bilinguals’ control processes, which could in turn change the way they resolve conflicts in linguistic and nonlinguistic tasks. On the other hand, given that shared features and structures receive joint activation from the two languages, it is not surprising if bilinguals opt for language-similar structures than those only exist in one language. These small yet accumulative change would slowly change the way both languages are used (Kroll et al., 2015).

The two constructs investigated in Chapter 4 and 5, reflexive pronoun *ziji* and *wh*-topicalizations in Mandarin Chinese both have corresponding structures in the second language English (self and *wh*-questions, correspondingly). Given the status of parallel-activation of both languages in the bilingual mind on the lexical and the syntactic level, it is interesting to see if L1 processing changes in face of the L2-to-L1 transfer and the cognitive demands to keep the two languages separate.
Chapter 3

Controlling the level of activation in two languages

In Chapter 2, I reviewed the literature on language co-activation at different levels of bilingual language processing. Since both languages are activated to varying degrees in the bilingual mind, control mechanisms are needed to regulate the activation level among different languages and structures to produce and comprehend speech in the target language with minimal cross-language interference. This chapter first reviews behavioral and neural studies that showed bilinguals engaging control mechanisms when performing linguistic tasks (Section 3.1). Then I introduce models of cognitive control that can be or already have been applied to the bilingualism research (Section 3.2); for instance, the Inhibition Control model (Green, 1998), the Unity and Diversity model (Miyake et al., 2000), and the Adaptive Control Hypothesis (Green & Abutalebi, 2013). Finally, I briefly review the research on the cognitive consequence of bilingualism (Section 3.3). The interaction between bilingual speakers’ language use and cognitive functions is bi-directional. Not only do cognitive abilities affect bilingual language processing, but bilingual processing also hones specific aspects of cognitive functions.

3.1 Cognitive control and bilingual processing

Bilingual speakers have the remarkable ability to switch rapidly between two languages based on their communication needs, with minimal intrusion from the unwanted language. A large body of research has been devoted to exploring the control
mechanisms underlying language selection and switching, referred to as “bilingual language control” (bLC). Some researchers proposed that inhibitory mechanisms were involved in the process (Green, 1998; Meuter & Allport, 1999). Others argued for a language-specific selection mechanism (Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006; La Heij, 2005).

As one of the first attempts to investigate bilingual language-switching, Meuter and Allport (1999) proposed that language-switching and selection depend on similar inhibition processes to those responsible for non-linguistic task-switching. They predicted that switching to a stronger L1 is more costly than switching to a weaker L2. Participants were asked to name numerals in either their first or second language unpredictably. The results supported their hypothesis: significantly larger response latencies were observed when participants switch from the L2 to the L1 than vice versa. The authors attributed the asymmetrical switching costs to the difference in the two languages’ proficiency levels and the negative priming effect. The active inhibition of a stronger L1 is needed to enable naming in a weaker L2; the inhibition persists in the following switch trial, making it more difficult to name in the L1.

Levy and colleagues further investigated the inhibitory control in bilingual processing and attributed first language attrition partly to inhibition-induced forgetting (Levy et al., 2007). Using a retrieval practice paradigm adapted from Anderson, Bjork, & Bjork (1994), they asked participants to retrieve English labels of the pictures they previously named in either L1 English or L2 Spanish in the practice phase. Results showed that naming a picture in Spanish impaired access to the corresponding English word: the more frequently English learners of Spanish produced Spanish labels for pictures, the worse their later retrieval of corresponding English labels. Furthermore, lower proficiency in L2 Spanish was associated with more significant phonological inhibition, which indicated that the native language is more vulnerable to inhibition-reduced forgetting when people struggle to produce the foreign vocabulary. These results were compatible with the inhibitory account of language control (Green, 1998) in that bilinguals experience interlingual competition and use inhibition mechanisms to select the target language in bilingual

\[1\] A third approach, language non-selective selection mechanism, was proposed by Finkbeiner, Gollan and Caramazza (2006). Their primary argument is that language-selection need not be competitive in nature. They offered a Selection by Threshold mechanism that circumvents the “hard problem” and selects the first node that reaches the activation threshold.
production. In addition, the magnitude of inhibition appears to be affected by the difference in proficiency levels of the two languages.

The influence of language proficiency on control mechanisms was also witnessed in Costa & Santesteban (2004). However, Costa and colleagues found qualitative rather than quantitative differences in bLC among bilingual speakers with different proficiency levels. In a picture-naming task, they investigated the language-switching performance among L2 learners (Experiment 1) and highly proficient bilinguals (Experiment 2, 3: L1 and L2; Experiment 4: L1 and L3). With L2 learners, they replicated the asymmetrical switching cost found in Meuter & Allport (1999); switching from the L2 to the L1 was more difficult than vice versa. On the other hand, highly proficient bilinguals displayed symmetrical switching costs regardless of the difference in proficiency levels between the two languages involved in the task. The authors argued that the difference in language-switching costs between L2 learners and highly proficient bilinguals might reveal a qualitative difference in the control mechanisms involved in lexical access.

To understand the nature of bLC and its influential factors, Costa and colleagues further investigated language-switching performances of highly proficient bilinguals with different language combinations (Spanish-Basque, Spanish-English) and different age of L2 acquisition (Costa et al., 2006). Bilingual speakers showed symmetrical switching cost regardless of language combinations or age of L2 acquisition (Experiment 1); however, they showed asymmetrical switching costs when one of the languages involved was very weak (L4 in Experiment 3; a newly-learned language in Experiment 4). These results cannot be accounted for by either inhibitory control (Green, 1998) or language-specific selection (Costa & Santesteban, 2004). Instead, the authors proposed that both inhibitory control and language-specific selection mechanisms are involved in language-switching among highly proficient bilinguals. Suppose one of the languages involved is a very weak L4 or a newly-learned language that does not have an established lexical representation, language-specific selection mechanism cannot function; bilinguals must rely on inhibition to select the appropriate language and lexical items.

Another strain of research concerning the nature of bLC focuses on its relationship with domain-general executive functions (EF), such as monitoring/updating, inhibition and switching. The question is two-fold: first, whether bilingual speakers recruit domain-general EF during language processing; and second, whether there is
structural overlap between the brain regions responsible for bLC and domain-general EF. Recent studies suggest that a life-time experience of juggling two languages has consequences for domain-general EF (see Section 3.3); if bLC is subsidiary to the domain-general EF system, it explains why bilingual language use can generate effects to non-linguistic domains.

To investigate the role of domain-general EF during bilingual language processing, Linck and colleagues examined the consequences of individual differences in inhibitory control and working memory capacities for language processing tasks \((\text{Linck et al., 2008})\). Highly proficient bilinguals performed a picture-naming task with cognates and non-cognates; their inhibitory control was measured by Simon task, and their working memory was measured by operation span tasks (Study 2, \(\text{Linck et al., 2008}\)). Results showed that 15.8% and 3.1% the magnitude of variances in cognate facilitation was accounted for by Simon effect \((F(1,58) = 10.89, p < .01)\) and by operation span scores \(F(1,58) = 1.85, p > .10\), respectively. Cognate facilitation signals activation of the non-target language during target-language processing. The significant correlation between the Simon effect and the cognate effect indicated that bilinguals’ inhibitory control affects their linguistic performance by modulating the activation level of the non-target language. On the other hand, working memory resources did not show a reliable correlation to the cross-language activation among highly proficient bilinguals (cf. \(\text{Linck et al., 2014}\)).

As for the relationship between the bLC and the domain-general EF system, Calabria and colleagues (2012) compared the switching costs in language switching and non-linguistic switching tasks among the same group of participants. Highly proficient Spanish-Catalan bilinguals named pictures in L1 or L2 (Experiment 1) and L1 or L3 (Experiment 3); they also switched between two card sorting rule-sets (by colour or by shape). Participants showed symmetrical switching costs in both linguistic switching tasks (L1 vs. L2 and L1 vs. L3). However, they showed asymmetrical switching costs in the non-linguistic switching task: switching from the more difficult task (by shape) to the easier task (by colour) was more costly than otherwise. The results indicated that highly proficient bilinguals perform linguistic switching and non-linguistic switching tasks in a qualitatively different way. The authors also examined the magnitude of switching costs between the two tasks, and they did not find any significant correlation. An interesting pattern emerged when they compared switch costs across two experimental blocks in the linguis-
tic and non-linguistic task. In the linguistic task, switch cost in the L1 decreased significantly from block 1 to block 2, while switch costs in the non-linguistic task stayed the same across blocks. The decreasing switching cost during linguistic tasks suggested flexibility in the bLC. Based on the different switching and adaptation patterns, Calabria and colleagues concluded that the bLC is not fully subsidiary to the domain-general EF system.

Recent advances in neuroimaging techniques allows researchers to investigate the neural correlates underlying bilingual language control more directly (see Calabria, Costa, & Green, 2018, for a review). In contrast to the behavioural results in Calabria et al. (2012), De Baene and colleagues (2015) found a certain degree of neural overlap between language control and non-verbal cognitive control among the same group of early bilingual speakers. They used closely-matched linguistic switching and non-linguistic switching tasks: three-language and three-task paradigm (cf. Abutalebi et al., 2011). Conjunction analysis of the fMRI results revealed that both language-switching and task-switching engaged common areas in the distributed frontal-parietal network. Specifically, lateral and medial prefrontal cortex (PFC) and superior parietal lobule were commonly activated during linguistic and non-linguistic tasks (see also Abutalebi & Green, 2007). Disjunction analysis also displayed some areas specifically involved in linguistic (precentral and postcentral gyri) or non-linguistic switching (dorsal premoter cortex).

Switching consists of one kind of cognitive control. Successful switching, either linguistic or non-linguistic, would require other cognitive processes, such as goal maintenance, interference inhibition and response inhibition (see Section 3.2 for a further breakdown of the control processes involved in bilingual processing).

Coderre, Smith, van Heuven and Horwitz (2016) investigated the functional overlap of cognitive control and language processing in the same group of Spanish-English early bilinguals. To fully disassociate different aspects of bilingual cognitive control, they tested linguistic control, non-linguistic control and language processing. Linguistic and non-linguistic control was measured by an adapted Flanker task, and language processing was assessed through a semantic categorisation task. Note that the Flanker task has been associated with interference suppression and response inhibition (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002); it has been used to measure participants’ ability to resolve conflicts (e.g., Luk, Anderson, Craik, Grady, & Bialystok, 2010). The conjunction analysis of fMRI results of all three
tasks showed a significant cluster in the left inferior frontal gyrus (LIFG; BA47). LIFG has been associated with bilingual language control, linguistic control and non-linguistic control (see Luk, Green, Abutalebi, & Grady, 2011, for a review), albeit with different participants. The Coderre et al. (2016) study provided direct evidence that bilingual speakers recruit domain-general EF during language processing.

This section is in no way an exhaustive review of the literature concerning cognitive control and bilingual processing. However, based on the limited selection of studies, it is evident that bilingual speakers recruit cognitive control mechanisms to regulate the activation of two languages. As for the exact nature of bilingual language control, current literature has shown both qualitative differences and functional overlap between the bLC and the domain-general EF system. In specific contexts, bilinguals’ language proficiency and the nature of the tasks also affect how bilinguals recruit their cognitive control network (see also Abutalebi & Green, 2007).

3.2 Models of cognitive control in bilinguals

The last section demonstrated that bilingual speakers sometimes recruit cognitive control mechanisms to modulate interferences from the non-target language and switch between languages based on their communicational needs (Section 3.1). However, the specific processes involved in bilingual cognitive control remains an open question. This section will introduce cognitive control models that can be or already have been applied to bilingualism research, specifically, the Inhibition Control model (Green, 1998), the Unity and Diversity model (Miyake et al., 2000), and the Adaptive Control Hypothesis (Green & Abutalebi, 2013).

The three models have different focuses. The Inhibition Control model can be viewed as a bilingual production model because it emphasises how the control system coordinates with the lexico-semantic system. The Unity and Diversity model concerns the organisation of the domain-general executive functions and identifies its components and their roles in complex cognition. The Adaptive Control Hypothesis incorporates the language mode theory (Grosjean, 1988, 1997) in their model and concerns how cognitive processes themselves might adapt over time, which holds great potential in predicting bilingual speakers’ development trajectory based on their language experience. They also spell out the neural basis for these processes.
3.2.1 Inhibition Control (IC)

Green (1998) proposed the IC model to account for the language control mechanisms of bilingual speakers. Specifically, it aims to address how bilinguals resolve the competition between different languages, different tasks and different responses. Building on the model of action proposed by Norman and Shallice (1986), the IC model assumes that “the regulation of language processes and the control of action have much in common” (Green, 1998, p. 68). Furthermore, in contrast to the earlier “language switch” proposal, the IC model achieves language regulation by modifying activation levels of the language network.

![Inhibition Control Model Diagram](image)

Figure 3.1: The structure of the Inhibition Control Model (Green, 1998); G = Goal, I = Input, and O = Output

The IC model is depicted in Figure 3.1. For bilingual speech production, a specific communicational goal drives the conceptualiser to form a mental representation, which is passed on to the supervisory attention system (SAS) and language task schemas. Language task schemas consist of distinct and separate linguistic tasks the SAS activates or modifies to fulfil the communicational goal, such as word production and translation. Language task schemas compete to control output from the bilingual lexical-semantic system; the SAS monitors this process concerning the task goal by altering the activation level of a selected task schema.
Within the bilingual lexico-semantic system, the IC model adopted the lemma concept from Levelt’s production model \cite{Levelt1999}. Each lexical concept is associated with a lemma, which, once selected, sends activation to its associated word forms. Green argued that the locus of word selection is at the lemma level, and lemmas are specified with a language tag \cite{Green1986}. The inhibitory control process suppresses lemmas with incorrect language tags after lemmas linked to active concepts have been activated to guarantee successful production in the intended language. Thus, Green also argued that inhibitory control is reactive, and it takes time to overcome inhibition from previous episodes \cite{Green1998, p. 72}.

In short, the IC model describes an inhibitory control process that exerts control on multiple levels of the language network. The SAS alters activation levels of the competing language task schemas, which then select lemmas by activating and inhibiting language tags.

### 3.2.2 Unity and Diversity of Executive Functions

Miyake and colleagues \cite{Miyake2000} conducted an individual differences study of executive functions. Specifically, they examined the relationship among three often-postulated executive functions and their roles in complex cognitive tasks. The three executive functions are: shifting between tasks and mental sets (shifting), updating and monitoring of working memory representations (updating) and inhibition of dominant or prepotent responses (inhibition). The primary goal was to determine the extent to which these three cognitive processes are separable or overlapped. The secondary goal was to investigate how specific cognitive control processes are organised and coordinated to perform complex cognitive tasks, which have suffered from low internal and test-retest reliability. Those tasks are the Wisconsin Card Sorting Task (WCST), the Tower of Hanoi task (TOH), the random number generation task (RNG), the operation task and dual-tasking.

137 participants took part in the study and completed a battery of cognitive tasks designed to tap specific cognitive processes such as shifting, updating and inhibition (Figure 3.2A). Participants also completed five complex cognitive tasks: WCST, TOH, RNG, the operation span task and dual-tasking (a spatial scanning task and a word generation task).
To answer the first question, “To what extent are the three target executive functions separable”, Miyake and colleagues conducted a series of confirmatory factor analyses (CFA). Results showed that a full, three-factor model (Figure 3.2A) fits the data significantly better than a unitary, one-factor model, or any of the two-factor models, indicating that shifting, updating and inhibition are distinguishable constructs. Figure 3.3 showed the standardised factor loadings of each task to the corresponding executive functions (straight single-headed arrows) and correlations between the factors (curved double-headed arrows). The moderate to high correla-
tion estimates (.42 to .63) indicated the three executive functions are moderately correlated. Taken together, results from the CFA showed that shifting, updating, and inhibition are separable but moderately related constructs, thus indicating the unity and diversity of executive functions.

Figure 3.3: The estimated three-factor model. Single-headed arrows have standardized factor loadings next to them. The loadings, all significant at the .05 level, are equivalent to standardized regression coefficients (beta weights) estimated with maximum likelihood estimation. The numbers at the ends of the smaller arrows are error terms. Squaring these terms gives an estimate of the variance for each task that is not accounted for by the latent construct. The curved, double-headed arrows have correlation coefficients next to them and indicate significant correlations between the latent variables. (Miyake et al., 2000, p. 70)

Miyake and colleagues used structural equation modeling (SEM) to investigate the roles of the three executive functions in complex cognitive tasks, such as WCST and TOH (Figure 3.2B). Results showed that (1) WCST primarily taps the shifting component; (2) inhibition contributes to the TOH performance; (3) the RNG task primarily recruits the inhibition and updating processes; and (4) updating plays an important role in the operation span performance. The performance of dual-tasking did not seem to relate to any of the three executive functions significantly. These findings highlighted the diverse nature of executive functions. They
also showed heterogeneity of the commonly used executive control tasks: different cognitive functions, such as shifting, updating and inhibition, contribute differentially to those tasks.

### 3.2.3 Adaptive Control Hypothesis

In contrast to the *Inhibition Control* model and the *Unity and Diversity* Model, the *Adaptive Control Hypothesis* (Green & Abutalebi, 2013) takes a more dynamic and developmental perspective of the cognitive control processes. Green and Abutalebi proposed that not only do bilinguals recruit cognitive control processes to adapt to communicational needs, but the cognitive processes themselves also adapt to “recurrent demands placed on them” in different contexts (Table 3.1). In other words, they believe there is a training effect on bilingual language control processes. Green and Abutalebi also considered the “interaction cost” as a factor motivating adaptive changes in bilingual control processes (Green & Abutalebi, 2013, p. 521). Adapting a cognitive process means changing its capacity, efficiency, or its connectedness with other cognitive processes.

<table>
<thead>
<tr>
<th>Single language</th>
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<td>One language is used in one environment and the other used in a second distinct environment</td>
<td>No frequent switching between languages</td>
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<th>Dual language</th>
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<tr>
<td>Two languages are used in one environment, typically with different speakers</td>
<td>Switching between languages may occur within one conversation but no within one utterance</td>
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<tr>
<th>Dense code-switching</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Two languages are used in one environment, usually with another bilingual speakers with the same languages</td>
<td>Bilinguals routinely interleave their languages in a single utterance, borrow and adapt words from one language into the context of the other language</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.1:** Three interaction contexts; Green & Abutalebi (2013)

As displayed in Figure 3.1, Green and Abutalebi (2013) identified three interaction contexts, which differ in the number of languages, the frequency of code-switching, and the existence of intra-sentential code-switching. They also argued that these contexts pose different demands on bilingual language control processes. Expanding the decomposition proposed by Miyake et al. (2000), they distinguished
the following eight cognitive processes (Table 3.2).

<table>
<thead>
<tr>
<th>Control processes</th>
<th>Interactional contexts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single language</td>
</tr>
<tr>
<td>Goal Maintenance</td>
<td>+</td>
</tr>
<tr>
<td>Interference control: conflict monitoring and interference suppression</td>
<td>=</td>
</tr>
<tr>
<td>Salient cue detection</td>
<td>=</td>
</tr>
<tr>
<td>Selective response inhibition</td>
<td>=</td>
</tr>
<tr>
<td>Task disengagement</td>
<td>=</td>
</tr>
<tr>
<td>Task engagement</td>
<td>=</td>
</tr>
<tr>
<td>Opportunistic planning</td>
<td>=</td>
</tr>
</tbody>
</table>

**Table 3.2:** + indicates the context increases the demand on that control process (more so if bolded); = indicates that the context is neutral in its effects. Please see main text for explanation of the control processes (Green & Abutalebi, 2013, p. 519)

In any interaction contexts, establishing and maintaining a communication goal is essential. The process is referred to as *goal maintenance*, for example, choosing to speak in one language instead of the other. Meanwhile, when interferences arise, like overhearing other speakers conversing in a different language in the immediate environment, *interference control* is required to help sustain the current goal. Green and colleague identified two control processes under interference control: *conflict monitoring* and *interference suppression*.

In a dual-language context, where two languages are used and code-switching is allowed within the same conversation, the ability to switch back and forth is demanded. Green and Abutalebi (2013) proposed four separate but interconnected processes for this purpose. Firstly, the need to switch to a different language is usually triggered by a salient cue, for instance, the arrival of a new addressee. *Salient cue detection* is crucial to initiating the switch. Secondly, once the new communicational goal has been established, bilingual speakers need to stop their ongoing response that does not fit the new goal, which might recruit another process named *selection response inhibition*. Finally, the inhibition triggers disengagement of the previous task, allowing the speaker to engage with the new one: *task disengagement* and *task engagement*.

Compared to the single-language context, where the activation level of the non-target language is much lower than the target language, speakers in a dual-language context might face more interferences and competition from the language non-in-use. Thus, Green and Abutalebi (2013) proposed that *goal maintenance*, con-
Sentence processing in first language attrition would be more demanded in the dual-language context than the single-language context.

In a dense code-switching context, Green and Abutalebi (2013) argued that the highly-demanded cognitive process is opportunistic planning. In contrast to the dual-language context, intra-sentential code-switching is present in the dense code-switching context. Speakers frequently borrow and adapt words and phrases from one language and integrate them into the other language’s syntactic frame.

To sum up, the Adaptive Control Hypothesis argued for the differential contribution of eight separate but related cognitive processes to three interaction contexts: single-language context, dual-language context and dense code-switching context. The three contexts represent the kind of interactions bilinguals face, and their recurrent demands on bilingual language control processes are one factor that motivates adaptive change. The hypothesis made several testable predictions about bilinguals’ linguistic and cognitive performance.

Firstly, the hypothesis predicts that bilingual speakers in different interactional contexts show different behavioural patterns of adaptive response. For example, in an experimental condition where participants are free to switch between languages at will, bilinguals from a dense code-switching context would be more fluent than those from a single-language or a dual-language context. Similarly, the fluency of bilinguals from the single-language and the dual-language context would be greater than those from the dense code-switching context when only one language is required. Additionally, for bilinguals from a dual-language context, the cascade of cognitive processes triggered by a salient cue to switch would be more integrated and triggered more quickly than those from a single-language context.

Secondly, the hypothesis predicts adaptive changes in the neural regions and circuits underlying the cognitive control processes in each context. It follows that bilinguals from different interactional contexts will display distinct neural activations when performing the same task (see also, Abutalebi & Green, 2007, 2008).

Green and Abutalebi (2013) also noted the individual differences in adaptive response: language proficiency, sensitivity to social cues and cognitive control capacity are factors that may constrain adaptive change. Additionally, individuals vary in the extent they engage in different contexts; they may also experience all
three interactional contexts but to different degrees. Since recurrent exchanges in a specific context is a proximal factor driving the adaptive change, adaptive changes to control processes and their neural substrates will reflect the distribution of exchanges typical of those contexts (see Abutalebi & Green, 2016, for a review of bilingual neural adaptations).

Hartanto and Yang (2016) were among the first studies to test the Adaptive Control Hypothesis. They investigated the task-switching performance of bilingual speakers from the single-language context (SLC) and the dual-language context (DLC). Using a modified colour-shape switching task, they found that DLC bilinguals showed smaller switching costs than SLC bilinguals, while no significant differences were found in mixing costs. The results supported the authors’ prediction: disparate bilingual experience leads to differences in cognitive processes. In this case, the DLC bilinguals’ experience with language switching within the same contexts would hone their cognitive processes regarding task-set switching, compared to SLC bilinguals who rarely switch languages within the same context.

**Individual attrition trajectories: the effect of cognitive control**

The flexibility of bilingual language control (Calabria et al., 2012; Costa & Santesteban, 2004) suggests that for bilingual speakers who already attained the advanced or higher proficiency level and are adept to frequent language switching, chances are their cognitive control abilities, which have shown signs of adaption (e.g., Hartanto & Yang, 2016), do not pose severe limitation to their linguistic performance. However, for bilinguals who struggle to maintain the intermediate or lower level proficiency in one of their languages, cognitive control abilities could play a significant role in their language performance.

It may help to think about the effect of cognitive control abilities on bilingual language performance in two waves. During the first wave, shortly after the onset of bilingualism, the cognitive control abilities, either general or language-specific, modulate the linguistic performance in either language (Levy et al., 2007; Linck et al., 2008; Costa et al., 2006). Then during the second wave, as cognitive processes adapt to the bilingual experience (e.g., dual-language context or single-language context) and individuals develop strategies to cope with the cognitive demand of maintaining two languages, the question “what is the effect of cognitive control
on the linguistic performance” becomes somewhat irrelevant, and a more relevant question would be what aspects of cognitive control modulate language processing in what context (Costa & Santesteban, 2004; Hartanto & Yang, 2016).

The current literature does not generate strong enough evidence to provide predictions regarding the effect of cognitive control abilities and individual attrition trajectories. Cherciov (2011) is one of the few studies that investigated the predictive power of cognitive abilities in L1 maintenance. She found that superior cognitive control abilities did not “discourage L1 attrition” (Cherciov, 2011, p. 166-67). Cherciov came to the conclusion that “the levels of L1 attrition...[is] dependent on a combination of attitudinal and personal background variables” (2011, p. iii).

Cognitive control abilities does not dictate what you do rather how well you perform when you carry out certain tasks. Motivation, on the other hand, plays a bigger role in terms of how well a person maintain their already acquired language (Ben-Rafael & Schmid, 2007; Schmid, 2002). Environmental factors, especially the linguistic environment they are in, shapes cognitive control abilities in ways that support their daily language use the best (Hartanto & Yang, 2016; Yang, Hartanto, & Yang, 2016).

3.3 The cognitive consequences of bilingualism

Due to joint activations of two language systems and non-selective access to the target system, bilingual speakers face sustained demands to select an appropriate utterance in the target language, despite that alternative expressions are also available (see Chapter 2). This recurrent mental practice sometimes recruits cognitive processes used for domain-general executive control (Section 3.1). Some studies found that using more than one language can shape individuals’ performance on nonverbal tasks that tap into domain-general executive functions (see Bialystok, Craik, Green, & Gollan, 2009, for a review).

Researchers found bilinguals outperformed their monolingual peers in several different domains in studies comparing bilingual and monolingual speakers with matched age and intelligence. It was first reported in inhibition and interference con-
trol, usually measured by the Simon task\(^2\) (Bialystok, 2001; Bialystok, Klein, Craik, & Viswanathan, 2004). It was also observed in the domain of shifting (Bialystok & Martin, 2004; Garbin et al., 2010; Prior & Macwhinney, 2010). Garbin and colleagues reported behavioural and neuronal differences between bilingual and monolingual speakers when performing a non-linguistic switching task (2010). Working memory is another domain where bilingual/monolingual differences have been reported. Since Bialystok et al. (2004, Study 3), where bilinguals showed reduced working memory cost compared to monolinguals, several studies have reported more efficient use of working memory resources by bilingual speakers (Antón, Carreiras, & Duñabeitia, 2019; Bialystok et al., 2008; Luo, Craik, Moreno, & Bialystok, 2013). Advantageous performance has also been reported in other attentional processes, such as directing attention and inhibiting task-irrelevant stimuli (Soveri, Laine, Hämäläinen, & Hugdahl, 2011). The enhanced performance on nonverbal tasks for domain-general executive control was associated with the bilingual experience, specifically the repeated practice of inhibiting the non-target language and switch between languages based on the context. This phenomenon was coined “bilingual advantage”.

Bilingual advantage has been reported among all age groups, but most consistently in older adults, who are at the onset of cognitive declining (Bialystok, Craik, & Ryan, 2006; Bialystok, Craik, & Freedman, 2007; Craik, Bialystok, & Freedman, 2010; Luo et al., 2013; Bak, Nissan, Allerhand, & Deary, 2014; Bak, 2016). In Bialystok et al. (2004, Study 2), they compared performances on the Simon task between younger and older adults and found that the bilingual groups showed smaller age-related increases in the Simon effect than the monolingual groups. Bilingualism appeared to reduce age-related decline in inhibition and interference control; similar effects were also observed in later studies investigating aging and bilingualism (e.g., Bialystok et al., 2006). Furthermore, the cognitive benefits associated with bilingualism extend beyond the healthy population, as Bialystok and colleagues reported that bilingual patients exhibit a delay in the onset of dementia symptoms compared to monolinguals (Bialystok et al., 2007; Craik et al., 2010). Infants and young children also displayed cognitive benefits associated with bilingualism, but the results were somewhat mixed (Adesope, Lavin, Thompson, & Ungerleider, 2010).

\(^2\) Simon task is one of the most commonly used tasks to measure inhibition and interference control. This task is based on stimuli-response compatibility and assesses participants’ ability to control interferences from the irrelevant spatial information and inhibit preponent responses. The difference in response latencies between congruent and incongruent trials is the Simon effect.
Duñabeitia et al., 2014). Studies that did find superior performance among bilingual children showed the benefits manifested in conflict resolution, cognitive flexibility and working memory (Bialystok & Viswanathan, 2009; Morales et al., 2013).

The bilingual advantage is not without its controversies. On the one hand, several large-scale studies with a battery of executive control tasks failed to replicate the bilingual advantage found in seminal studies (Prior & Gollan, 2011, 2013; Paap & Greenberg, 2013; Paap, Johnson, & Sawi, 2014). On the other hand, meta-analyses on bilingualism and cognition research repeatedly showed small or no bilingual advantage in nonlinguistic executive function tasks, especially among young adults (see Lehtonen, Soveri, Bruin, & Antfolk, 2018, for a review of meta-analysis studies). Since Hilchey and Klein (2011) cast doubt on the bilingual advantage in inhibition and interference control, more attention has been drawn to various methodological issues associated with previous studies. The issues can be further divided into four categories: test validity and reliability issues, the publication bias, confounding variables related to bilingualism and the problematic cross-sectional design. Bilingualism is not an unitary effect, so it is problematic to treat bilingualism as a category variable, as there are many different types of bilingual speakers. Associated with this issue is the natural, cross-sectional experimental design (Luk & Bialystok, 2013; Lehtonen et al., 2018). Since many researchers have addressed the last two issues of the bilingualism literature, in the remainder of this section, I will address the first two problems separately.

Hilchey and colleague reviewed thirteen studies of inhibition and interference control using either the Simon task or the Flanker task. They found a global RT advantage instead of an advantage on conflict resolution (manifested as reduced interference effects) in bilinguals. That is, bilingual speakers outperform their monolingual peers in both congruent and incongruent trials, and the bilingual advantage is mostly equivalent in both conditions (i.e., Costa, Hernández, & Sebastián-Gallés, 2008). Accordingly, Hilchey and colleague proposed a bilingual executive processing advantage in contrast to a bilingual inhibition control advantage. They argued that the locus of bilingual advantage is not inhibition processes, but a more global conflict-monitoring system.

However, Paap and Greenberg found no coherent evidence for bilingual advantage in executive processing in three large sample studies (283 participants in total; Paap & Greenberg, 2013). They used a battery of non-linguistic cognitive
tasks, including Anti-saccade task, Simon task and Flanker task, to investigate inhibition control, monitoring and switching in bilingual and monolingual speakers. They found no significant group differences across 15 indicators of executive processing, even after matching bilinguals and monolinguals on their parents’ education level. Paap and Greenberg also commented on the task validity: the absence of correlation between tasks that tap the same cognitive process (i.e., inhibitory control in the Simon task and the Flanker task) undermines the validity of these task as measures for domain-general cognitive abilities.

In a later study, Paap and colleagues (2014) measured monolingual and bilingual speakers inhibitory control, monitoring and switching abilities with four tests commonly used to test for bilingual advantages in executive functions. Across 13 different indices and two types of data analysis, they find very few significant results. Additionally, cross-task correlations of indices that were assumed to measure the same component of executive functioning returned non-significant and many near zero. These results indicate poor convergent validity, which further suggest that existing literature of bilingual advantages (or disadvantages) may reflect task-specific differences.

As early as 2000, Miyake and colleagues addressed the low internal and test-retest reliabilities among complex cognitive tasks such as Wisconsin Card Sorting Task and the operation task (Miyake et al., 2000, see Section 3.2.2 for details). Since then, numerous studies among different populations (children, young adult, older adults) replicated the unity and diversity patterns found in Miyake et al. (2000), albeit not always using the same tasks (for a review Friedman & Miyake, 2017, pp. 188). More specifically, all studies confirmed the separation between the shifting and the updating components, but the status of the inhibition component remains controversial: one study found that updating and inhibition are not separable, while some studies failed to find an inhibition factor. Given the controversial status of the inhibition component (cf. Rey-Mermet, Gade, & Oberauer, 2018), one possibility for low replicability of bilingual advantage studies is that there might exists a shifting-inhibition trade-off: the ability to shift flexibly among task sets and goals contradicts with the ability to inhibit task-irrelevant information and maintain current task goals. As a consequence, individuals with weak goal maintenance may show smaller switch costs (Herd et al., 2014).

Furthermore, relatively simple cognitive tasks (such as the Simon task) did
not show high test-retest reliabilities either. To investigate the test-retest reliability and temporal stability of common executive function tasks, Soveri and colleagues administered five EF tasks that presumably tap the inhibition (*Simon task*), working memory (*visuoverbal N-back task, visuospatial N-back task, Letter-memory task*) and switching abilities (*Number-letter task*) ([Soveri et al., 2018](#)). Test-retest reliability test revealed the highest reliability among the working memory tasks, while all RT measures in the Simon task showed low to marginal reliabilities. The author compared the Simon task results to two previous studies that observed slightly higher reliability scores ([Paap & Oliver, 2016](#); [Wöstmann et al., 2013](#)). The authors argued that different versions of the Simon task were used in the Wöstmann et al. (2013) study, and the easier conditions in the current study may result in the lower reliabilities.

Taken together, it is possible that the inconsistent findings regarding bilingual cognitive performance partly stem from the “impure” measurements for those cognitive abilities. Particularly, the low to moderate test-retest reliabilities of common inhibition tasks warrant caution in our use and interpretations of those tasks.

De Bruin and colleagues addressed the publication bias in the bilingual advantage literature ([de Bruin, Treccani, & Della Sala, 2015](#)). They looked at conference abstracts from 1999 to 2012 that focused on bilingualism and executive control. They found that studies fully supporting the bilingual-advantage theory were mostly likely to be published, followed by studies with mixed results; while studies challenging the bilingual advantage were published the least. The discrepancy was not due to differences in sample sizes or statistical power, which points to the existence of publication bias. In a later meta-analysis study, Lehtonen and colleagues controlled for the publication bias by including unpublished Masters and PhD thesis. Nevertheless, they did not find any significant results of the bilingual advantage ([Lehtonen et al., 2018](#)).
Chapter 4

Wh-topicalization in the first language attrition: the increasingly liberal judgments by L1 attriters

4.1 Introduction

This chapter presents the study investigating wh-topicalization in the first language (L1) attrition, among Mandarin-English late bilingual speakers. Compared to native English speakers, speakers of Mandarin Chinese can either keep the wh-phrases in situ or move it to the top of the sentence under specific discourse conditions, namely, wh-topicalization (Wu, 1999). Converging evidence demonstrated that first language attrition usually occurs where the two languages have partial structural overlap (see Section 1.1). The overlap between Mandarin wh-topicalization and English wh-movement makes it a “launchpad” (Schmid & Köpke, 2017a, p. 643) and an ideal testing ground for cross-language interaction.

This chapter is structured as follows. In Section 5.1, I first introduce the linguistic properties of Mandarin wh-topicalization compared to English wh-movement (Section 4.1.1). I then discuss different perspectives and theories on L1 attrition and their predictions concerning wh-topicalization among Mandarin-English late bilingual speakers (Section 4.1.2). Before presenting the current study (Section 4.2, 4.3), I briefly review L2 acquisition studies of wh-topicalization, since no L1 attrition study has been conducted regarding this syntactic feature to the best of my knowledge (Section 4.1.3). In the end, I discussed the implications of the results in relation to
L1 syntactic attrition and bilingual sentence processing in general (Section 4.4).

4.1.1 Wh-topicalization in the native language

When formulating a wh-question, speakers of wh-movement languages, such as English, move the wh-phrase from its canonical position to the sentence’s left periphery. In contrast, Mandarin Chinese usually speakers keep the wh-phrase in its original place (Wu, 1999). So Mandarin is considered a primarily wh-in situ language (see Yuan & Dugarova, 2012, for a review). However, under specific discourse conditions, the wh-phrase can be moved to the top of the sentence, a phenomenon called wh-topicalization. Example 1a and 1b illustrate the difference between an English and a Chinese wh-question: when ‘which dish’ was moved to top of English sentence, its Mandarin counterpart ‘na-dao cai’ (which-cl dish) stayed in situ.

(1) a. ni xihuan na-dao cai?
   you like which-cl dish
   ‘Which dish do you like?’

   b. Which dish do you like?

Staying in situ is not the only option for Mandarin wh-questions: wh-topicalization is grammatical when the wh-phrase in question is linked to the discourse by reference to a set of things, or a group of people in the presupposition background (Wu, 1999, p. 83). In Example 2a, the context sentence- ‘Among today’s specials’- gives speakers a set of dishes to choose from, thus linking the wh-word which to the discourse. This process is called D(iscourse)-linking. In Example 3a, despite the lack of a context sentence, the intensifier ‘zui’ (most) serves a similar function. The superlative form presupposes a shared set of dishes in the speakers’ minds, and it helps provide a context necessary for a felicitous wh-topicalization.

1 cl: classifier.
(2) a. Zai jintian-de caidan-shang, na-dao cai ni xihuan?
    Among today-poss menu-locative, which-cl dish you like
    ‘Among today’s specials, which dish do you like?’

    b. Zai jintian-de caidan-shang, ni xihuan na-dao cai?
    Among today-poss menu-locative, you like which dish
    ‘Among today’s specials, which dish do you like?’

(3) a. Na-dao cai ni zui xihuan?
    Which-cl dish you most like
    ‘Which dish do you like the most?’

    b. ni zui xihuan na-dao cai?
    You most like which-cl dish
    ‘Which dish do you like the most?’

As we can see from Example 2b and 3b, having a contextual or a semantic licenser (i.e., the intensifier ‘zui’) to link the wh-word to the discourse (D-linking) is a necessary but not sufficient condition for wh-topicalization: staying in situ is always a valid option in Mandarin wh-questions. Wu (1999) pointed out that, in addition to D-linking, the topic feature must be checked to trigger wh-topicalization (see also Pan, 2006; Tang, 1988).

In summary, Mandarin and English have different realizations of practically the same structure. Not only does Mandarin have more options when it comes to wh-questions, namely, stay in situ or topicalization, it also has more restrictive rules compared to English. Both the topic feature and the D-linking requirement must be satisfied in Mandarin wh-topicalization, while only the wh-feature needs to be checked in English wh-movement. For Mandarin-English bilingual speakers under the influence of both languages during sentence processing (see Section 2.2 for discussions of language co-activation on the sentence level), their linguistic performance
in Mandarin *wh*-topicalization is likely to be affected by the bilingual experience and diverge from their monolingual peers.

### 4.1.2 Processing *wh*-topicalization at the syntax-discourse interface

In Chapter 1 Section 1.1, I discussed the vulnerability of syntax-discourse and syntax-pragmatics structures in L1 attrition. Bilingual speakers experience difficulties integrating discourse and syntactic information (Kilborn, 1992; Roberts, Gullberg, & Indefrey, 2008). On the one hand, parallel activation of the non-target language may interfere with the target-language processing; on the other hand, the cognitive load required for retrieving and integrating information from different sources is taxing on bilinguals limited cognitive resource, leading to inconsistent performance (Section 1.3).

When Chinese speakers are immersed in the L2 English environment for a prolonged period, they receive more positive evidence of the *wh*-movement, which shares similar surface structure with the *wh*-topicalization. English input serves as an indirect positive evidence for *wh*-movement (see Seliger, 1991, p. 237). It is possible that the restrictions from Mandarin *wh*-topicalization become more relaxed due to the competition from “L2 rules which are formally less complex and have a wider linguistic distribution” (Seliger, 1989, p. 173).

From a neuro-cognitive perspective, attrition usually occurs when structures from the two languages are in competition (Green, 1998; M. Paradis, 1993, 2004). After bilingual speakers live in the second language environment for an extended period of time, the L2 structure would be more frequently activated, as the corresponding L1 structure gets inhibited. Activation Threshold Hypothesis (see M. Paradis, 2004) predicts this process leads to higher activation threshold for the L1 structure, which means that it would take more effort to reach the activation threshold and to reactivate the previously inhibited structure.

For Mandarin-English bilinguals who live in the L2 environment for an extended period, with the decrease of Mandarin input, the frequency of *wh*-in *situ* structures drops consequently. At the same time, *wh*-movement from their L2 English, which resembles *wh*-topicalization on a surface level appears more frequently.
Sentence processing in first language attrition

This would cause the threshold of *wh*-movement and *wh*-topicalization to decrease, and so easier to activate both in comprehension and production, compared to the alternative *wh*-in situ structure.

The Interface Hypothesis, proposed by Sorace and her colleagues combines both linguistic (structure) and psycholinguistic (processing and use) accounts in order to account for L1 attrition effects (Sorace & Filiaci, 2006; Sorace, 2011). The current hypothesis postulates that structures that involve syntax and other cognitive domains, such as discourse and pragmatics, are more difficult to be fully acquired in advanced L2 acquisition (Sorace & Filiaci, 2006); they are also more vulnerable to early L1 attrition compared to structures without such interfaces (Sorace, 2011).

The argument is based on “...the assumption that the syntax–discourse interface is a ‘higher’ level of language use, integrating properties of language and pragmatic processing, whereas syntax–semantics involves formal properties of the language system alone” (Tsimpli & Sorace, 2006, p. 653). Furthermore, it argues that the effect of L1 attrition among late bilinguals does not involve the underlying knowledge, but rather the ability to integrate that knowledge in real-time processing. One of the reasons that “interface structures” behave differently from others, is that integrating information across different cognitive domains in real-time is taxing on participants’ limited cognitive resources; meanwhile, inhibiting the other language already consumes resources (Green, 1998), leaving the participants performing inconsistently (Sorace, 2011, 2016).

Based on the discussion above, we can see the processing of *wh*-topicalization lies at the syntax-discourse interface. Compared to *wh*-movement in English, *wh*-topicalization in Mandarin requires speakers not only to have prior knowledge of the syntactic rules, they also have to extract necessary discourse information (whether it is originates from the context, or from a single word “zui” (*most*), update the representation in their working memory and integrate the discourse information into syntactic processing, before they can judge the acceptability of the sentence. Structures that require speakers to monitor information both within and outside

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2 Some may argue that when the D-linking cue comes from a single word “zui” (*most*), the *wh*-topicalization lies at the syntax-semantics interface. However, since D-linking is not the only requirement, and the **topic** feature always has to be checked to fully license a grammatical *wh*-topicalization, in general, this phenomenon lies at the external interface of syntax and discourse (or syntax, semantics and discourse, either way, the discourse domain is involved in the process), where contextual information, which is outside of syntax proper, has to be taken into consideration.
of syntax proper has been shown to be cognitive-demanding, and more susceptible to language attrition, compared to structures only involve features internal to grammars (see Sorace, 2011, for a review). Thus, I expect to see attrition effects during the processing of *wh*-topicalizations among late Mandarin-English bilingual speakers.

Since it is the first time that *Wh*-topicalizations and its related properties are studied in the context of L1 attrition, we seek insights in previous L2 acquisition studies on this particular structure.

### 4.1.3 *Wh*-topicalization in the second language

When speakers from a *wh*-movement language try to acquire the syntactic and discourse properties of Chinese *wh*-topicalization, they have to establish the concept of D-linking, and distinguish D-linked from non-D-linked *wh*-phrases in their L2 grammar. This task requires one to rapidly retrieve and integrate syntactic and discourse information, which can be cognitive demanding and difficult to fully acquire for L2 learners (Sorace & Filiaci, 2006; Sorace, 2011). However, Yuan and Dugarova (2012) and Dugarova (2014) both reported that L2 learners have acquired the D-linking property of *wh*-topicalization, but showed incomplete acquisition in another property that they argued to be semantic in nature.

In both studies, they found that D-linked *wh*-topicalizations headed by simplex *wh*-NPs, such as *who* or *what*, were either incorrectly rejected (Yuan & Dugarova, 2012), or highly dispreferred (Dugarova, 2014) by L2 learners of Chinese, when they were accepted by native speakers of Mandarin. In Yuan and Dugarova (2012) study, there are two D-linking cues: the context sentence and the intensifier ‘zui’ (most) (*4a*); and in Dugarova (2014) study, the only D-linking cue is the context sentence (*4b*). The authors argued that the incomplete acquisition could be attributed to the internal structure of the *wh*-phrases, namely *wh*-DP and *wh*-NP differ in their D-linking power, and L2 learners failed to fully establish this underlying structure in their L2 grammar. They further argued that this provides evidence for incomplete acquisition at the syntax-semantics interface, but not at the syntax-discourse interface (as they successfully differentiate D-linked from non-D-linked *wh*-topicalizations, at least those with complex *wh*-DPs).
(4) a. (Xiao Wang, Xiao Liu, Xiao Li, zhe ji-ge nuhai dangzhong,) Shei Zhangsan zui xiang jian?
Zhangsan most like meet
‘(Of the girls, Xiao Wang, Xiao Liu, and Xiao Li,) Who does Zhangsan like to meet most’?

b. (Jintian renshi de ji-ge nanhai dangzhong), shei ta bu xiang jian?
‘(Of the boys met today) who does she not want to see?’

If L2 learners can only process wh-topicalizations with complex wh-DPs but not simplex wh-NPs, it is debatable whether their acquisition is complete at the syntax-discourse level: failing to link simplex wh-NPs with D-linking cues can be viewed as a failure to integrate semantic and discourse information. Admittedly, it is not always easy to pinpoint the interfaces involved in processing a given structure. Wh-topicalization in Mandarin (at least) involves the syntax-discourse interface, since the D-linking feature and the TOPIC feature need to be established in the discourse, and the topicalization is syntactic in nature. In addition, previous studies have shown that whether the wh-phrase is a determiner phrase headed by which, or it is a noun phrase headed by what, can influence the D-linking power of said wh-phrase, thus affecting the acceptability of the wh-topicalization (Dugarova, 2014; Yuan & Dugarova, 2012). Second language learners diverge from native speakers in that they sometimes failed to accept grammatical, D-linked wh-NP shows that semantic knowledge is also involved in parsing and judging the structure. It is beyond the scope of current paper to discuss the distinction between syntax-discourse and syntax-discourse-semantics interface, the bottom-line is that, we should error on the side of caution before saying a specific structure does or does not involve a certain domain.

In addition, we are not certain whether wh-topicalizations with simplex wh-NPs are completely unacceptable, or just indeterminate for L2 learners. It was later
pointed out that Yuan and Dugarova (2012) study did not have balanced D-linked and non-D-linked conditions, and context sentences were not provided for all D-linked conditions. In a later study, Dugarova (2014) managed to replicate part of the results from Yuan and Dugarova (2012) in a more balanced design: L2 learners’ acceptabilities for sentences like 4b were significantly lower than those by the native speakers, but they do not completely reject those sentences either.

In summary, despite limitations in experimental design, previous L2 acquisition studies indicated that L2 learners from a wh-movement language, such as English or Russian, have some difficulty accepting wh-topicalizations with wh-NPs (such as who or what), even when they are fully licensed by the discourse.

Now consider the late Mandarin-English bilingual speakers immersed in a L2 environment (here and after, L1 attriters), the dynamics between their two languages largely resembles the L2 learners of Mandarin (see Montrul, 2005, for discussions of differences and similarities between L2 acquisition and L1 attrition). English is the more frequently used and more active language; when the two languages of a bilingual mind are in competition, it is more likely that the more active and/or more dominant language would influence the less active and/or less dominant language. In both Mandarin L2 acquisition and Mandarin L1 attrition, the linguistic performance in Mandarin is likely to be influenced by English. One important distinction between the two bilingual populations is that, in contrast to L2 learners’ incomplete (either developing or stabilized) knowledge, L1 attriters have stabilized syntactic knowledge and higher language proficiency. Investigating wh-topicalizations among L1 attriters and comparing their performance with that of L2 learners can help shed light on the internal structure of wh-topicalizations, and possibly tease apart the effect of representational and processing deficit.

### 4.1.4 Research questions and predictions

Using a word-by-word, speeded acceptability judgment task (here and after, SGJ), the current study investigated bilingual speakers’ acceptability judgment of wh-topicalization in Mandarin Chinese, while they were supposedly under the influence of L1 attrition. To investigate possible effects of general cognitive abilities on the

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3 When we say “influenced by English”, it would either be linguistic transfer from English directly, it could also be processing cost induced through the competition with English.
degree of attrition, a battery of tasks measuring working memory (see Foster et al., 2015) and cognitive control abilities (see Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994) were also conducted.

Three groups of Mandarin-English bilinguals were tested: Mandarin-English passive bilinguals in China (see below for more information on passive bilinguals), Mandarin-English bilinguals with short-term residence, and Mandarin-English bilinguals with long-term residence in the L2 English environment. The short-term group was retested in the same environment after 6 months; detailed linguistic profiles of each group will be discussed in Section 4.2.1. Our research questions are listed as follows:

1. Do bilingual speakers with different lengths of residence (< 8 mths, 8-12 mths, > 36 mths), and different bilingual profiles (passive vs. active bilinguals) behave differently on a group level when judging the acceptability of wh-topicalization? More specifically:
   (a) Do bilingual speakers undergoing language attrition still distinguish between D-linked and non-D-linked topicalization?
   (b) If they do, does the type of wh-phrases affect their judgments?

2. If they do, would the general cognitive abilities, such as attention and working memory, affect the judgments?

I predict that wh-topicalization is vulnerable to L1 attrition; since Chinese and English share partial structural overlap in this structure, and process of wh-topicalization involves retrieving and integrating information from different sources. More specifically, bilingual speakers who were exposed to the L2 environment for an extended period would be less likely to reject ungrammatical, non-D-linked wh-topicalization.

Regarding the exact influence of cognitive abilities, I do not have a prediction at this stage simply because the relationship between cognitive abilities and linguistic performance is not linear, especially in the bilingual population. On the one hand, maintaining two languages is taxing on the limited cognitive resources and individuals’ cognitive capacities will constrain their ability to perform certain tasks;
on the other hand, bilingual experience can shape individuals’ cognitive functions so that they are adept to the linguistic environment.

The cognitive measures collected in the current experiment will be entered as control variables instead of predictive variables in the statistical analysis for two reasons. Firstly, due to time limitations, only working memory and attention spans were measured, which will not give a comprehensive picture of individuals’ cognitive capacities to be able to predict their attrition trajectories; secondly, as I discussed previously, the non-linear, bi-directional relationship between experience and cognition determine that they work jointly to shape the linguistic outcome. Accordingly, it is more appropriate to treat the cognitive measures as control variables instead of predictive ones.

4.2 Methods

In this study, participants were asked to complete a word-by-word SGJ task, followed by two shortened complex span tasks (Foster et al., 2015), three elevator counting tasks from the Test for Everyday Attention (TEA) (Robertson et al., 1994), and one sociolinguistics questionnaire (Schmid & Dusseldorp, 2010). The target structure is Chinese wh-topicalization, which, in native standards, is only acceptable when both D-linking and TOPIC requirements are satisfied. In the current experiment, TOPIC features are checked in all conditions.

The complex span tasks were designed to measure working memory capacities (Oswald, McAbee, Redick, & Hambrick, 2015), which have shown to be influential during L1 and L2 pronoun resolution (Cunnings & Felser, 2013; Hendriks et al., 2014; Nieuwland & van Berkum, 2006). The elevator counting tasks were taken from the Test of Everyday Attention (TEA). They were designed to measure cognitive control abilities, including sustained attention, attention inhibition and mental shifting (Robertson et al., 1994). I adapted and used the sociolinguistic questionnaire from Schmid and Dusseldorp (2010) to record participants’ background information and language experience. Details of the materials and procedures are presented

4 The original questionnaire was shortened and translated into Mandarin. It can be retrieved from languageattrition.org; for English translation of the adapted Chinese questionnaire, see Appendix A.
in Section 4.2.2 and 4.2.3 below.

4.2.1 Participants

A total of 115 Mandarin-English bilinguals participated in the experiment (see Table 4.1). Among them, 76 participants were recruited from Edinburgh, U.K.. They are categorized as active bilinguals, as they all reported to use both Mandarin and English daily. The remaining 39 participants were recruited from Chongqing, China. They are categorized as passive bilinguals since English was only acquired as a foreign language in a classroom environment, and was rarely used for daily communication. Also, those participants had never stayed in any English-speaking country for more than a month (see Grosjean, 2010, for definitions of active and passive bilinguals). The passive bilinguals function as the control group, and their judgments of wh-topicalization sentences were used as the baseline for comparison.

<table>
<thead>
<tr>
<th>Location</th>
<th>Group</th>
<th>Number</th>
<th>Age (mean and standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chongqing</td>
<td>Mandarin-English passive bilinguals (Control)</td>
<td>39</td>
<td>25.92(1.82)</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Mandarin-English short-term bilinguals (Short-term)</td>
<td>40</td>
<td>23.43(1.75)</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Mandarin-English short-term bilinguals (Retest)</td>
<td>26</td>
<td>24.03(1.55)</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Mandarin-English long-term bilinguals (Long-term)</td>
<td>36</td>
<td>26.75(6.47)</td>
</tr>
</tbody>
</table>

Table 4.1: Participants profiles; participants in the retest came from the short-term group

It is common practice in bilingualism research to employ monolingual speakers as the control group and view their performance as the “norm”. Establishing the baseline is essential to making comparisons and tracking linguistic performance; however, merely comparing bilinguals with monolinguals implies viewing bilingualism dichotomously (bilingual vs. monolingual). It contradicts our current understanding of bilingualism: a bilingual is not two monolinguals in one person (Grosjean, 1989, 2010). Furthermore, an increasing number of studies have shown that short-term training in a second language could lead to development in the neural encoding of speech (Song, Skoe, Wong, & Kraus, 2008, among others). Since English language education has been accorded much importance in the last quarter century in mainland China (Hu, 2005), adding the high frequency of international communication that we are all inevitably exposed to in daily life, it is practically impossible to recruit true monolingual speakers. Therefore, I used passive bilinguals as the control group (see Bonfieni et al., 2019, for similar practice).
Among the active bilinguals recruited in the U.K., 36 participants lived in the L2 environment (English speaking countries, including but not limited to the U.K.) for no less than 36 months; they are labeled as the long-term group. The remaining 40 participants are Chinese international students from the University of Edinburgh, who had lived in the U.K. for 8 months or less by the time the experiment took place. They are labeled as the short-term group, and 26 were retested six months later (labeled as the retest group). The difference in length of residence (LoR) is significantly different between the two tests ($p < .001^{***}$) (see Table 4.2).

<table>
<thead>
<tr>
<th></th>
<th>Short-term group</th>
<th>Retest group</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>23.43(1.75)</td>
<td>24.03(1.55)</td>
<td>NS</td>
</tr>
<tr>
<td>LoR (mths)</td>
<td>6(1)</td>
<td>12.04(0.9)</td>
<td>***</td>
</tr>
</tbody>
</table>

Table 4.2: Comparison between the short-term group and their retest; $t$-test; * : $p < .05$; ** : $p < .01$; *** : $p < .001$

Unlike the short-term group, participants from the long-term group were recruited from various channels, such as Chinese Sunday schools, local churches, and university staff members. Therefore, individual differences in occupation, income and education background within-group are expected to be than those of the short-term group. L2 proficiency, educational level and LoR were controlled for during the recruiting process (see Table 4.3).

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Short-term Group</th>
<th>Long-term Group</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25.92 (1.82)</td>
<td>23.43 (1.75)</td>
<td>26.75 (6.47)</td>
<td>**</td>
</tr>
<tr>
<td>LoR (mths)</td>
<td>NA</td>
<td>6 (1)</td>
<td>60 (46)</td>
<td>***</td>
</tr>
<tr>
<td>IELTS</td>
<td>6.56 (0.17)</td>
<td>6.82 (0.46)</td>
<td>7 (0.63)</td>
<td>NS</td>
</tr>
<tr>
<td>L2 Education</td>
<td>1 (0)</td>
<td>0.98 (0.08)</td>
<td>0.93 (0.15)</td>
<td>NS</td>
</tr>
<tr>
<td>Highest degree</td>
<td>0.5 (0)</td>
<td>0.74 (0.08)</td>
<td>0.74 (0.21)</td>
<td>NS</td>
</tr>
<tr>
<td>L1 proficiency Before</td>
<td>NA</td>
<td>0.86 (0.16)</td>
<td>0.85 (0.15)</td>
<td>NS</td>
</tr>
<tr>
<td>L1 proficiency Now</td>
<td>NA</td>
<td>0.86 (0.17)</td>
<td>0.73 (0.2)</td>
<td>**</td>
</tr>
<tr>
<td>L1 Use</td>
<td>NA</td>
<td>0.06 (0.16)</td>
<td>0.12 (0.22)</td>
<td>NS</td>
</tr>
<tr>
<td>L2 Proficiency Before</td>
<td>NA</td>
<td>0.47 (0.27)</td>
<td>0.51 (0.16)</td>
<td>NS</td>
</tr>
<tr>
<td>L2 Proficiency Now</td>
<td>NA</td>
<td>0.69 (0.18)</td>
<td>0.54 (0.14)</td>
<td>***</td>
</tr>
</tbody>
</table>

Table 4.3: Responses to the sociolinguistic questionnaire in three bilingual groups, and comparison (standard deviation in parentheses; $t$-test for numerical variables, Mann-Whitney U test for ordinal variables; ordinal variables coding: 0, 0.25, 0.5, 0.75, 1); * : $p < .05$; ** : $p < .01$; *** : $p < .001$; IELTS refers to the International English Language Testing System.
All participants reported themselves to be native Mandarin speakers, and they had achieved advanced to near-native English proficiency (IELTs score 6.5 and above). However, biological ages were significantly different between the short-term and the long-term bilinguals. Not only has age shown to be one of the predictors for the degree of L1 attrition (see Schmid & Köpke, 2017a, for a review), it is also an influential factor in general cognitive function and can affect online linguistic performance (Hendriks et al., 2014). So participants’ ages were recorded and factored in the later analysis. Note that the ‘L1 proficiency before/after’ and ‘L2 proficiency before/after’ were self-reported values on a 5-point Likert-scale. Even though they do not necessarily represent actual proficiency, they still provide valuable insight into participants’ confidence in their language skills.

We can see from Table 4.3 that all three groups did not differ significantly amongst each other, in terms of length of L2 education and IELTS scores, indicating similar L2 proficiency levels. It is typical for Mandarin-English bilinguals growing up in mainland China to receive foreign language education since elementary school (see Hu, 2005). One of the characteristics of Chinese foreign language education is the emphasis on grammar and vocabulary, and the lack of communication skills training. Thus, a similar length of L2 education does not necessarily indicate similar proficiency levels, so I used the IELTS test score as an additional screening criterion. IELTS is one of the most widely used ESL (English as a second language) tests, covering all four language skills: reading, writing, listening, and speaking. In terms of education level (highest degree), the control group consisted of undergraduate students; it significantly differs from the short-term and long-term group demographics, including mostly postgraduate students. Education level can affect participants’ linguistic performance, especially during controlled tasks (see Köpke & Schmid, 2004). Finally, both the long-term and short-term group bilinguals rarely use L1 in their daily communication.

4.2.2 Design and materials

As discussed in Section 4.1, acceptability judgments of Mandarin wh-topicalization can be affected by wh-types (wh-DP or wh-NP) and discourse conditions (D-linked or non-D-linked). Consequently, I used a 2 * 3 (wh-types * D-linking) within-subject factorial design for the stimuli (Table 4.4).
For experimental trials, there are two types of wh-phrases, and each has three conditions in terms of D-linking: non-D-linked, D-linking by contexts, or D-linking by intensifier ‘zui’ (most).

For non-experimental trials, there are also two types of wh-phrases, and each has two conditions in terms of grammaticality. The grammatical control conditions consist of wh-in situ sentences with the same wh-phrases and main verbs as corresponding experimental trials, but the wh-phrases stay in their base-generation positions. For the ungrammatical controls, I constructed ungrammatical wh-questions with superficially similar structures to the experimental sentences, but their ungrammaticality is not caused by illicit wh-topicalization.

There are 160 stimuli across ten conditions, among which 96 are experimental trials across six conditions. Each participant sees all 160 sentences, and sentences with the same main verbs were presented in different blocks (see Section 4.2.3.1 for details). Exemplar sentences are presented in 4.5, 4.6. For the full stimuli list, see Appendix B.

Note that the current design is not balanced concerning the grammaticality of the sentences: ungrammatical experimental sentences, adding the ungrammatical controls, consist of 40% of the stimuli. Because the wh-phrases and the main verbs among six experimental conditions have to be matched, it is not easy to obtain equal numbers of grammatical and ungrammatical items. I decided not to increase the number of ungrammatical control items so that the experiment’s length does not exceed participants’ attention span.

<table>
<thead>
<tr>
<th>Type</th>
<th>D-linking</th>
<th>Conditions</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex</td>
<td>non-D-linked</td>
<td>1. *Which bare</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td>D-linked</td>
<td>2. Which + context</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Which + most</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>4. In situ control</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. *Ungrammatical control</td>
<td>N = 16</td>
</tr>
<tr>
<td>Simplex</td>
<td>non-D-linked</td>
<td>6. *What bare</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td>D-linked</td>
<td>7. What + context</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. What + most</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>9. In situ control</td>
<td>N = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. *Ungrammatical control</td>
<td>N = 16</td>
</tr>
</tbody>
</table>

Table 4.4: Stimuli structures; * marks ungrammatical conditions
Stimuli norming  I recruited 12 participants who did not take part in the main experiment to complete an online questionnaire developed using the Qualtrics® survey software (Qualtrics, 2005). Firstly, I wanted to see if the grammatical and ungrammatical controls can be judged successfully; secondly, if participants can distinguish between wh-topicalization with and without D-linking. The Wilcoxon-signed rank test indicates that not only did participants successfully judged grammatical and ungrammatical controls ($p < .001^{***}$), they were also sensitive to different D-linking conditions ($p < .001^{***}$).
### Conditions | Exemplar sentences
---|---
1. **Which bare** | *Na-jian liwu Liu Xue xiang yao tui?*  
Which-CL gift Liu Xue wants to return  
*Which gift does Liu Xue want to return?*
2. **Which + context** | *Zai chunjie shoudao-de liwu dangzhong, na-jian liwu Xiao Zhang xiang yao tui?*  
Among Spring Festival received-poss gift loc, which-CL gift Xiao Zhang wants to return?  
‘Among the gifts received during the Spring festival, which gift does Xiao Zhang want to return?’
3. **Which + most** | *Na-jian liwu Xu Hui zui xiang tui*  
Which-CL gift Xu Hui most want-to return  
‘Which gift does Xu Hui want to return the most?’
4. **In-situ control** | *Li Lin xiang yao tui na-jian liwu?*  
Li Lin wants to return which-CL gift?  
‘Li Lin wants to return which gift?’
5. **Ungrammatical control** | *Ungrammatical sentences with which DP phrases*

**Table 4.5:** Stimuli examples Part 1; * marks ungrammatical sentences; words underlined appeared on the same frame in the SGJ presentation
<table>
<thead>
<tr>
<th>Conditions</th>
<th>Examplar sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. What + context</td>
<td>♦ Zai yijing xuan-de kecheng limian, Shenme Xiao Zhang xiang yao tui ♦ Among already chosen-poss courses loc, what Xiao Zhang wants to drop? ♦ ‘Among the courses she has already enrolled in, what does Xiao Zhang wants to drop?’</td>
</tr>
<tr>
<td>8. What + most</td>
<td><em>Shenme Xu Hui zui xiang tui?</em> ♦ What Xu Hui most want-to drop? ♦ ‘What does Xu Hui want to drop the most?’</td>
</tr>
<tr>
<td>9. In-situ control</td>
<td>♦ Li Lin xiang yao tui shenme? ♦ Li Lin wants to drop what ♦ ‘Li Lin wants to drop what?’</td>
</tr>
<tr>
<td>10. Ungrammatical control</td>
<td>♦ <em>Ungrammatical sentences with what NP phrases</em></td>
</tr>
</tbody>
</table>

**Table 4.6:** Stimuli examples Part 2; * marks ungrammatical sentences; words underlined appeared on the same frame in the SGJ presentation
4.2.3 Procedures

4.2.3.1 Speeded acceptability judgment task

Stimuli were presented electronically using the E-Prime 3.0 software (Psychology Software Tools Inc., 2016). During the experiment, participants sat in front of a computer in a sound-attenuating experiment booth. After 800 ms display of a fixation point, sentences were presented word-by-word (Table 4.5, 4.6) at the centre of the screen at a controlled speed (see Figure 4.1). Each phrase consists of 1-2 bisyllabic words (2-4 Chinese characters). Studies have shown that the word-by-word presentation format resulted in significantly more accurate comprehension than the character-by-character format; since Chinese words, rather than Chinese characters, are the reading unit (Lin & Shieh, 2006).

All materials were presented in a white against black background. Text and background color combinations with a more considerable color difference have been shown to yield significantly better reading performances (Wang & Chen, 2003). The presentation rate was 240 cpm (characters per minute, i.e., 250 ms for each character), and the presentation time for a bisyllabic word was 500 ms. According to Lin and Shieh (2006, p. 149), when the presentation rate is at 240 cpm instead of 500 cpm, a...
At the end of each sentence, participants judged the sentence’s acceptability a scale from 1 to 5, with 1 being completely unacceptable, and 5 being completely acceptable. They indicated their answers by pressing the corresponding button on an SR (serial-response) box. The question stayed on the screen until participants made the decision, or the time limit expired (3000ms). A 1000ms interval blank screen separated the sentences (Figure 4.1).

The 160 stimuli were divided into four blocks with 40 sentences in each block. Sentences from six experimental conditions and four control conditions were distributed equally in each block. There is the same number of *wh*-DP sentences and *wh*-NP sentences in each block. Sentences in each block were pseudo-randomized, with the restriction that sentences with the same verbs cannot be seen in the same block. Experimental blocks were presented in randomized order. Participants were given 3 minutes to rest in between blocks.

### 4.2.3.2 Complex span tasks

![Figure 4.2: Structure of complex span tasks (Foster et al., 2015:228)](image)

A shortened version of the complex span tasks developed by Foster et al.
Sentence processing in first language attrition (2015) was used to measure participants’ working memory capacity (WMC, Figure 4.2). Unlike traditional span tasks, complex span tasks used a dual-task paradigm, which has been shown to tap into higher-order cognition that involves both processing and storage components (Unsworth, Redick, Heitz, Broadway, & Engle, 2006; Oswald et al., 2015).

Instead of using the full battery of tests, I used one block from the operation span task (Ospan) and one block from the symmetry span task (Sspan). This combination was shown to predict 78.5% fluid intelligence in total; and it accounts for an additional 14.9% of the variance (of fluid intelligence) for virtually the same amount of time for conducting either task alone (Foster et al., 2015).

4.2.3.3 Cognitive control tasks

For measuring sustained attention (Elevator Task Sustained Attention), selective attention (Elevator Task with Distraction), and mental shifting (Elevator Task with Reversal), elevator counting subset version A from the Test of Everyday Attention (TEA) was conducted after the span tasks, strictly observing the procedure in the manual (Robertson et al., 1994, p. 14-18).

In the Elevator Task Sustained Attention (Elvt1), participants were asked to count the number of tones they heard, which signifies the elevator has passed one floor. The interval between each tones varies. This task was designed to test participants’ ability to maintain their attention. There are two practice trials and seven experimental trials in this task.

In the Elevator Task with Distraction (Elvt2), participants were asked to count the same tone they have heard before while ignoring the distracting tone, which is a higher tone. This task was designed to measure participants’ ability to inhibit interference and selectively pay attention to the relevant information. There are two practice trials and ten experimental trials in this task.

In the Elevator Task with Reversal (Elvt3), participants heard three different tones: a high-pitched tone, a neutral tone, and a low-pitched tone. The high-pitched tone signals that the elevator is moving up, while the low pitched-tone is moving down. The task starts with a neutral “floor” tone; the elevator always goes up first, but there will be either a high or a low tone every so often. If there is a
high tone, the subject is to say ‘up’ sub-vocally instead of counting, then continue to count upwards with the neutral tones. When a low-tone is heard, the elevator will stop going up and is about to go down. The subject must say ‘down’ sub-vocally and then count backward with the neutral tones. Another high tone will require the subject to start counting upwards again, and so on. This task was designed to measure participant’s ability to switch among different tasks flexibly. There are three practice trials and ten experimental trials in this task.

4.3 Results

4.3.1 Data analysis

There are two main questions I am trying to address here: whether the bilingual experience, such as the length of residence (LoR) and bilingual profiles, affects the acceptability judgments of *wh*-topicalization; and whether general cognitive abilities, such as attention and working memory, affect the judgment as well (see 4.1.4). To answer these questions, I evaluated the effect of group (reference level: the control group), type (reference level: what-NP), and condition (reference level: the Bare condition) on the acceptability judgment of *wh*-topicalization and the response latency, with linear mixed effects models (LMM; Baayen, Davidson, & Bates, 2008), using the lmer function of the lme4 package (version 1.1-12; Bates, Maechler, & Bolker, 2012) in RStudio (0.99.896; RStudio Team, 2015).

Before fitting the model, I removed 795 trials (3.54%) with response times less than 150 ms. Response times were then centered to have a mean of zero so that we could assume a normal distribution truncated at zero. Likert-scale ratings were treated as continuous data and standardized to have a mean of zero. Following the same practice, I also standardized the complex span task scores (*Ospan, Sspan*) and the elevator task scores (*Elvt1, Elvt2, Elvt3*) to aid convergence of LMMs. The descriptive statistics were presented in Table 4.7.

I ran separate analyses to evaluate the difference in response latencies and acceptability judgments. In all instances, I first fitted models using the maximal random effects structure (Barr, Levy, Scheepers, & Tily, 2013), except that correlations among random effects were fixed to zero to aid convergence (Matuschek, Kliegl, Va-
<table>
<thead>
<tr>
<th>Group</th>
<th>Type</th>
<th>D-linking</th>
<th>Likert-scale Rating</th>
<th>Response latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bare</td>
<td>3.60 (0.36)</td>
<td>695.45 (135.70)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Context</td>
<td>4.10 (0.29)</td>
<td>696.46 (155.52)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most</td>
<td>4.13 (0.36)</td>
<td>670.44 (177.67)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bare</td>
<td>2.99 (0.32)</td>
<td>793.44 (161.15)</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>Context</td>
<td>3.62 (0.26)</td>
<td>716.11 (166.96)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most</td>
<td>3.60 (0.28)</td>
<td>744.86 (134.20)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bare</td>
<td>3.84 (0.35)</td>
<td>907.61 (173.17)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Context</td>
<td>4.36 (0.35)</td>
<td>720.79 (214.52)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>4.48 (0.36)</td>
<td>704.51 (169.21)</td>
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<td></td>
<td></td>
<td>Bare</td>
<td>2.60 (0.34)</td>
<td>966.79 (173.87)</td>
</tr>
<tr>
<td></td>
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<td>3.33 (0.36)</td>
<td>869.80 (183.26)</td>
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<td>943.49 (173.85)</td>
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<td>765.51 (150.19)</td>
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<td></td>
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<td>781.46 (176.18)</td>
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<td>695.90 (155.46)</td>
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<td></td>
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Table 4.7: Descriptive statistics: Likert scale ratings and response latency (mean/sd) by group, type and discourse condition

As random effects, I fitted random intercepts for subjects and items. I also fitted by-subject and by-item random slopes for the effects of type and condition. In instances where the maximal random effects structure did not converge, I removed the effect of condition in the random effects structure.

As fixed effects, I incrementally entered group, type and condition into the model. The best fit model was selected using log-likelihood ratio tests comparing whether including additional predictors significantly improved the model’s fit. Both group and condition predictors were dummy coded, and the type predictor was contrast coded as (-.5, .5).
Other variables of interest, including WMC (Ospan, Sspan) and cognitive control abilities (Elvt1, Elvt2, Elvt3) were entered in the second stage of analysis to avoid over-fitting the model. Log likelihood ratio tests were also used to select the best fit model.

4.3.2 Analysis of cognitive control measures

Let us first look at the distribution of cognitive scores in working memory and attention span tasks. Figure 4.3, 4.4 and 4.5 showed the performance of three elevator tasks in the control group, the short-term group (first-test) and the long-term group. As we can see from Figure 4.3, there is no significant group-wise difference in their Elvt1 scores ($p > .05$) and all three groups’ performances are at ceiling.

![Elevator Task Sustained Attention](image)

**Figure 4.3:** Elevator Task Sustained Attention

Group differences started to emerge in the Elevator Task with Distraction (Elvt2). Simple linear regression with group as the independent variable showed that both the short-term and the long-term group outperformed the control group, indicating that active bilinguals are better at sustaining attention in noisy conditions than the passive bilinguals ($\beta = 29.41, SE = 5.13, t = 5.73^{***}$; $\beta = 26.69, SE = $...
4.96, \( t = 5.38^{***} \); Figure 4.4. Post-hoc test with Tukey method did not show significant difference in Elvt2 scores between the long-term and short-term group (\( p = .86 \)).

![Figure 4.4: Elevator Task with Distraction](image)

Again, both the short-term and the long-term bilinguals scored significantly higher in the Elevator Task with Reversal (Elvt3), suggesting that passive bilinguals were not as flexible as the other two groups when switching between different tasks (\( \beta = 35.00, SE = 5.48, t = 6.38^{***}; \beta = 39.78, SE = 5.30, t = 7.50^{***} \); Figure 4.5). Active bilinguals in the short-term and the long-term group did not differ significantly in Elvt3. (\( p > .1 \)).

![Figure 4.5: Elevator Task with Reversal](image)

In terms of the two measures of working memory, Ospan and Sspan, simple linear regressions with group as the independent variable returned null results for both measures (\( ps > .05 \)). Combined with the distribution pattern displayed in Figure 4.6 and 4.7, one can come to the conclusion that individual differences in the working memory capacity within-group mask any potential difference between
groups. It is not unlikely that between-group difference will emerge with a larger group size.

To discover if there is any improvement in terms of working memory and attention span within the short-term group between two tests, which were approximately 6 months apart, I ran simple linear regressions of 5 cognitive measurements separately, with group as the independent variable. The results did not show any significant improvement in sustained attention (Elvt1), mental switching (Elvt3), operation span (Ospan) or symmetry span (Sspan). There appears to be some improvement with marginal significance in the Elevator Task with Distraction (Elvt2); however, the effect size is small ($r = .27$) and it is equally possible that participants experienced practice effect ($\beta = 6.80, SE = 3.38, t = 2.01$; Figure 4.8).

In summary, active bilinguals both in the short-term and the long-term group outperformed the control group of passive bilinguals in Elevator Task with...
Distraction (Elvt2) and Elevator task with Reversal (Elvt3), which indicates that active bilinguals are better at resisting interference and switching between different tasks. The superior inhibition and task-switching abilities of active bilinguals may either be a sampling bias or an adaptive trait from managing two languages. All group performed at ceiling in Elevator Task Sustained Attention and there was no significant difference between groups in terms of verbal working memory (Ospan) and spatial working memory (Sspan).

4.3.3 Analysis of response latency

Response latency was collected and interpreted as a measure of computational complexity. One has to process the sentence before making a judgment, thus the time it takes for one to judge the sentence could be indicative of processing strategies or preferences. The methodology utilized in the current study, the speeded acceptability judgment task, is a version of timed grammaticality judgment task used to explore sentence processing. Generally speaking, long response latency would indicate processing difficulties, encountering ambiguous or ungrammatical utterances in non-pathological populations.

In Clifton and Fraizer’s (2004) study, they used two speeded judgment tasks...
experiments to test the given-before-new preference with double-object and NP-PP sentences. The authors interpreted the shorter reaction time of a certain structure as evidence of preference for said structure compared to the alternatives, and the judgment data was consistent with this interpretation.

Meng and Bader (2000) also administered speeded grammaticality judgment tasks to compare the processing of different types of ambiguous garden path sentences with the processing of corresponding ungrammatical sentences. The reaction time of correct responses were analysed and the results showed that (1) correct judgments to ambiguous sentences were associated with longer reaction times compared to unambiguous ones; (2) correct responses to agreement sentences took longer than correct responses to case sentences; (3) ungrammatical sentences were associated with the longest reaction time. Together with accuracy data, the reaction time data were associated with reanalysis (grammatical vs. ungrammatical sentences) and processing difficulty (ambiguous vs. unambiguous sentences).

To detect the between-group difference in response latency, and effects of discourse conditions and *wh*-phrase types, I created a linear mixed-effects model with the group, type, condition, an interaction term between group and condition, and an interaction term between group and type as fixed effects (m1). Including those fixed effects significantly improved the model in each step. Firstly, I want to investigate if response latencies differed significantly on a group level; secondly, whether different discourse conditions and *wh*-phrase types lead to significantly different response latencies; and finally, whether participants with different LoR and bilingual profiles reacted differently to the type and condition manipulations (for descriptive statistics of the response latency, see Table 4.7).

Results showed a significant group difference (Table 4.8). Compared to the control group (baseline), participants from the short-term group and the long-term group took more time judging the sentences ($\beta = 227.18, SE = 55.86, t = 4.07***; \beta = 159.17, SE = 57.38, t = 2.77**$). Also, *post hoc* test with Tukey adjustment revealed a significant difference within the short-term group between the first test and the retest: participants from the short-term group took less time judging the sentences in the retest ($\beta = -134.78, SE = 14.46, z = -9.32***$). No significant difference in response latencies was detected between the short-term and the long-term group.
As shown in Figure 4.9, passive bilinguals from the control group reacted with a similar speed in all three conditions ($p > .1$, NS). In comparison, active bilinguals from the short-term (first test) and the long-term group appear to have spent longer time judging sentences, especially in the Bare condition, compared to the Context condition and the Most condition. Significant interactions between group and condition confirmed this observation. The difference in response latencies between the Bare condition and the Context condition was significantly larger in the short-term group than the control group, with sentences in the Bare condition processed significantly slower than those in the Context condition ($\beta = -80.68, SE = 28.87, t = -2.79**$); similarly, differences between the Bare condition and the Most condition were also larger in the short-term group and the long-term group compared to the control group ($\beta = -75.79, SE = 28.86, t = -2.62**$);

Table 4.8: Estimated coefficients of mixed effect analysis (m1) on response latency of acceptability judgment task; $p < .1$, $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$
Sentence processing in first language attrition

**Figure 4.9:** Comparisons of response latencies among 4 bilingual groups across 3 conditions; error bars = standard error; control: passive bilinguals; short-term: active bilinguals 6 – 8mths LoR; retest: short-term retested after 6mths; long-term: active bilinguals ≥ 36mths LoR

\[
\beta = -82.91, SE = 29.66, t = -2.80**. \] It seems that with longer LoR in the L2 environment, participants experienced more difficulty judging sentences in the *Bare* condition.

I also found a significant simple effect of condition, meaning that participants generally spent less time processing *wh*-topicalization in the *Context* condition than they did in the *Bare* condition (\(\beta = -61.57, SE = 30.54, t = -2.02^*\)). Participants also appeared to have spent less time in the *Most* condition than in the *Bare* condition, but the difference did not reach statistical significance (\(\beta = -33.70, SE = 30.52, t = -1.10, NS\)). Recall that sentences in the *Context* and the *Most* conditions are grammatical, D-linked *wh*-topicalizations, while sentences in the *Bare* condition are not. Longer response latency in the latter condition could indicate that participants were less confident with their judgment, and they could have spent more time entertaining the grammatical alternatives. This interpretation requires further support from the acceptability judgment data.

---

\(^6\)Except for short-term bilinguals in the retest; for further discussion see Section 4.4.
In terms of the effect of type, we found that participants generally took less time processing \textit{wh}-topicalizations with \textit{wh}-DP than they did with \textit{wh}-NP ($\beta = -79.61, SE = 32.81, t = -2.43^{**}$). This effect was largely driven by participants in the short-term and long-term groups, while participants from the control group did not differ significantly in the response latency when processing different types of \textit{wh}-phrases ($p > .1$; Figure 4.10). Differences in response latencies between \textit{which} DP and \textit{what} NP was also smaller in the control group than in the short-term group or the long-term group ($\beta = -69.46, SE = 37.94, t = -1.83$; $\beta = -81.30, SE = 38.97, t = -2.09^{*}$).

To investigate the effect of cognitive control abilities on response latency to the linguistic task, I incrementally added results from the elevator counting tasks (Elvt1, Elvt2, Elvt3) and results from the complex span tasks (Ospan, Sspan) into the previous model (m1) as fixed effects (m2). Including Elvt1, Elvt3, Ospan, and Sspan significantly improved the fit of m2 in each step, while adding Elvt2 did not. It was then removed from the model. I found a significant effect of Elvt3, and participants with higher Elvt3 scores spent less time in the SGJ ($\beta = -26.35, SE = 6.42, t = -4.10^{***}$). Recall that Elvt3 is intended to reflect the ability to switch
among different tasks (mental shifting), and this result suggests that participants who were better at switching took less time to complete the task at hand than their peers. A similar effect was found with Sspan. Designed to measure the spatial working memory, the significant effect of Sspan indicates that participants with better spatial working memory spent less time in the SGJ ($\beta = -18.72, SE = 3.96, t = -4.73***$). No significant effect of Ospan was found.

To sum up, response latencies were significantly affected by participants’ bilingual experience, characteristics of the linguistic structure, and individual differences in general cognitive abilities. L1 attriters reacted slower than non-attriters when judging the acceptability of wh-topicalization. However, the short-term attriters became faster in the second test after six months. In terms of response latencies, participants in all groups appeared to distinguish among different discourse conditions and different wh-types, but to a different degree. Furthermore, participants with better mental shifting and larger spatial working memory took less time in the SGJ than their peers. Implications of these findings will be further discussed in Section 4.4.

### 4.3.4 Analysis of Likert-scale rating

To detect between-group differences in the acceptability judgments, and effects of discourse conditions and wh-phrase types, I created a linear mixed-effects model with group, condition, type, an interaction term between group and condition, and an interaction term between group and type as fixed effects (m3). Including those fixed effects significantly improved the model in each step. First, I want to investigate if the acceptability judgments differed significantly on a group level; secondly, whether different discourse conditions and wh-phrase types lead to a significant difference in the judgments; and finally, whether participants with different LoR and bilingual profiles reacted differently to the condition and type manipulations (for descriptive statistics of the Likert-scale rating, see Table 4.7).

Before analyzing the experimental trials, I first looked at the control stimuli. During the un-timed tasks in the stimuli norming (see Section 4.2.2), participants successfully distinguished between the grammatical and the ungrammatical controls ($p < .001***$). We need to be certain that participants can do the same in the experimental setting.
4.3.4.1 Analysis of non-experimental trials

Because the Likert-scale ratings for both grammatical and ungrammatical controls were not normally distributed ($W = 0.62, p < .001***$; $W = 0.88, p < .001**$), I ran the Wilcoxon signed-rank test (Wilcoxon, 1946) to compare responses to the grammatical and ungrammatical controls. Results showed that participants in the current experiment were able to distinguish grammatical and ungrammatical controls in their judgments ($V = 7.7e + 6, p < .001***$).

![Likert scale ratings for control stimuli](image)

**Figure 4.11:** Likert-scale ratings of control stimuli across 4 bilingual groups

4.3.4.2 Analysis of experimental trials

As expected, participants generally rated D-linked and non-D-linked wh-topicalization differently during the experimental trials. On average, sentences in the Context condition were rated 0.58 points higher than those in the Bare condition ($β = 0.58, SE = 0.06, t = 9.81***$), and sentences in the Most condition were rated 0.59 points higher than those in the Bare condition ($β = 0.59, SE = 0.06, t = 9.98***$).

In addition, there was a significant difference in judgments between two tests in the short-term group: participants rated all conditions significantly lower in the retest ($β = -0.22, SE = 0.02, z = -9.17***$). I also found significant interactions between group and condition. Compared to the control group, the difference in judgments between the Context condition and the Bare condition was smaller in
the retest group and the long-term group ($\beta = -0.23, SE = 0.05, t = -4.31***; 
\beta = -0.15, SE = 0.05, t = -3.21**$). The group condition interaction was not sig-
nificant when comparing the control group with the short-term group. These findings 
indicate that some active bilinguals were less likely to distinguish between D-linked 
and non-D-linked sentences.

**Figure 4.12:** Comparisons of acceptability judgments among 4 bilingual groups across 3 
conditions; error bars = standard error

Similarly, when I set the short-term group as the baseline for pair-wise com-
parisons, interactions between group and condition were also significant: differences 
in judgments between the *Context* condition and the *Bare* condition were smaller 
in the retest group and in the long-term group, compared to the short-term group 
($\beta = -0.22, SE = 0.06, t = -3.60***; \beta = -0.15, SE = 0.05, t = -4.40***$). In 
summary, active bilinguals did not distinguish D-linked and non-D-linked conditions 
as much as passive bilinguals in the control group; and among the active bilinguals, 
the longer they were immersed in the L2 environment, the less they distinguished 
between D-linked and non-D-linked conditions.

Results also showed that participants were more accepting towards *wh-*
topicalizations with *wh*-DPs than those with *wh*-NPs ($\beta = 0.55, SE = 0.12, t = 
4.48***$). Besides, differences in judgments between *wh*-DP and *wh*-NP were larger in 
the the short-term and long-term groups than in the control group ($\beta = 0.50, SE =$
0.16, \( t = 4.11^{***} \), \( \beta = 0.45, SE = 0.17, t = 2.71^{***} \). This result indicates that as participants spent more time in the L2 environment, their ability to link \( wh-NP \) to the discourse decreased, and they were less likely to accept \( wh-NP \) topicalizations than \( wh-DP \) topicalizations (Figure 4.13).

**Figure 4.13:** Comparisons of acceptability judgments among 4 bilingual groups between 2 \( wh \)-phrase types; error bars = standard error

To investigate the role of cognitive control abilities, I incrementally added \( Group \) * \( Elvt1 \), \( Group \) * \( Elvt3 \), \( Group \) * \( Ospan \), and \( Group \) * \( Sspan \) into the previous model (m3) as fixed effects (m4); including these effects significantly improved the model in each step. Results showed that the difference in Likert-scale ratings between the short-term group and the control group was smaller for participants with higher \( Elvt1 \) and \( Elvt3 \) scores (\( \beta = -0.29, SE = 0.06, t = -5.10^{***} \); \( \beta = -0.28, SE = 0.06, t = -4.40^{***} \)). In addition, the difference in Likert-scale ratings between the short-term group and the control group was smaller for participants with higher \( Sspan \) scores (\( \beta = -0.20, SE = 0.06, t = -3.27^{**} \)). These findings suggest that the short-term bilinguals with better-sustained attention, better mental shifting abilities, and larger spatial working memory were more likely to maintain their acceptability judgments at the native level.
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Table 4.9: Estimated coefficients of mixed effect analysis on performance of acceptability judgment task (Likert-scale ratings); \( p < .1, \) *\( p < .05, \) **\( p < .01, \) ***\( p < .001 \)

### 4.3.5 Summary of the results

Combining the response latency data and the judgment data, active bilinguals, both with short-term and long-term residence in the L2 environment showed signs of L1 attrition. Regarding the acceptability judgments of wh-topicalizations, both attriters and non-attriters rated the D-linked wh-topicalizations higher than the non-D-linked wh-topicalizations; which confirmed that D-linking is a necessary condition for Mandarin wh-topicalization. They also rated *wh*-topicalizations with *wh*-DPs higher than those with *wh*-NPs, both in the D-linked and non-D-linked conditions. This result showed that *wh*-NPs are less preferred than *wh*-DPs in wh-topicalization in native grammar, which is somewhat inconsistent with previous findings in Yuan
and Dugarova (2012) and Dugarova (2014). I will further discuss this discrepancy in Section 4.4. Furthermore, results showed significant differences between attriters and non-attriters in their acceptability judgments. Among attriters with different LoR, I found further evidence for L1 attrition and its sensitivity to the amount of time spent in the L2 environment: compared to the short-term group, participants in the retest, and the long-term group distinguished between the D-linked and non-D-linked conditions to a lesser degree.

In terms of the response latency data (see Figure 4.9, 4.10), I found that the control group participants reacted to different conditions and types with similar speed, and they were faster than all three active bilingual groups. It suggests that they were equally confident in their judgment across different conditions and types, and they did not find any of those conditions particularly tricky to judge. Note that the short-term participants were faster in the retest than the first test when they were judging the acceptability of \(wh\)-topicalizations. Compared to the control group, I found that participants from the long-term, the short-term, and the retest groups took more time processing non-D-linked \(wh\)-topicalizations and \(wh\)-topicalizations with \(wh\)-NPs than the alternatives (D-linked \(wh\)-topicalizations, and \(wh\)-topicalizations with \(wh\)-DPs). Despite the longer response latency, the acceptability judgment for those conditions/types were still significantly lower than the alternatives. These results could suggest uncertainty in their judgments, processing difficulties, or both. Moreover, both Elvat3 and Sspan significantly affected the response latency: participants with better attention switching abilities and larger spatial working memory were faster in judging \(wh\)-topicalization sentences.

In summary, we can see an overall decrease in discourse sensitivity, and an increase in difficulty when rejecting ungrammatical non-D-linked \(wh\)-topicalization among active bilingual speakers, whether they had lived in the L2 environment for eight months, 14 months, three years, or longer. In addition, participants’ capacities in attention control and working memory significantly affected the judgment process.

4.4 Discussion

The aim of this study is three-fold. I first compared the acceptability judgments of \(wh\)-topicalization among four bilingual groups to see whether this structure is sus-
ceptible to L1 attrition. Secondly, I investigated whether different linguistic features and bilingual experience affect the attrition process. Finally, I explored the cognitive factors involved acceptability judgments to see if the degree of L1 attrition is modulated by general cognitive abilities, such as attention and working memory.

My findings suggest that both the length of residence (LoR) and bilingual profiles (passive vs. active) affect the acceptability judgment of *wh*-topicalization, at least in the speeded presentation paradigm. Passive Mandarin-English bilinguals were used as the baseline in the comparisons. Unlike the three active bilingual groups living in the L2 dominant environment for an extended period, passive bilinguals had never been exposed to a naturalistic L2 environment. Despite they had reached an advanced to near-native proficiency in the L2, they did not use English for their daily communication. Recall that all three active bilingual groups showed decreased sensitivity to different discourse conditions than the control group, manifested as a decreased distinction between D-linked and non-D-linked conditions in their acceptability judgments. I interpret this change in linguistic behaviors as evidence for L1 attrition. In particular, the short-term group showed significant change in their judgments when they were retested six months later. Furthermore, the short-term group also differed significantly from the long-term group. These findings lend further support to my predictions: the syntax-discourse interface structure *wh*-topicalization is susceptible to L1 attrition; it is also sensitive to the length of exposure in the L2 environment.

Previous attrition studies showed inconclusive results in their grammaticality (or acceptability) judgment tasks ([de Bot et al., 1994; Köpke, 2002; Schmid, 2009; Schmid & Dusseldorp, 2010; Tsimpli et al., 2004]). Methodology differences could explain some of the inconsistencies because whether the task is timed and whether the context has been provided can significantly influence the results ([Mancini, 2018; Schütze, 2016]).

In an offline, untimed judgment task, researchers have no control over either processing time or processing strategy. Participants have the liberty to re-parse and re-analyze the sentence, or even go back to previous questions and revise their answers. Thus, traditional grammaticality judgment task is more likely to elicit a “carefully reasoned decision with some amount of deliberation” ([Schütze, 2016, p. 146]). Also, their processing strategy is likely to deviate from regular parsing, where more attention would be paid to comprehending the meaning than monitoring.
the well-formedness of sentences.

In the current experiment, with controlled speed of presentation and limited reaction time (3000ms), participants were less likely to recruit their explicit knowledge, which is less automatic and more time-consuming than implicit knowledge. They were “forced” to rely heavily on their intuition to make the judgments. It could also account for the discrepancies between the current and previous studies (Dugarova, 2014; Yuan & Dugarova, 2012). In contrast to their findings, the native speakers and the attriters in the current experiment disprefer *wh*-NPs in *wh*-topicalizations. The two previous studies used untimed, offline GJT, which allowed participants to entertain different interpretations of the sentence in all possible contexts, rather than simply evaluating the acceptability or plausibility of the sentence under the current context as in the current study.

In addition to methodology differences, violating hard or soft grammatical constraints has different consequences for acceptability judgments (Keller, 1998; Sorace & Keller, 2003; Sorace, 2006). Sorace and her colleges argued that violations of hard constraints trigger strong unacceptability, while soft constraints violations lead to mild unacceptability (Sorace & Keller, 2003). Besides, soft and hard constraints differ concerning cross-linguistic variation, making it incredibly relevant to L1 attrition studies. For late bilingual speakers whose L1 was fully developed before coming into contact with the L2, clear-cut, categorical grammatical constraints usually remain intact under the influence of the L2; while grammatical rules that requires integrating knowledge from different domains, such as discourse information and real-world knowledge, have shown to be vulnerable to cross-language influence (Sorace, 2000; Gürel, 2004, 2007; Tsimpi et al., 2004). Recall that the acceptability of *wh*-topicalizations is highly context-dependent, which is one of the properties of soft constraints (Sorace & Keller, 2003, p. 1512). Consequently, it is more likely to see changes in the acceptability judgments of *wh*-topicalization than other morphosyntactic structures, especially when using sensitive measurements like SGJ (Bader & Häussler, 2010).
4.5 Conclusion

This study investigated the acceptability judgments of *wh*-topicalization among Mandarin-English bilingual speakers with varying lengths of exposure to the second language. The results indicate that the length of residence in a second language environment modulates linguistic performance.

Using passive Mandarin-English bilinguals as the control group, I found that active bilinguals showed decreased sensitivity to different discourse conditions: even though their judgments for the non-D-linked *wh*-topicalizations were significantly different from those for the D-linked *wh*-topicalizations, the contrast between the two conditions were not as drastic as the control group. Regarding different *wh*-phrases, both the control group and the active bilingual groups showed a dispreference towards *wh*-topicalization with a simplex *wh*-NP like *what*, compared to *wh*-topicalization with a complex *wh*-DP like *which*. Based on those findings, I argue that the acceptability judgments of *wh*-topicalization are approaching “neutral” as L1 attrition progresses.

I also measured general cognitive abilities, such as attention control and working memory capacities. The results showed that the attention switching component and the spatial working memory component significantly correlated with response latencies. Furthermore, participants with more flexible attention control and better spatial working memory judged sentences more similarly to the control group. This finding indicates that general cognitive abilities modulates change in linguistic behaviours.

Last but not least, this study has shown that Speeded Acceptability Judgment Task, with careful stimuli design, consistent control of the presentation, and limited response latency, is an effective measurement to capture subtle change in bilinguals’ linguistic performance. Future studies are also encouraged to consider the gradience of acceptability when investigating linguistic changes in the L1 attrition. Because similar to the bilingual population, the acceptability is also a continuum.
Chapter 5

Reflexive processing in the first language attrition: the role of language, experience and cognitive load

5.1 Introduction

During a conversation, tracking and retrieving reference to pronouns is crucial to fully comprehending the speakers’ intention. Pronoun resolution involves not only linguistic knowledge, but also general cognitive functions such as attention and working memory (Brown-Schmidt, 2009; Cunnings & Felser, 2013). For bilingual speakers whose two languages differ in terms of pronominal syntax, this task could be even more challenging. Both languages in the bilingual mind are active and constantly interacting with each other: “not only does the native language influence the L2, but the L2 comes to influence L1 once bilinguals are adequately proficient in the L2” (Kroll et al., 2015, p. 378). This chapter presents the study that investigates reflexive processing in L1 attrition, among late Mandarin-English bilingual speakers. Investigating how bilingual speakers process reflexives in their native language not only adds to the literature of bilingual sentence processing, it can also further our understanding on how L1 processing may change as a result of the co-activation of two languages; this process is also broadly defined as L1 attrition (Schmid & Köpke, 2017b). For the purpose of the current paper, I limit the scope of L1 attrition to the adulthood, that means the onset of bilingualism is after complete acquisition and stabilization of the native language (cf. Flores, 2010).
Following Schmid and Köpke (2017a), I also view L1 attrition as a natural result of the co-activation of languages. Despite the negative connotation of the word “attrition”, L2-induced change in the L1 does not necessarily mean loss or erosion of the L1, nor was the change permanent or irreversible (see Chapter 2 for discussions of language co-activation). When investigating preferences of the relative-clause attachment, Dussias and Sagarra found that Spanish-English bilinguals with extensive exposure to English (≥ 7 yrs) attached the relative clause to the second noun, while Spanish-bilinguals with limited exposure (≤ 8 months) and Spanish monolinguals attached the relative clause to the first noun. Their findings indicate that parsing strategies in the L1 undergo change as a function of exposure to the L2, and the degree of change is modulated by the length of exposure to the L2 environment (Dussias, 2004; Dussias & Sagarra, 2007). Similarly, Chamorro and her colleges found that the degree of L1 attrition is sensitive to input changes. When immersed in the L2 environment, Spanish-English bilinguals showed different interpretation preferences for overt pronouns from the Spanish monolinguals. However, this L1 attrition effects decreased due to L1 re-exposure for as short as one week (Chamorro, Sorace, & Sturt, 2015). These findings show that the seemingly stable L1 system in late bilingual speakers remains open to influence from the L2. However, the underlying mechanisms remains unclear.

This chapter is structured as follows. In Section 5.1, I first introduce the linguistic properties of reflexive pronouns in Mandarin and how they differ from English reflexives (Section 5.1.1). I then review online processing studies of reflexive ziji among native Mandarin speakers (Section 5.1.2). Before presenting the current study (Section 5.2, 5.3), I reviews the literature on pronoun resolution and cognitive factors (Section 5.1.3) before I reviewed the L1 attrition studies pertaining to the pronominal system (5.1.4). In the end, I discussed the implications of the results in relation to L1 syntactic attrition and bilingual sentence processing in general (Section 5.4).

5.1.1 Pronoun resolution at the interface of syntax, semantics and discourse

There are two types of reflexives in Mandarin Chinese: one is the bare reflexive ziji ‘self’; the other is the compound reflexive, which combines ziji ‘self’ with a
pronoun, such as *taziji* ‘himself/herself’, *woziji* ‘myself’, and *nimenziji* ‘yourselves’. The compound reflexives behave in a similar way with their English counterparts. For example (Example 5a and 5b, cited from Huang, Li, & Li, 2008):

(5) a. *Zhangsan* zhidao *Lisi* lao piping *taziji*<sub>i/j</sub>.
   Zhangsan know Lisi constantly criticize himself
   “Zhangsan, knows Lisi criticizes himself<sub>i/j</sub> all the time.”

b. *Zhangsan* zhidao *[Lisi] rewei *taziji*<sub>i/j</sub> zui congming*.
   Zhangsan know Lisi think himself most clever
   “Zhangsan, knows that Lisi thinks he<sub>i/j</sub> is the smartest.”

However, when it comes to *ziji* in its bare form, it is not always bound within its local domain, as suggested by the Binding Principle (Chomsky, 1981). While local binding (LOC) is always possible (given that local binder is available), long-distance binding (LD) can appear under certain circumstances, thus causing ambiguities when there are more than one potential antecedents (Huang et al., 2008, see Example 6a and 6b).

   Zhangsan know Lisi often at others face criticize self
   “Zhangsan, knows that Lisi often criticizes him<sub>i</sub>/himself<sub>j</sub> in the presence of others.”

b. *Zhangsan* xiangxin *[Lisi] rewei [ziji<sub>i/j</sub>-DE erzi zui congming]*.
   Zhangsan believe Lisi think self-DE erzi most clever
   “Zhangsan, believes Lisi thinks that his<sub>i/j</sub> son is the smartest.”

The ambiguity can be resolved, using discourse information that favors either a local or a distant antecedent (Example 7a and 7b).
(7) a. \( Lisi_j \) xihuan zai beihou yilun bieren, \( Zhangsan_i \) zhidao \([Lisi_j\) chang zai bieren mianqian piping ziji/\( i_j\)].
Lisi like at behind-the-back judge people, Zhangsan know Lisi often at others face criticize self

“\( Lisi_j \) likes to judge people behind their back, Zhangsan, knows that Lisi often criticizes him/\( ?himself_i \) in the presence of others.”

b. \( Lisi_j \) hen shanyu fanxing, \( Zhangsan_i \) zhidao \([Lisi_j\) chang zai bieren mianqian piping ziji/\( i_j\)].
Lisi very good-at self-reflection, Zhangsan know Lisi often at others back criticize self

“\( Lisi_j \) is very good at self-reflection, Zhangsan, knows Lisi often criticize \( ?him_i/\)himself_i in the presence of others.”

The current study focuses on reflexive in its bare form ziji ‘self’, which differs from its English counterpart in the way that it can refer to distant antecedents beyond the local domain (Example 6a and 6b).

(8) a. *\( Zhangsan_i \) huida ziji.
Zhangsan answer self

*“Zhangsan_i answered self_i.”

b. \( Lisi_j \) rang Zhangsan_i huida ziji/\( i_j \).
Lisi ask Zhangsan answer self

“\( Lisi_j \) asked Zhangsan_i to answer him_i/\( *himself_j \).”

c. \( Zhangsan_i \) jiantao ziji.
Zhangsan reflect self

“Zhangsan_i reflected on himself_i.”
d. \( \text{Lisi}_{i} \text{ rang Zhangsan}_{i} \text{ jiantao ziji}_{i/j} \).

Lisi ask Zhangsan reflect self

“Lisi\(_i\) asked Zhangsan\(_i\) to reflect on *him\(_i\)/himself\(_j\).”

e. \( \text{Zhangsan}_{i} \text{ rang Lisi}_{j} \text{ buyao shanghai ziji}_{i/j} \).

Zhangsan ask Lisi no-to hurt self

“Zhangsan\(_i\) asked Lisi\(_j\) not to hurt him\(_i\)/himself\(_j\).”

Apart from the discourse information, the semantic meaning of the verb can also influence the binding of ziji to antecedents. Jin (2003) classified the Chinese transitive verbs into two categories according to whether these verbs can take ziji as an object. If the verb in a simple subject-verb-object (SVO) sentence cannot take ziji as an object, i.e., if the agent and the patient of the verb cannot be the same person, like in sentence 8a, then when this SVO sentence is used as a subordinate clause, like in sentence 8b, ziji can only be referring to the matrix subject. On the other hand, if the verb in a simple SVO sentence can only take ziji as an object, i.e., if the agent and the patient of the verb must be the same person, like in sentence 8c, then when this SVO sentence is used as a subordinate clause, like in sentence 8d, ziji can only be referring to the local subject (Jin (2003), cited from Li & Zhou, 2010). The first category is called reflexive verb, while the second is called non-reflexive verb (Li & Zhou, 2010, p. 98). There is a third category in which the verb can take both reflexive and non-reflexive as an object, and in this way, if the SVO sentence is used as a subordinate clause, ziji can refer to either the local or the matrix subject, causing ambiguity; like in sentence 8e.

To sum up, ziji can either refer to the local and the distant antecedents, while self is (almost) always bound within its local domain. Additionally, the interpretation of ziji can be affected by semantic meaning of the verb and discourse information in the current context. Converging evidence demonstrated that first language attrition usually occurs where the two languages have partial structural overlap (see Chapter 1 Section 1.1). The overlap between Mandarin reflexive ziji and English self makes it an ideal testing ground for cross-language interaction.
5.1.2 Online processing of zi ji

Even though long-distance binding (LD) of Chinese reflexive zi ji ‘self’ is formally possible, many experimental studies have shown that local binding (LOC) is easier to process for native mandarin speakers: participants either showed preference towards the local antecedents when more than one potential antecedents are available (Gao, Liu, & Huang, 2005; Liu, 2009); or process local bindings more quickly than long-distance bindings (Z. Chen, Jäger, & Vasishth, 2012; Jäger, Engelmann, & Vasishth, 2015; Li & Zhou, 2010). This phenomenon is called the “locality effect” (Shuai, Gong, & Wu, 2013).

Results from cross-modal priming studies indicate that at initial stages of processing, zi ji is more likely to refer to the local antecedent. Gao and colleagues (Gao et al., 2005; Liu, 2009) presented participants with audio stimuli in the form of Example (9). No context information was presented, and the semantic content was controlled for. Upon reaching the sentence-final zi ji, participants were presented with a visual probe word. When the probe was presented immediately after the anaphor, participants recognized probes that were semantic associates of local antecedents significantly more quickly; this locality effect disappeared (Gao et al., 2005), or reversed (Liu, 2009) at slightly longer SOAs (160ms or 370ms). The authors argued that the results indicated there are multiple stages of processing, and during the early stage of syntactic processing, local binding dominates over long-distance binding.

(9) Laoshi, gaosu jizhe, yao zunzhong zi ji, i
Teacher tell journalist should respect self

“The teacher, i told the journalist, j to respect him, i/himself, j.”

Similar results were obtained using a self-paced reading paradigm. Chen and his colleagues (2012) found that a locally bound zi ji was read more quickly than a zi ji bound with a distant antecedent (distances between the antecedent and the anaphora were matched across conditions). In addition, the interference effect induced by animate interposed NPs was only present in the long-distance binding conditions, which provided further support that long-distance binding is

1For procedures of cross-modal priming, see (Nicol & Swimney, 1989)
more difficult to process than local binding. The results from Cheng et al. (2012) were later replicated in an eye-tracking-while-reading study (Jäger et al., 2015). Together, these studies showed that long-distance binding was more time-consuming and error-prone than local binding. Results also showed that syntactic information, as well as semantic information (i.e., animacy) is used in the processing of ziji, thus putting reflexive ziji at the syntax-discourse interface.

In addition to the behavior research, Li and Zhou (2010) conducted an EEG/ERP experiment in Mandarin, measuring the electrophysiological response to the anaphor ziji in sentences like 10a and 10b.

(10) a. Xiaoli_i rang Xiaozhang_j buyao weizhuang ziji_i/j.
   Xiaoli ask Xiaozhang not-to disguise self

   “Xiaoli_i asked Xiaozhang_j not to disguise *him_i/himself_j.”

b. Xiaoli_i rang Xiaozhang_j buyao qianlian ziji_i/j.
   Xiaoli ask Xiaozhang not-to embroil self

   “Xiaoli_i asked Xiaozhang_j not to embroil him_i/*himself_j.”

Li and Zhou observed a significantly larger positivity (P300/P600) at ziji, when the semantic meaning of the verb blocked the local binding, forcing ziji to bind with a distant antecedent (Example 10b), compared to when the semantics of the verb confined ziji at its local domain (Example 10a). Traditionally, P300 has been associated with the cognitive process of memory updating, while P600 associated with difficulty in syntactic integration, reanalysis or repair process. The results suggested that long-distance binding requires more processing resources, probably due to its violation against the Binding Principle A (Li & Zhou, 2010).

In summary, interpretations of reflexive ziji can be influenced by either discourse or semantic information in the context, placing the pronominal structure in Mandarin at the interface of syntax and discourse, or syntax and semantics. Compared to the local binding, binding ziji outside of the local domain appears to be more demanding, manifested as larger response latencies and enhanced brain activities. It is worth mentioning that, in the syntax-discourse conditions, binding
ziji ‘self’ with the less preferable antecedent will not lead to ungrammaticality; it will, however, in the syntax-semantics conditions.

5.1.3 Cognitive factors involved in pronoun processing

In Chapter 1, I discussed the vulnerability of syntax-discourse and syntax-pragmatic interface structures in L1 attrition (Section 1.1, 1.3), which could be partly attributed to the amount of computation required to integrate syntactic rules and contextual information in real-time (Sorace, 2011, 2016). For example, pronoun resolution requires rapid retrieval and integration of discourse information, while excluding inappropriate pronoun-antecedent mappings based on syntactic, semantic constraints and perspective information (Brown-Schmidt, 2009).

Studies showed that even monolingual speakers sometimes struggle with syntax-discourse interface structures, such as pronoun resolution. Hendriks and colleagues found that both children and elderly adults were less efficient than young adults in pronoun resolution (Hendriks et al., 2014). They investigated the production of reflexive pronouns at different discourse positions (introducing, maintaining, and re-introducing the referent) and the comprehension of reflexives in sentences with or without topic-shifts. Results showed that compared to young adults, who were highly sensitive to the informational needs of hypothetical conversation partners in both production and comprehension, children and elderly adults performed inconsistently. Children failed to consider the other person’s perspective in both tasks: they tended to produce ambiguous pronouns that were unrecoverable by listeners; they were also insensitive to topic-shift markers made by speakers. Elderly adults, on the other hand, considered the perspective of hypothetical conversation partners in both tasks, but they produced many more full NPs than necessary, which showed they lacked the cognitive capacity to keep track of the discourse prominence of referents. The authors concluded that referential choice depends on perspective-taking as well as cognitive capacity, which fluctuates across the lifespan.

Along the similar vein but with a focus on working memory capacity (measured by the reading span task), Nieuwland and Van Berkum (2006) conducted an EEG/ERP study to measure the response to referential ambiguities among participants with varying working memory capacities. They found that readers with high reading span scores were more sensitive to referential ambiguity than the low-span
group. The result suggested that working memory is taxed by referential ambiguities.

Furthermore, van Rij and colleagues presented stimulations based on the ACT-R computer model, which predicted that working memory constraints only affect adults’ pronoun resolution in stories with a topic shift, but not those without (J. R. Anderson, 2007). They tested this prediction in a dual-task experiment, where participants performed moving-window comprehension task while holding three or six digits (low and high working memory load conditions) in the working memory for later recall. The offline data confirmed the prediction, in that participants showed more difficulties detecting topic shifts in the high working memory load condition than the low working memory load condition; no such effect was found in stories without topic shifts. In other words, sufficient working memory resources are needed for pronoun resolution, especially when the cognitive load is high.

The dual-task analogy for bilingual language processing is not new (Sandoval, Gollan, Ferreira, & Salmon, 2010). If we can draw a parallel between the extra working memory load in a dual-task experiment and the additional demand from the bilingual language control, it stands to reason that bilingual speakers in L1 attrition are at least as susceptible to processing breakdown as monolingual speakers under extra processing load, if not more.

5.1.4 Attrition to the pronominal system

The last two decades have witnessed a wealth of literature on L1 attrition and pronoun resolution, especially since Sorace and colleagues proposed the Interface Hypothesis (2006). The term “interface” in Interface Hypothesis is best described as “the interaction and integration of information between the core computational system and other linguistic or non-linguistic domains” (White, 2011).

Just like the field of bilingualism, Interface Hypothesis has undergone several transitions. First proposed to account for the residual optionality of end-state L2 acquisition (Sorace & Filiaci, 2006), it was later extended to account for the emerging optionality in bilingual first language acquisition (Sorace & Serratrice, 2010).
and in L1 attrition among late bilingual speakers with near-native proficiency in their L2 (Sorace, 2011). The theory evolved from a dichotomy of “narrow syntax” and “interface” (Tsimpli et al., 2004; Sorace & Filiaci, 2006) to a more fine-grained distinction between “internal interfaces” (e.g., syntax-semantics interface) and “external interfaces (e.g., syntax-discourse interface) (Tsimpli & Sorace, 2006; Sorace, 2011).

The current hypothesis postulates that structures that involve syntax and other cognitive domains, such as discourse and pragmatics, are more difficult to acquire fully in advanced L2 acquisition; they are also more vulnerable to early L1 attrition compared to structures without such interfaces. Furthermore, it argues that the effect of L1 attrition among late bilinguals does not involve the underlying knowledge, but rather the ability to integrate that knowledge in real-time processing. One of the reasons that “interface structures” behave differently from others, is that integrating information from different linguistic and cognitive domains is taxing on bilinguals’ cognitive resources which would otherwise be used to resolve competition from the non-target language (Green, 1998), leaving bilinguals performing inconsistently (Sorace, 2011, 2016). Interface Hypothesis attributed the selectivity in L1 attrition not only to the influence from the second language, but also to the computation complexity of interface structures and to the limited cognitive resources of an overburdened speaker.

Since its proposal, the pronominal system has been a popular testing ground for Interface Hypothesis because comprehending and producing pronouns requires rapid integration of the linguistic domains like syntax and semantics with the extralinguistic domains, such as pragmatics and discourse. Consider the use of null and overt subject pronouns in null-subject languages, such as Italian and Spanish. Different from non-null subject languages like English, they allow null subject pronouns depending on the context. Generally speaking, null pronouns signal the continuation of a topic (i.e., old information), while overt pronouns signal a topic-shift (i.e., new information). The distribution of null and overt pronouns is governed by both syntactic rules and discourse information, and the processing involves retrieving and integrating the syntactic and discourse information.

Tsimpli and colleagues (2004) were among the first to investigate the attrition of pronoun resolution against the predictions of Interface Hypothesis. More accurately, the hypothesis Tsimpli and colleagues had in mind at the time of the ex-

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English bilinguals in the U.K. with a minimal length of residence of 10 years were tested, along with their monolingual peers in Italy. Results from the picture verification task in the forward anaphora condition showed that compared to their monolingual peers, Italian-English bilingual speakers overextended the use of overt pronouns (i.e., using overt pronouns in topic-continuation contexts), while their interpretation of null pronouns remained native-like.

Working with the Turkish-English bilingual population, Gürel (2004) also detected attrition to the Turkish overt pronoun *o* but not to the overt reflexive *kendsi* or the null pronoun *pro*. In referential pronominal contexts during a storytelling task, Turkish-English bilinguals allowed significantly more bound interpretations of the overt pronoun *o* than their monolingual peers, which, in native grammar, should strictly obey the Binding principle B (Chomsky, 1986) and follow the disjoint reading. Later, the same pattern was observed during the picture verification task. Gürel attributed the selectivity of L1 attrition to either the frequency of use or syntactic properties of the pronouns, or both (Gürel, 2004, p. 74-75). The finding is in line with the prediction of Interface hypothesis that syntax-discourse interface structures are sensitive to L1 attrition. In contrast, in a later study where Gürel investigated the pronoun use of English-Turkish speakers who lived in Turkey for an extended period, she did not find any attrition in their binding interpretations (2007).

Spanish-English bilinguals are another population of interest when studying the attrition patterns in pronoun use. Chamorro and colleagues also found the over-extension of overt pronouns among Spanish-English bilinguals in L1 attrition using both online and offline measures (hearafter attriters; 2015). In the eye-tracking study, monolingual Spanish speakers showed a strong preference for overt pronouns to co-refer with object antecedents; in contrast, attriters did not exhibit sensitivity to one antecedent over another. However, in the offline acceptability judgment task with the same stimuli, attriters displayed intact knowledge of the use of null versus overt pronouns, and their performance did not diverge from the monolingual norm. A notable feature of their findings is that the use of overt pronouns was susceptible to L1 attrition after being exposed to the L2 environment for a relatively short period—5 years, compared to a minimum of 10 years in the Tsimpli et al. (2004) experiment was the sensitivity of interpretable features [+Interpretable] proposed by Sorace (2000), which could be considered the precursor or the first version of Interface Hypothesis (see also White, 2011).
The short time-span during which optionalities emerge in bilingual speakers’ native grammar demonstrated the vulnerability of pronoun resolution to language attrition.

The studies reviewed so far have focused on late bilinguals, people whose onset of bilingualism started after the native grammar had been fully established and entrenched. Studies with heritage speakers, simultaneous or sequential early bilinguals whose onset of bilingualism started before complete acquisition of the heritage language, also lend some support to the Interface Hypothesis regarding the vulnerability of syntax-pragmatics and syntax-discourse interface structures.

Using a story-retelling task (Little red riding hood), Montrul (2004) collected and compared subject pronominal expressions from 14 intermediate, 10 advanced heritage and 20 monolingual speakers of Spanish. Results showed that although they showed robust syntactic knowledge of null subjects, intermediate heritage speakers overextended their overt subject pronouns (with a 50% error rate), which significantly deviates from the monolingual speakers and the advanced heritage speakers.

As one of the first study that investigates a language combination that have different scripts, Kim and colleagues tested both early and late Korean-English bilinguals for their binding interpretations of Korean reflexive caki (‘self’) (2010). Different from its English counterparts (himself or herself), caki has a wider Governing Category (Chomsky, 1986), where it can bind the antecedent it does not c-command (Kim et al., 2010, p. 5). Using a Truth Value Judgment Task with stories, Kim and colleagues measured the acceptability of sentences with caki by early Korean-English bilinguals (incomplete L1 learners), late Korean-English bilinguals (L1 attriters), late English-Korean bilinguals (incomplete L2 learners) and monolingual Korean speakers. Kim and colleagues did not find the expected L1 attrition effects in the L1 attrition group because their performance was similar to Korean monolinguals while incomplete L1 and L2 learners patterned alike (Kim et al., 2010, p. 10). Kim and colleagues argued that the lack of attrition effects can be accounted for by frequent if not dominant L1 use by potential L1 attriters, who were recruited.

4 Until recently, researchers generally use “10-year-stay in the L2 country” as a recruitment criterion for participants in L1 attrition studies (Gürel, 2004, p. 60). The tacit assumption was that L1 syntactic attrition took a long time and prolonged L2 immersion to manifest (if at all) (de Bot & Glyne, 1994, p. 27).
from close-knit Korean communities. The small sample size could also have contributed to the null result.

To sum up, L1 attrition to the pronominal system among late, mature bilingual speakers is probable after extended immersion in the L2 environment. However, the underlying mechanism, the contributing factors and the degree of L1 attrition remains controversial. Early bilinguals, however, depending on their proficiency levels, could either align with the native speakers or L2 learners, due to the incompleteness of their L1 acquisition. Different features of the pronominal system go through attrition differently, for example, null and over pronouns. Although the finding regarding the vulnerability of interface structures, especially those pertaining to syntax-pragmatics or syntax-discourse interface is not unanimous, a repeating pattern has emerged in null subject languages where potential attriters over-extend their overt pronouns during comprehension and production. Their vulnerability could be partly attributed to the amount of computing required to integrate syntactic rules and contextual information in real-time language use. In the bilingual mind where knowledge and information from both languages are simultaneously activated (see Chapter 2), tracking discourse information and rapidly integrating it with other linguistic knowledge is not an easy task.

5.1.5 Research questions and predictions

To sum up, pronoun resolution requires speakers to rapidly retrieve and integrate syntactic rules and discourse information, which can be taxing on working memory capacities and attentional resources. Additionally, bilingual speakers experience decreased L1 activation and increased cognitive demands in maintaining two languages, pronoun resolution is expected to be particularly susceptible to L1 attrition.

Furthermore, Sorace (2016) proposed a a “trade-off” between the inhibition abilities and the ability to integrate information from multiple resources in real-time, assuming that ‘anaphora dependencies (partially) draw on the same pool of attentional resources used to keep the two languages separate’ (2016, p. 9), This potential trade-off could be the loci of difficulty when processing anaphora dependencies online. Thus, the research questions and predictions of the current study is as follows.
1. For bilingual speakers with different length of residence (<8mths, 8–12mths, >36mths), and different bilingual profiles (passive vs. active bilinguals), do they show different reflexive-antecedent binding patterns on a group level when processing the reflexive ziji on-line? More specifically:

(a) Would there be an “locality effect” in on-line reflexive processing among bilingual speakers, the same way to saw in monolingual speakers in previous studies?

(b) If there were any attrition effects, would they be different at the syntax-discourse interface and the syntax-semantics interface?

2. If they do, would the general cognitive abilities, such as attention and working memory, affect their on-line comprehension?

I expect the binding interpretations of reflexive ziji to be sensitive to language attrition; and I expect participants of the long-term group to experience more attrition effects. Accordingly, they are expected to refer ziji more frequently to the local antecedent, regardless of the discourse context. Even though ziji ‘self’ in its bare form can be bound outside the local domain, the locality effect during online comprehension indicates that binding ziji with a distant antecedent requires more cognitive resources (see Section 5.1.2), which would otherwise be used to inhibit interference from the irrelevant antecedent or the irrelevant language (L2 English).

I also expect there to be an effect of the interface: syntax-discourse interface (i.e., the external interface) being more affected by L1 attrition than the syntax-semantics interface (i.e., the internal interface). Finally, I expect there to be correlations between the cognitive control abilities, such as working memory and attention, and the linguistic performance of bilingual speakers.

Regarding the exact influence of cognitive abilities, I do not have a prediction at this stage simply because the relationship between cognitive abilities and linguistic performance is not linear, especially in the bilingual population. On the one hand, maintaining two languages is taxing on the limited cognitive resources and individuals’ cognitive capacities will constrain their ability to perform certain tasks; on the other hand, bilingual experience can shape individuals’ cognitive functions so that they are adept to the linguistic environment (see Chapter 3, Section 3.3).

The cognitive measures collected in the current experiment will be entered
as control variables instead of predictive variables in the statistical analysis for two reasons. Firstly, due to time limitations, only working memory and attention spans were measured, which will not give a comprehensive picture of individuals’ cognitive capacities to be able to predict their attrition trajectories; secondly, as I discussed previously, the non-linear, bi-directional relationship between experience and cognition determine that they work jointly to shape the linguistic outcome. Accordingly, it is more appropriate to treat the cognitive measures as control variables instead of predictive ones.

5.2 Methods

In this study, participants were asked to complete a word-by-word speeded comprehension task, followed by two complex span tasks, three elevator counting tasks, and a sociolinguistic questionnaire. The speeded comprehension task was presented in the rapid serial visual presentation (RSVP) format, followed by a two-alternative forced-choice (2AFC). The target structure is Chinese reflexive *ziji*, which, unlike its English counterparts, allows for both local binding and long-distance binding (see Section 5.2.1).

The complex span tasks were designed to measure working memory capacities (Oswald et al., 2015), which have shown to be influential during L1 and L2 pronoun resolution (Cunnings & Felser, 2013; Hendriks et al., 2014; Nieuwland & van Berkum, 2006). The elevator counting tasks were taken from the Test of Everyday Attention (TEA). They were designed to measure cognitive control abilities, including sustained attention, attention inhibition and mental shifting (Robertson et al., 1994). I adapted the sociolinguistic questionnaire from Schmid and Dusseldorp (2016) to record participants’ background information and language experience. Details of the materials and procedures are presented in Section 5.2.2 and 5.2.3.

The original questionnaire was shortened and translated into Mandarin. It can be retrieved from languageattrition.org; for English translation of the adapted Chinese questionnaire, see Appendix A.
5.2.1 Participants

A total of 115 Mandarin-English bilinguals participated in the experiment (see Table 5.1) participated in the experiment. Among them, 76 participants were recruited in Edinburgh U.K., while the rest 39 participants were recruited in Chongqing, China. The U.K.-based participants are categorized as active bilinguals because they had been immersed in the L2 English environment, and all reported to use both languages daily. In comparison, the China-based participants had never stayed in any English-speaking country for more than a month; they have previous English knowledge, but it was acquired as a foreign language and used in a classroom environment. So the China-based participants are categorized as passive bilinguals (see Grosjean, 2010, for definitions of active and passive bilinguals).

<table>
<thead>
<tr>
<th>Location</th>
<th>Group</th>
<th>Number</th>
<th>Age (mean and standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>Mandarin-English passive bilinguals (Control)</td>
<td>39</td>
<td>25.92(1.82)</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Mandarin-English short-term bilinguals (Short-term)</td>
<td>40</td>
<td>23.43(1.75)</td>
</tr>
<tr>
<td></td>
<td>Mandarin-English short-term bilinguals (Retest)</td>
<td>26</td>
<td>24.03(1.55)</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>Mandarin-English long-term bilinguals (Long-term)</td>
<td>36</td>
<td>26.75(6.47)</td>
</tr>
</tbody>
</table>

Table 5.1: Participants profiles; participants in the retest came from the short-term group

In bilingualism research, it is common practice to employ monolingual speakers as the control group and view their performance as the “norm”. Although it is essential to establish a baseline to compare different populations, simply comparing bilinguals with monolinguals implies viewing bilingualism in a dichotomous manner (bilingual vs. monolingual). It contradicts our current understanding that a bilingual is not two monolinguals in one person (Grosjean, 1989, 2010). In addition, an increasing number of studies have shown that short-term training in a second language could lead to development in the neural encoding of speech (Song et al., 2008, among others). In mainland China, English language education has been accorded much importance in the last quarter-century (Hu, 2005), so it is practically impossible to recruit monolingual speakers in the “traditional” sense. Therefore, for both practical and theoretical reasons, I decided to break from the “common practice” and use passive bilinguals as the control group (for similar practice see Bonfieni et al., 2019).

Among the 76 active bilinguals recruited in the U.K., 36 participants had been living in the L2 environment (English speaking countries, including but not
limited to the U.K.) for 36 months and above; they are labeled as the **long-term group**. The rest 40 participants were Chinese international students from the University of Edinburgh, who lived in the U.K. for eight months and below by the time the experiment took place. They are labeled as the **short-term group**, and 26 were retested six months later (labeled as the **retest group**). The difference in length of residence (LoR) is significantly different between the two tests ($p < .001$***) (Table 5.2).

![Table 5.2](chart3.png)

Table 5.2: Participants: short-term group and their retest

Unlike the short-term group, participants from the long-term group were recruited from various channels, such as Chinese Sunday schools, local churches, and university staff members. Therefore, individual differences in occupation, income, education background within-group are expected to be bigger than those of the short-term group. Previous studies have abundantly demonstrated the impact of external factors on bilinguals’ language abilities, such as educational level, language contact, and LoR (see Section 1.2). So I controlled for the L2 proficiency, educational level, and LoR during participant recruitment (see Table 4.3), and I also recorded the quality and quantity of language contact through the sociolinguistics questionnaire.

![Table 5.3](chart4.png)

Table 5.3: Responses to the sociolinguistic questionnaire in three bilingual groups, and comparison (standard deviation in parentheses; t-test for numerical variables, Mann-Whitney U test for ordinal variables; ordinal variables coding: 0, 0.25, 0.5, 0.75, 1): * : $p < .05$; ** : $p < .01$; *** : $p < .001$. 

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All participants reported themselves to naive Mandarin speakers, who had advanced to near-native English proficiency- IELTS (International English Language Testing System) score 6.5 and above. However, biological ages were significantly different between the short-term and the long-term bilinguals. Not only has age shown to be one of the predictors for L1 attrition (see Schmid & Köpke, 2017a, for a review), it is also an influential factor in general cognitive function, which can affect online linguistic performance (Hendriks et al., 2014). So the age difference was recorded and factored in the later analysis (Table 5.3). Note that the ‘L1 proficiency before/after’, and ‘L2 proficiency before/after’ were self-reported values on a 5-point Likert-scale. Even though they do not necessarily represent actual proficiency, they provide valuable insight into participant’s confidence in their language skills.

We can see from Table 5.3 that all three groups did not differ significantly amongst each other in terms of length of L2 education and IELTS scores, indicating similar L2 proficiency levels. It is typical for Mandarin-English bilinguals growing up in mainland China to have received formal language education since elementary school (Hu, 2005). One of the characteristics of Chinese foreign language education is the emphasis on grammar and vocabulary, and the lack of communication skills training. Thus, a similar length of L2 education does not necessarily indicate similar proficiency levels. The IELTS score was used as an additional screening criterion. IELTS is one of the most widely used ESL (English as a second language) tests that cover all four language skills: reading, writing, listening, and speaking. Regarding education level (highest degree), the control group consisted of undergraduate students; it significantly differs from the short-term and long-term group demographics, which included mostly postgraduate students. Education level can affect participants’ linguistic performance, especially in controlled tasks (see Köpke & Schmid, 2004). Finally, both the long-term and short-term group bilinguals rarely use L1 in their daily communication.

### 5.2.2 Design and materials

A total of 160 experimental sentences were initially created, among which 86 sentences were adapted from the stimuli used in Li and Zhou (2010). After stimuli norming, 144 sentences were finally selected for the experiment. All sentences have the “context sentence + target sentence (P-NP1 + VP1 + P-NP2 + VP2 + ｚिज)”
structure (see Table 5.4). The critical word *ziji* was always at the sentence-final position, followed by a comprehension question about the referent of *ziji*.

**Stimuli structure**  I used a $2 \times 2$ (interface * distance) within-subject factorial design to investigate the interface and binding distance effects, as shown in Table 5.4. There are equal numbers of LD-biased and LOC-biased sentences in both the syntax-discourse and syntax-semantics conditions.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Distance</th>
<th>Number of trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax-discourse</td>
<td>Local binding (LOC)</td>
<td>$N = 40$</td>
</tr>
<tr>
<td></td>
<td>Long-distance binding (LD)</td>
<td>$N = 40$</td>
</tr>
<tr>
<td>Syntax-semantics</td>
<td>Local binding (LOC)</td>
<td>$N = 32$</td>
</tr>
<tr>
<td></td>
<td>Long-distance binding (LD)</td>
<td>$N = 32$</td>
</tr>
</tbody>
</table>

**Table 5.4: Stimuli structures**

In the syntax-discourse conditions, discourse information from the context sentences was responsible for directing the reflexive reference towards either the matrix subject (P-NP1) or the local subject (P-NP2). Also, the same set of verbs were used in both the LD-biased and the LOC-biased conditions. The same 40 pairs of proper names (in the matrix subject and the local subject positions) were used in the LD-biased and LOC-biased syntax-discourse conditions.

In comparison, in the syntax-semantics conditions, the verbs’ semantic meaning was sufficient for identifying the reference of *ziji*; context sentences in those two conditions were not relevant to the pronoun resolution. Their purpose is to keep the sentence structure consistent between the syntax-discourse and syntax-semantics conditions. As discussed in Section 6.1.1, reflexive verbs were used in the LOC-biased, syntax-semantics condition, and non-reflexive verbs were used in the LD-biased condition. The same 32 pairs of proper names, different from those used in the syntax-discourse conditions, were used in theses two conditions.

The effect of prominence, or more specifically, the “first mention effect”, was considered when constructing the context sentences. Half the context sentences were constructed with matrix subjects mentioned first, and the other half with local subjects mentioned first.

Note that semantic cues in the syntax-semantics conditions and discourse
cues in the syntax-discourse conditions have different effects on the sentences’ grammaticality. In the syntax-semantics conditions, the reflexive-antecedent binding is categorically determined by the verb’s semantic meaning, which is to say, if participants choose to bind the antecedent with the matrix subject (P-NP1) in a sentence with a reflexive verb, it would be ungrammatical. In contrast, the LD-biased or the LOC-biased discourse information does not affect the grammaticality, rather than the sentence’s plausibility. That is to say, if participants choose to bind the antecedent with the local subject (P-NP2) in the LD-biased syntax-discourse condition, it would be implausible, but still, syntactically correct.

**Stimuli norming**  Ten other Mandarin-English passive bilinguals recruited from the same population as the control group participants were asked to complete an online questionnaire developed using Qualtrics survey software (Qualtrics, 2005). They were asked first to answer whether ‘ziji’ (self) was referring to the distant (P-NP1) or the local subject (P-NP2), and then to rate on a 7-point Likert scale to what extent ziji could refer to the distant (point 1) or the local subject (point 7).

For the chosen 40 sentences in the syntax-discourse, LD-biased condition, at least eight participants judged ziji to be referring to the matrix subject (P-NP1); the average score was 1.75 (SD = 0.47), meaning that the reflexive-binding was strongly biased towards the long-distance antecedent. For the 40 sentences in the syntax-discourse, LOC-biased condition, at least eight participants judged ziji to be referring to the local subject (P-NP2), and the average score was 6.33 (SD = 0.41), which means the binding was strongly biased towards the local antecedent.

32 sentences were selected for the syntax-semantic, LD-biased condition, at least 9 participants judged ziji to be referring to the matrix subject, and the average score was 1.37 (SD = 0.21). 32 sentences were also selected for the syntax-semantics, LOC biased condition, with at least 8 participants judging ziji as the antecedent for the local subject, and the average score was 6.46 (SD = 0.34).

Because ratings were not normally distributed in three out of four conditions, the non-parametric Wilcoxon signed-rank test was employed to compare LOC-biased and LD-biased conditions. In the syntax-discourse condition, LD-biased sentences were rated significantly different than the LOC-biased sentences (p < .001***), and the same with the syntax-semantics conditions (p < .001***). However, the
Table 5.5: Stimuli norming results: 7 point Likert-scale, with point 1 referring to the distant antecedent, and point 7 referring to the local antecedent; standard deviation in parentheses; * : $p < .05$; ** : $p < .01$; *** : $p < .001$.

LOC-biased sentences were not rated differently between the two interfaces ($p = .21$), the LD-biased sentences were rated significantly higher in the syntax-discourse conditions than in the syntax-semantics condition ($p < .001***$). Recall that the higher the rating, the stronger the preference towards local binding. This result indicates that firstly, for native mandarin speakers, even when the discourse information favors the long-distance antecedent, $ziji$ is more likely to be interpreted as the local antecedent; which is consistent with previous studies that found locality effects \cite{Z. Chen et al., 2012, Li & Zhou, 2010, Liu, 2009}. Secondly, compared to the syntax-semantic conditions, the syntax-discourse conditions showed more variability in binding preferences.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Distance</th>
<th>Number of trials</th>
<th>Likert-scale rating</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syntax-discourse</td>
<td>LOC</td>
<td>$N = 40$</td>
<td>6.33 (0.47)</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>$N = 40$</td>
<td>1.75 (0.47)</td>
<td></td>
</tr>
<tr>
<td>Syntax-semantics</td>
<td>LOC</td>
<td>$N = 32$</td>
<td>6.46 (0.34)</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>LD</td>
<td>$N = 32$</td>
<td>1.37 (0.21)</td>
<td></td>
</tr>
<tr>
<td>Interface</td>
<td>Binding</td>
<td>Number</td>
<td>Sample Sentence</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>---------</td>
<td>--------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| Syntax-discourse | LOC     | N = 40 | Zhangsan 看见 Lisi 站在楼顶, Zhangsan 让 Lisi 不要上海自己.  
|                |         |        | ‘Zhangsan saw Lisi standing on the rooftop, Zhangsan asked Lisi not to hurt himself.’ |
|                | LD      | N = 40 | Lisi 刀威胁 Zhangsan, Zhangsan 让 Lisi 不要 hurt 自己.  
|                |         |        | ‘Lisi threatened Zhangsan with a knife, Zhangsan asked Lisi not to hurt him.’ |
| Syntax-semantics | LOC     | N = 32 | Zhangsan 看见 Lisi 进偷东西, Zhangsan 让 Lisi 承认自己.  
|                |         |        | ‘Zhangsan caught Lisi stealing, Zhangsan asked Lisi to confess himself.’ |
|                | LD      | N = 32 | Zhangsan 没有收到 Lisi 的回复, Zhangsan 让 Lisi 回答自己.  
|                |         |        | ‘Zhangsan haven’t received Lisi’s reply, Zhangsan asked Lisi to answer him.’ |

Table 5.6: Stimuli structure and examples; words underlined appeared on the same frame in the speeded presentation
5.2.3 Procedure

5.2.3.1 Speeded comprehension task

Stimuli were presented electronically using the E-Prime 3.0 software (Psychology Software Tools Inc., 2016). During the experiment, participants sat in front of a computer in a sound-attenuating experiment booth. After 800 ms display of a fixation point, sentences were presented word-by-word (Table 5.6) at the center of the screen at a controlled speed (see Figure 5.1). Each phrase consists of 1-2 bisyllabic words (2-4 Chinese characters). Studies have shown that the word-by-word presentation format resulted in significantly more accurate comprehension than the character-by-character format; since Chinese words, rather than Chinese characters, are the reading unit (Lin & Shieh, 2006).

![Speeded comprehension task diagram]

**Figure 5.1:** Presentation of the speeded comprehension task

All materials were presented in a white against black background. Text and background color combinations with a more considerable color difference have yielded significantly better reading performances (Wang & Chen, 2003). The presentation rate was 240 cpm (characters per minute, i.e., 250 ms for each character), and the presentation time for a bisyllabic word was 500 ms. According to Lin and Shieh (2006, p. 149), when the presentation rate is at 240 cpm instead of 500 cpm, a significantly higher recall accuracy (90% vs. 87.1%) can be obtained. The 240 cpm
presentation rate was chosen for participants to read as fast as possible without compromising their comprehension.

At the end of each sentence, participants answered whether ‘ziji’ (self) referred to the matrix or the local subject, by pressing the corresponding right and left button on an SR (serial-response) box. Responses and reaction times were recorded for later analysis. The question stayed on the screen until the participants made responded, or the time limit expired (3000ms). The left and right assignment of response buttons to the binary question ‘Who is ziji?’ was counterbalanced across participants. A 1000ms interval blank screen separated the sentences (Figure 5.1).

Sentences were divided into four blocks, with 36 sentences in each block. Sentences from the four conditions were distributed equally in each block (LD discourse * 10, LOC discourse * 10, LD semantic * 8, and LOC semantic * 8). Also, there were equal numbers of LD-biased and LOC-biased sentences in each block. In addition, sentences in each block were pseudorandomized, with the restriction that sentences with the same verbs cannot be seen in the same block. Experimental blocks were presented in randomized order. Participants were given 3 minutes to rest in between blocks.

5.2.3.2 Complex span tasks

A shortened version of the complex span tasks developed by Foster et al. (2015) was used to measure participants’ working memory capacity (WMC, Figure 5.2). Unlike traditional span tasks, complex span tasks used a dual-task paradigm, which has been shown to tap into higher-order cognition that involves both processing and storage components (Unsworth et al., 2009; Oswald et al., 2015).

Instead of using the full battery of tests, I used one block from the operation span task (Ospan) and one block from the symmetry span task (Sspan). This combination was shown to predict 78.5% fluid intelligence in total; and it accounts for an additional 14.9% of the variance (of fluid intelligence) for virtually the same amount of time for conducting either task alone (Foster et al., 2015).
5.2.3.3 Cognitive control tasks

For measuring sustained attention (Elevator Task Sustained Attention), selective attention (Elevator Task with Distraction), and mental shifting (Elevator Task with Reversal), elevator counting subset version A from the Test of Everyday Attention (TEA) was conducted after the span tasks, strictly observing the procedure in the manual (Robertson et al., 1994, p. 14-18).

In the Elevator Task Sustained Attention (Elvt1), participants were asked to count the number of tones they heard, which signifies the elevator has passed one floor. The interval between each tones varies. This task was designed to test participants’ ability to maintain their attention. There are two practice trials and seven experimental trials in this task.

In the Elevator Task with Distraction (Elvt2), participants were asked to count the same tone they have heard before while ignoring the distracting tone, which is a higher tone. This task was designed to measure participants’ ability to inhibit interference and selectively pay attention to the relevant information. There are two practice trials and ten experimental trials in this task.

In the Elevator Task with Reversal (Elvt3), participants heard three different tones: a high-pitched tone, a neutral tone, and a low-pitched tone. The high-
pitched tone signals that the elevator is moving up, while the low pitched-tone is moving down. The task starts with a neutral “floor” tone; the elevator always goes up first, but there will be either a high or a low tone every so often. If there is a high tone, the subject is to say ‘up’ sub-vocally instead of counting, then continue to count upwards with the neutral tones. When a low-tone is heard, the elevator will stop going up and is about to go down. The subject must say ‘down’ sub-vocally and then count backward with the neutral tones. Another high tone will require the subject to start counting upwards again, and so on. This task was designed to measure participant’s ability to switch among different tasks flexibly. There are three practice trials and ten experimental trials in this task.

5.3 Results

5.3.1 Data analysis

There are three main questions I am trying to answer here: firstly, whether the bilingual experience, such as LoR and bilingual profiles (passive vs. active), affects reflexive processing; second, whether the linguistic performance is affected by the interface or binding distance; and finally, whether the linguistic performance is affected by individual differences in general cognitive abilities, such as attention and working memory. To answer these questions, I evaluated the effect of group (reference level: the short-term group, see Section 5.3.2 for details), interface (reference level: syntax-semantics interface), and distance (reference level: local binding) on response latency with linear mixed-effects models (LMM). I evaluate the same effects on binding preference (LD or LOC) and accuracy score (0 or 1) with generalized linear mixed-effects models (GLMM; Baayen et al., 2008). I used the lmer and glmer function of the lme4 package (version 1.1-12; Bates et al., 2012) in RStudio (0.99.896; RStudio Team, 2015).

Before fitting the model, I removed 23 trials (0.11%) with response times below 150ms. Response times were then centered to have a mean of zero to assume a normal distribution truncated at zero. Following the same practice, I also standardized the complex span task scores (Ospan, Sspan) and the elevator task scores (Elvt1, Elvt2, Elvt3) to aid convergence of the model. The means and standard
deviations were presented in Table 5.7.

<table>
<thead>
<tr>
<th>Group</th>
<th>Interface</th>
<th>Distance</th>
<th>Response accuracy (%)</th>
<th>Reaction time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discourse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Long-distance (LD)</td>
<td>77.10 (10.07)</td>
<td>1050.84 (149.16)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>72.65 (12.65)</td>
<td>1025.47 (163.53)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semantics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>86.23 (12.65)</td>
<td>1035.12 (145.79)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>81.29 (12.12)</td>
<td>1016.17 (172.07)</td>
<td></td>
</tr>
<tr>
<td>Short-term</td>
<td>Discourse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>82.37 (8.75)</td>
<td>962.18 (139.64)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>78.93 (10.56)</td>
<td>878.35 (156.02)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semantics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>89.24 (13.82)</td>
<td>913.71 (110.86)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>84.53 (12.56)</td>
<td>842.14 (144.45)</td>
<td></td>
</tr>
<tr>
<td>Retest</td>
<td>Discourse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>85.91 (13.22)</td>
<td>942.18 (150.97)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>84.13 (12.23)</td>
<td>815.13 (160.24)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semantics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>90.92 (13.43)</td>
<td>908.58 (141.95)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>90.72 (12.05)</td>
<td>848.05 (139.57)</td>
<td></td>
</tr>
<tr>
<td>Long-term</td>
<td>Discourse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>83.55 (7.69)</td>
<td>1008.87 (168.75)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>83.05 (10.55)</td>
<td>916.68 (138.42)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Semantics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-distance (LD)</td>
<td>89.95 (12.46)</td>
<td>973.97 (137.42)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local (LOC)</td>
<td>90.71 (10.86)</td>
<td>917.96 (142.90)</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.7: Average response latencies for correct trials, and response accuracies of the speeded comprehension task among four bilingual groups; standard deviations in parenthesis

I ran separate analyses to evaluate differences in reaction times, binding preferences, and response accuracy among four bilingual groups. In all instances, I managed to fit models using the maximal random effects structure (Barr et al., 2013) with subject and item as crossed random effects, except that correlations among random effects were fixed to zero to aid convergence (Matuschek et al., 2017).

For fixed effects, the group predictor was dummy coded (reference level: short-term group), and both the interface and the distance predictors were contrast coded as (−.5, .5). Other variables of interest, including WMC (Ospan, Sspan) and attention control (Elvt1, Elvt2, Elvt3) were entered in the second stage of analysis to avoid over-fitting the model. Log likelihood ratio tests were used to select the best fit model at every stage.
5.3.2 Analysis of cognitive control measures

Let us first look at the distribution of cognitive scores in working memory and attention span tasks. Figure 5.3, 5.4 and 5.5 showed the performance of three elevator tasks in the control group, the short-term group (first-test) and the long-term group. As we can see from Figure 5.3, there is no significant group-wise difference in their Elvt1 scores ($p > .05$) and all three groups’ performances are at ceiling.

![Figure 5.3: Elevator Task Sustained Attention](image)

Group differences started to emerge in the Elevator Task with Distraction (Elvt2). Simple linear regression with group as the independent variable showed that both the short-term and the long-term group outperformed the control group, indicating that active bilinguals are better at sustaining attention in noisy conditions than the passive bilinguals ($\beta = 29.41, SE = 5.13, t = 5.73***; \beta = 26.69, SE = 4.96, t = 5.38***$; Figure 5.4). Post-hoc test with Tukey method did not show significant difference in Elvt2 scores between the long-term and short-term group ($p = .86$).

Again, both the short-term and the long-term bilinguals scored significantly higher in the Elevator Task with Reversal (Elvt3), suggesting that passive bilinguals were not as flexible as the other two groups when switching between differ-
Figure 5.4: Elevator Task with Distraction

Active bilinguals in the short-term and the long-term group did not differ significantly in Elvt3. ($p > .1$).

Figure 5.5: Elevator Task with Reversal

In terms of the two measures of working memory, Ospan and Sspan, simple linear regressions with group as the independent variable returned null results for both measures ($ps > .05$). Combined with the distribution pattern displayed in Figure 5.6 and 5.7, one can come to the conclusion that individual differences in the working memory capacity within-group mask any potential difference between groups. It is not unlikely that between-group difference will emerge with a larger group size.

To discover if there is any improvement in terms of working memory and attention span within the short-term group between two tests, which were approximately 6 months apart, I ran simple linear regressions of 5 cognitive measurements
The results did not show any significant improvement in sustained attention ($Elvt1$), mental switching ($Elvt3$), operation span ($Ospan$) and symmetry span ($Sspan$). There appears to be some improvement with marginal significance in the Elevator Task with Distraction ($Elvt2$); however, the effect size is small ($r = .27$) and it is equally possible that participants experienced practice effect ($\beta = 6.80, SE = 3.38, t = 2.01$; Figure 5.8).

In summary, active bilinguals both in the short-term and the long-term group outperformed the control group of passive bilinguals in Elevator Task with Distraction ($Elvt2$) and Elevator task with Reversal ($Elvt3$), which indicates that active bilinguals are better at resisting interference and switching between different tasks. The superior inhibition and task-switching abilities of active bilinguals may either be a sampling bias or an adaptive trait from managing two languages. All group performed at ceiling in Elevator Task Sustained Attention and there was no significant difference between groups in terms of verbal working memory ($Ospan$)
and spatial working memory (Sspan).

### 5.3.3 Analysis of the response latency

Only response latencies for correct trials were analyzed (83%). Response latency was collected and interpreted as a measure of computational complexity. One has to process the sentence fully before answering the comprehension question, thus response latency between reading the sentence and answering the question could be indicative of processing strategies or preferences.

To investigate between-group differences in the reaction latency and effects of interface and binding-distance in on-line reflexive processing, I built a general linear mixed-effects model with group, interface, distance, an interaction term between group and interface, and an interaction term between group and distance as fixed effects (m1). I set the short-term group as the baseline in group comparison because I am interested in comparisons between the short-term and the retest group, and between the short-term and the long-term groups.

Results showed significant effects of distance and group. As expected, I found that long-distance binding took a significantly longer time to process than local binding ($\beta = 93.17, SE = 25.60, t = 3.64\, **$). The short-term participants took less time in the retest than they were 6 months ago ($\beta = -56.44, SE = 18.24, t = -3.10\, *$). I also found a marginally significant interaction between group and distance: the difference in response latencies between the two tests in the short-term group was larger in the syntax-discourse conditions than in the syntax-semantics
Figure 5.9: Comparisons of reaction times among 4 bilingual groups between 2 conditions (long-distance vs. local binding); error bars = standard error; control: passive bilinguals; short-term: active bilinguals 6–8mths LoR; retest: short-term retested after 6mths; long-term: active bilinguals ≥ 36mths LoR

Post hoc group-wise comparisons with Tukey adjustment revealed that participants in the retest group also spent less time than those in the control group ($\beta = 154.24, SE = 50.45, z = 3.06^{*}$). There is a numerical tendency for response latencies at the syntax-discourse interface to be longer than those at the syntax-semantics interface; however, the difference was only marginally significant ($\beta = 46.12, SE = 25.67, t = 1.80$). Longer reaction time could indicate more difficulty in processing, and reflexive processing in both the syntax-discourse conditions and the LD conditions appeared to be more demanding than their alternatives.

To test the effect of general cognitive abilities on the response latency, I updated m1 with four additional fixed effects: Elvt1, Elvt3, Ospan and Sspan (m2). Elvt2 was omitted because it did not improve the fit of the model. Results showed significant effects of Elvt3, Ospan and Sspan, which means that participants with...
Table 5.8: Estimated coefficients of mixed effect analysis on reaction time of the comprehension task; . : \( p < .1 \); \* : \( p < .05 \); \*\* : \( p < .01 \); \*\*\* : \( p < .001 \).

<table>
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<tr>
<th>Fixed effects</th>
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In summary, the current study replicated the locality effect during online reflexive processing: when Chinese reflexive ziji referred to a long-distance antecedent, the processing of said ziji took a longer time, which I interpret as a sign of extra processing cost. The marginal effect of interface suggested that participants treated internal and external interfaces differently, and they found reflexive-processing at the syntax-discourse interface more demanding than the alternative. There is a numerical trend for active bilinguals to be faster than the passive bilinguals in answering the comprehension questions, even though only two group-wise comparisons were significant: control vs. retest, and short-term vs. retest. Significant effects of cognitive control tasks and complex span tasks results suggested this result could be mediated by enhanced cognitive abilities and working memory.
5.3.4 Analysis of the binding preference

Before investigating the response accuracy, I first looked at binding preference, i.e., the likelihood participants choose distant or local antecedents in different conditions. I expected attriters and non-attriters to show different binding preferences, especially at the syntax-discourse interface (for details, see Section 5.1.4). After removing the 268 trials with non-performance (1.33%), I built a general linear mixed effect model with group, interface, and an interaction term between group and interface as fixed effects (m3). Results did not show any significant differences of binding preference on the group-level, nor was there any significant effect of Interface (Figure 5.10).

![Binding preferences diagram]

Figure 5.10: Percentage of local binding: comparisons among four bilingual groups

5.3.5 Analysis of the response accuracy

To investigate between-group differences in the response accuracy and whether attrition effects manifest differently in different experimental conditions, I built a general linear mixed-effects model with group, interface, distance, an interaction term between group and distance, and an interaction term between group and interface as fixed effects (m4).
Results showed significant effects of group, interface, and distance. Participants were more accurate in the syntax-semantics conditions than they were in the syntax-discourse conditions in general ($\beta = -0.54, SE = 0.14, z = -3.97^{***}$), and participants in the short-term group were more accurate when they were retested 6 months later ($\beta = 0.36, SE = 0.07, z = 5.02^{***}$). I also found that long-distance binding was more accurate than local binding despite its longer reaction time ($\beta = 0.32, SE = 0.12, z = 2.67^{**}$, see Figure 5.12a). Even though unexpected, this finding replicated the finding in Li and Zhou (2010), where they also reported higher accuracy in long-distance binding than in local-binding in their off-line post-experiment test (Li & Zhou, 2010, p 101). Additionally, post hoc group-wise comparisons with Tukey adjustment revealed that both short-term bilinguals in the retest and long-term bilinguals were more accurate than passive bilinguals in the control group ($\beta = -0.65, SE = 0.21, z = -3.17^{**}$; $\beta = -0.56, SE = 0.21, z = -2.75^*$). Furthermore, I found a significant interaction between group and distance. The difference in accuracy rates between the short-term and the long-term groups was larger in the LOC conditions than in the LD conditions ($\beta = -0.28, SE = 0.11, t = -2.53^*$, see Figure 5.12b).

To investigate the effect of attention control and working memory, I up-
dated m4 with three additional fixed effects: \( Evt1, Evt3, Sspan \) (m5). Including those effects significantly improved the fit of the model.\(^6\) Results showed that participants with higher scores in \( Evt3 \) and \( Sspan \), which signified better mental shifting and larger spatial working memory, were also more accurate in answering the comprehension questions (\( \beta = 0.14, SE = 0.03, z = 4.25***; \beta = 0.05, SE = 0.02, t = 2.57* \)). In addition, the comparison between the control group and the short-term group became significant (\( \beta = -0.70, SE = 0.25, z = -2.78** \)) in the updated model, which provides more support for L1 attrition in reflexive processing: when individual differences in the cognitive control abilities have been accounted for, immersion in the L2 environment leads to change of behaviors in the L1.

In summary, when answering the comprehension question, “who is \( ziji \) (‘self’)”, participants’ responses were significantly influenced by their spatial working memory and their ability to switch among different tasks. When individual differences have been accounted for, group comparisons became significant: passive bilinguals were less accurate than active bilinguals in general, and among the active bilinguals, participants who spent a longer time in the L2 environment became more accurate in their responses than their peers.

\(^6\)For group-wise comparisons and distributions of the cognitive control measures, see Section 4.3.2

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<table>
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Table 5.9: Estimated coefficients of mixed effect analysis on response accuracy of the comprehension task; $p < .1$; *: $p < .05$; **: $p < .01$; ***: $p < .001$.

5.4 General Discussion

The aim of this study is three-fold. I first compared the online processing of reflexive *ziji* among four different bilingual populations, and I tested whether this structure is susceptible to L1 attrition as previous literature suggested. Secondly, I investigated whether different linguistic features, i.e., interface and binding distance, affect the attrition process; Finally, I investigated the cognitive factors involved in pronoun resolution to see if the degree of L1 attrition is modulated by bilinguals’ cognitive control abilities, such as attention and working memory. The results not only showed that reflexive processing is susceptible to change, it also suggested that all three aspects: participants’ bilingual experience, linguistic features of the target structure, and individual differences in cognitive abilities, affect the online processing of *ziji*; they also interact with each other in the process. In the remainder of this paper, I will discuss the implications of the results and limitations of the experimental design, followed by suggestions for future research in first attrition at the interfaces,
and Chinese reflexive processing by bilingual speakers.

5.4.1 Linguistic features: the locality effect

Recall that the current study replicated the locality effect observed in monolingual speakers with Mandarin-English late bilinguals (see Section 5.1.2). During online reflexive processing: when Chinese reflexive ziji referred to a long-distance antecedent, the processing of said ziji took a longer time, which I interpret as a sign of extra processing cost. The longer processing time of long-distance binding is not (merely) due to linear distance, as Streb et al. (2004, among others) found enhanced P300/P600 effects during long-distance binding, which indicates more difficulties associated with long-distance binding.

The current study also found that despite its longer processing time, long-distance binding was also more accurate than local binding among all bilingual groups. There are two possible explanations for this result. Firstly, the matrix subject is always mentioned before the local subject, occupying a more prominent position in the discourse. It is possible that matrix subjects are better represented in the working memory, which leads to more accurate retrieval. In fact, Chen et al. (2000) study showed that in sentences where more than one potential antecedents were present, the antecedent that was mentioned first would be preferred over the alternative. Secondly, processing time may affect the final decision. In the cross-modal priming study by Liu (2009), locla binding dominates over long-distance binding at the early stage of syntactic processing, but the binding preference reversed at longer SOAs, indicating that there are multiple stages of processing. The current study used speeded rapid-serial visual presentation and has a time limit of 3000ms, which did not leave much time for participants to entertain alternative readings and alter their initial interpretations, especially in syntax-discourse conditions where the alternative reading is not ungrammatical.

5.4.2 Linguistic features: external vs. internal interfaces

Combining the reaction time data and the response accuracy data, it became clear that participants found it more challenging to integrate discourse information than
integrating semantic information during pronoun resolution: participants took less time and were more accurate when processing reflexives at the syntax-semantic interface.

If we compare the availability and complexity of semantic and discourse information, it makes sense that discourse-conditioned interface structures present a significant challenge compared to semantically conditioned ones. Firstly, discourse context expands beyond sentential boundaries and often requires readers to search beyond the local domain for information (see Section 5.1.1). Secondly, outside of sentence boundaries, discourse context often present multiple alternatives, in the case of pronoun resolution, multiple antecedents; as demonstrated in Example 11b. Compared to two possible antecedents in Example 11a, the subject laoshi (‘teacher’) and the object jizhe (‘journalist’), the proceeding context in Example 11b provides a third alternative yisheng (‘doctor’), which inevitably adds to the computation load of pronoun resolution.

(11) a. Laoshi, gaosu jizhe, yao zunzhong ziji. 
Teacher tell journalist should respect self

“The teacher told the journalist to respect him/himself.

b. Yisheng, xiang qi-lai le. Laoshi, gaosu jizhe, yao
Doctor remember PERF. Teacher tell journalist should
zunzhong ziji, respect self

“The doctor remembered. The teacher told the journalist to respect him/him/himself.

In addition, recall that in the current study, semantic cues in the syntax-semantics condition and the discourse cues in the syntax-discourse condition have different effects on the sentences’ grammaticality. In the syntax-semantics conditions, the reflexive-antecedent binding is categorically determined by the verb’s semantic meaning and binding the antecedent with the matrix subject in a sentence with a reflexive verb will be ungrammatical. In contrast, the LD-biased or LOC-biased discourse information does not affect the grammaticality but the plausibility
of the sentence (see Section 5.2.2). It has been argued that violations of hard constraints trigger strong unacceptability, while soft constraints violations lead to mild unacceptability (Sorace & Keller, 2005). If the finding applies to the case of pronoun resolution in Chinese Mandarin, it stands to reason that the mild unacceptability triggered by violating soft constraints, for example, local-binding in LD-biased context, allows for bigger leeway so that participants have more freedom to entertain alternative readings, which could account for more variability in binding preferences and longer processing time among L1 attriters in the syntax-discourse condition than in the syntax-semantics condition.

This finding is consistent with the prediction of Interface Hypothesis (Sorace, 2011) and in line with findings from Tsimipi (2004). The current study adds to the literature because it showed that participants’ linguistic performance were significantly influenced by their spacial working memory and task-switching abilities. Admittedly, the individual difference approach inevitably suffered from “background noises”. The absence of significant interactions between linguistic and cognitive performances prevents me from drawing any serious conclusions regarding cognitive load and different interface structures. Nevertheless, given the amount of literature indicating selective attrition with interface structures, it is worth exploring in the future research whether cognitive load underlies the distinction between the external and internal interfaces.

5.4.3 Ambiguity resolution in bilingual speakers

Probably the most surprising finding of the current study is that not only did active bilinguals in the U.K. show different reflexive-antecedent binding patterns from the passive bilinguals in China (control), but they also outperformed the control group in both accuracies and response latencies (see Section 5.3.3 and 5.3.5). The first explanation that came to mind is that there was a sampling bias where active bilinguals in the current study have more advanced linguistic abilities in general. The experimental and the control group did not stand on equal grounds which could explain why even after L1 attrition, the experimental group still outperformed the control group.

However, there are two flaws with this line of reasoning: imbalanced group design could not account for the superior performance of the long-term group over
the short-term group, or the improvement of short-term group after another 6 months of residence in the L2 environment (see Figure 5.11 and 5.12b). Granted, we cannot completely rule out the practice effect between two measurements of the short-term group, but it still does not explain the fact that active bilinguals in the long-term group were the most accurate in their binding interpretations.

A second plausible explanation for the observed pattern involves between-group differences in cognitive control abilities. One could argue that, since active bilinguals both in the short-term and the long-term group outperformed the control group of passive bilinguals in Elvt2 and Elvt3 (see 5.3.2), it is possible that better interference control and task switching abilities mediate the differences in linguistic performance between active bilinguals and the control group. Furthermore, when individual differences in cognitive control abilities have been accounted for, not only did the differences in comprehension accuracy between the long-term bilinguals and the control group, between the retest group and the control group remained significant, but the comparison between the short-term and the control group also became significant (see Section 5.3.5).

If we put reference tracking in the communication context and consider perspective-taking, a third plausible account begins to surface. According to the two-step model developed by Hendriks, Koster & Hoeks (2014), interpreting a referring expression, e.g., pronoun, consists of (a) first determine the best interpretation based on grammatical constraints, and (b) then, consider the perspective of speakers. Imagine Mandarin-English bilinguals living in a L2 dominant environment where the rules of pronoun resolution differ from their native language and where they could also overhear non-native expressions from heritage speakers and incomplete learners, it is imperative for them to hone their skills of reference tracking to avoid communication breakdown.

Sorace (2016) argued for a similar position where she attributed the overextension of overt pronouns among bilingual speakers to “a higher threshold for deciding whether a reduced form is sufficiently unambiguous” (Sorace, 2016, p. 8). Sorace agreed with Hendriks and colleagues (2014) in that speakers usually default to the most reduced form when possible and only consider selecting a form best understood by listeners at a later stage if at all. Maintaining an explicit reference (e.g., overt pronoun) to reference a salient subject/topic is costly because it requires inhibiting a default, reduced form that satisfies Grice’s maxim in quantity.
It makes sense if this behaviour is motivated by the communication need to avoid ambiguity at all costs.

Additionally, I also suspect training effect as one of reasons for active bilinguals’ superior linguistic performance. Active bilinguals in the current study were recruited either from universities, or from local communities that consists of young professionals. At the time of the study, they all had to pass certain English language proficiency tests as prerequisites either for employment or for school. The proficiency tests, such as IELTS (International English Test System) or TOEFL (Test of English as a Foreign Language), usually involve explicit, metalinguistic knowledge that are not implicated in daily language use. It is likely that while studying for the proficiency tests, active bilinguals become familiar, even comfortable with the format (multiple-choice questions), the modality (written test administered on computers) of those tests, as well as the psychological pressure from timed tasks. The training effects coming from past test-taking experiences could potentially account for the unexpected, superior performance from attriters compared to the passive-bilingual control group.

5.4.4 Problems of the naturalistic cross-sectional design

As one of the first attempts to understand attrition to reflexive pronouns in Chinese-Mandarin bilinguals and the influence of LoR in a L2 environment on the attrition process, I opted for the less time consuming, cross-sectional design where different bilinguals with varying lengths of residence in the L2 environment were tested. By doing this, I introduced extraneous variables of individual differences in language use, attitudes towards bilingualism, processing strategies and cognitive factors, as evidenced by the large within-group variance in working memory span scores (see Figure 5.6 and 5.7).

The most ideal solution for the design problems is a longitudinal study focusing on one group of bilinguals and carefully monitoring their bilingual profiles, language use and cognitive control abilities. Nevertheless, it is inevitable to go through the initial exploration phrase, in order to narrow down the “major players” in the game. This is how the current study contributes to future explorations in the field of L1 attrition.


5.5 Conclusion

Using a word-by-word speeded comprehension task with two-alternative forced-choice questions, the current study investigated reflexive processing among Mandarin-English late bilinguals. The results not only confirmed the locality effects found in previous studies, but they also revealed that bilinguals treat syntax-discourse and syntax-semantics interface structures differently, with the former posing more computation demands on the speakers. Results also showed that during on-line reflexive processing, active bilingual speakers with short or long-term exposure to the L2 environment have higher accuracy and smaller response latencies than their passive bilingual peers. In addition to the linguistic task, I conducted a battery of cognitive tasks to measure working memory capacities and cognitive control abilities such as attention maintenance, response inhibition and mental shifting. The significant correlations between cognitive tasks and the linguistic task suggest that general cognitive functions play a significant role during online processing, especially when the comprehension demands are high.
Chapter 6

General discussions

6.1 Summary of results

The current thesis presented two studies that investigate attrition effects in sentence processing among late, Mandarin-English bilinguals with different linguistic backgrounds. Together, the two studies aim to answer four research questions.

1. Will bilingual sentence processing undergo L1 attrition after long-term immersion in the L2 environment?

2. What syntactic structures are vulnerable to the attrition process, and why?

3. If the attrition process does affect L1 sentence processing, will speakers’ language experience, such as length of exposure to the L2 environment, affect the degree of attrition?

4. If the attrition process does affect L1 sentence processing, will speakers’ general cognitive abilities, such as attention control and working memory, affect the degree of attrition?

A total of 115 participants took part in both studies, among which 76 were active bilinguals recruited in Edinburgh, U.K. and 39 passive bilinguals in Chongqing, China. Demographic and other background information pertaining to language use were collected. Active bilinguals were further divided to the long-term group (N = 36) and the short-term group (N = 40) based on their length of
residence (LoR) in the L2 environment. 26 participants in the short-term group were retested 6 months after the first test, and their data formed the retest group ($N = 26$).

The syntactic structures under investigation are *wh*-topicalizations (Chapter 4) and reflexive pronoun *ziji* (‘self’, Chapter 5). Both structures require integrating information from multiple linguistic and non-linguistic domains for their processing and are the loci of cross-linguistic variation. Based on the current literature and theoretical frameworks, such as *Interface Hypothesis* and *Adaptive Control Hypothesis*, my initial hypothesis were not only would I observe attrition effects with *wh*-topicalization and *ziji*, the degree of attrition would also be affected by interfaces, LoR, and cognitive factors such as attention and working memory. The results, however, were mixed.

On the one hand, with *wh*-topicazation, not only did active bilinguals showed decreased sensitivity to different discourse conditions of *wh*-topicalizations, but the acceptability judgments are also approaching “neutral” as L1 attrition progresses (the short-term vs. the long-term group); which indicate that LoR in an L2 environment modulates the linguistic performance.

On the other hand, with the reflexive pronoun *ziji*, although active and passive bilinguals showed significant between-group differences in both comprehension accuracy and response latency, the results were in the opposite direction than predicted: active bilingual speakers with short or long-term exposure to the L2 environment have higher accuracy and shorter response latency than their passive bilingual peers. Additionally, the effect of LoR became significant only after individual differences in cognitive control abilities have been accounted for.

In terms of the influence of cognitive control abilities, among the battery of cognitive control measures, mental switching and spatial working memory, measured by Elevator Task with Reversal and the Symmetry Span test respectively, significantly modulate participants’ linguistic performance.

In the remainder of this chapter, I first propose plausible explanations to reconcile the inconsistencies in the finding. I then discuss how the current thesis contributes to our understanding of L1 attrition in sentence processing, especially the effect of linguistic properties, experience and cognitive load. Finally, I address
the limitations of the current thesis and offer suggestions for future research.

6.2 Reconcile the opposite patterns

If the two studies had been conducted with different participants, there would be many more ways to reconcile the inconsistencies, sampling bias, differences in proficiency, methodological discrepancies, just to name a few. It would make my work of providing a plausible explanation much easier, but it would also be less interesting.

It might seem obvious now, but it took me a while to consider the fact that judgment and comprehension involve very different cognitive processes. Firstly, judgment can be made with or without a meaningful comprehension that has complete meaning-to-form mappings, depending on the processing strategies participants adopt. Sometimes, if a sentence is ambiguous, a judgment task may require the participant to take extra steps, to entertain several plausible readings before making the final decision. While in other scenarios, if a participant believe they are judging a series of sentences with similar structures, they might start to develop short-cuts to ease their processing load.

Secondly, different from comprehension, which is a natural task speakers frequently practice in their daily lives, judgment, at least in the form of an acceptability judgement task, is not as natural. One may argue that we do frequently monitor the grammaticality of sentences we hear or read; however, our primary goal of reading and conversing remains comprehending the meaning, rather than judging the well-formlessness of a specific structure.

Thirdly, and more importantly, the penalty associated with accepting an infelicitous construct (e.g., a non-D-linked *wh*-topicalization) is far less severe than misinterpreting the reference for a reflexive pronoun. The latter would more likely lead to a communication breakdown. In other words, the mandarin-English bilinguals in the current studies can be lenient in their acceptability judgments of *wh*-topicalization, but they cannot afford misinterpreting the reflexive pronoun *ziji* (‘self’). Sorace (2016) argued for a similar position where she attributed the over-extension of overt pronouns among bilingual speakers to “a higher threshold for deciding whether a reduced form is sufficiently unambiguous” (Sorace, 2016, p. 8).
Sorace agreed with Hendriks and colleagues (2014) in that speakers usually default to the most reduced form when possible and only consider selecting a form best understood by listeners at a later stage if at all. Maintaining an explicit reference (e.g., overt pronoun) to reference a salient subject/topic is costly because it requires inhibiting a default, reduced form that satisfies Grice’s maxim in quantity (Grice, 1989). It makes sense if this behaviour is motivated by the communication need to avoid ambiguity at all costs.

Speaking of costs, I believe that the amount of computation involved in the speeded acceptability judgment task (see Figure 5.1) is less than that involved in the speeded comprehension task with two-alternative forced-choice questions (see Figure 4.1). Recall that in the study of wh-topicalization, participants were asked to judge the acceptability of sentences on a 5-point Likert-scale; while in the study of reflexive pronoun *ziji* (‘self’), participants had to decide who does *ziji* refer to and complete a two-alternative forced-choice, during which they have to retain two potential antecedents (full NPs) in their working memory before they can make the decision. Consider that active bilinguals outperformed passive bilinguals in interference control and mental switching (see Section 5.3.2), it is probable that their superior performance in reference interpretation can be (partly) attributed to their cognitive control abilities.

### 6.3 Understanding sentence processing in L1 attrition

The current thesis aims to contribute to the study of sentence processing in L1 attrition by investigating the performance of potential attriters when they judge the acceptability of *wh*-topicalization, and interpret the reference of reflexive pronoun *ziji* (‘self’). The most consistent finding regarding the processing of those two structures is that all participants, both active bilinguals and passive bilinguals, treat syntax-semantics and syntax-discourse interface properties differently.

In terms of response latencies, both studies found participants took longer to respond to discourse-conditioned structures than to the semantics-conditioned structures. L1 syntactic attrition studies have shown that longer latencies would either indicate indeterminacy, self-monitoring or caution in decision. (Kasparian &
Sentence processing in first language attrition

Steinhauer, 2016; Kasparian, Vespignani, & Steinhauer, 2017; Kasparian & Steinhauer, 2017. The current finding is consistent with the claim that integrating information from syntax and other cognitive domains (e.g., discourse, pragmatics) in real-time processing is particularly taxing and vulnerable to L1 attrition, compared to structures without such interfaces (Sorace, 2011).

Regarding the response accuracy in the reflexive pronoun study, both the active and passive bilinguals were more accurate in the syntax-semantic conditions, where semantic meaning of the verb dictates the binding interpretation, than in the syntax-discourse conditions, where the discourse information biases the interpretation towards either local or long-distance binding. This finding not only adds to the support for Interface Hypothesis, but it also indicates that processing potentially ambiguous information in the syntax-discourse condition is more demanding and error-prone than the processing the categorical, unambiguous sentence processing in the syntax-semantics condition.

However, it is not to say that we should treat interfaces in a sweeping, holistic manner. I do not believe that “external interfaces” are inherently problematic, nor are “internal interfaces” immune to emerging optionalities in L1 attrition. Case in point, despite the decreasing sensitivity to different discourse conditions among L1 attriters, the acceptability judgment of wh-topicalization at the syntax-semantics interface posed more difficulties (manifested as longer response latencies) and showed more variation among different groups. The result indicates that as participants spent more time in the L2 environment, the ability to link wh-NP (noun phrase) to the discourse decreased more than wh-DP (determiner phrase). Following Yuan and Dugarova (2012), I argue that the availability of the deictic feature in the wh-element involved is a variable affecting the D-linking properties of wh-elements. Currently, I do not have a satisfying explanation as to why the deictic feature in the wh-element, which should have been acquired in early childhood, undergoes change in L1 attrition; nevertheless, this finding contradicts the across-the-board view of interface structures.

The second consistent finding between the two studies is the effect of cognitive factors on linguistic performance by L1 attriters. It has been found that performances in the cognitive control tasks, especially in Elevator Task with Distraction, Elevator Task with Reversal and the Symmetry Span Task, had a significant positive correlated with participants’ linguistic performance. It is safe to say, at least some of
the cognitive processes implicated in those tasks were also involved in the linguistic tasks. In other words, if the tests administered truly measure the cognitive processes they were designed to measure, the significant correlation may indicate that interference control, mental switching and spatial working memory play a significant role in sentence processing, especially in the context of L1 attrition.

However, the role of cognitive control abilities in L1 attrition is less clear. Results from the current study were not strong enough to establish a casual relationship between cognitive control abilities and individual attrition trajectories. It may help to think about the effect of cognitive control abilities on bilingual language performance in two waves. During the first wave, shortly after the onset of bilingualism, the cognitive control abilities, either general or language-specific, modulate the linguistic performance in either language (Levy et al., 2007; Linck et al., 2008; Costa et al., 2006). Then during the second wave, as cognitive processes adapt to the bilingual experience (e.g., dual-language context or single-language context) and individuals develop strategies to cope with the cognitive demand of managing two languages, the question “what is the effect of cognitive control on the linguistic performance” becomes somewhat irrelevant, a more relevant question would be what aspects of cognitive control modulate language processing in what context (Costa & Santesteban, 2004; Hartanto & Yang, 2016).

The current literature does not generate strong enough evidence to provide predictions regarding the effect of cognitive control abilities and individual attrition trajectories. Cherciov (2011) is one of the few studies that investigated the predictive power of cognitive abilities and L1 maintenance. She found that superior cognitive control abilities did not “discourage L1 attrition” (Cherciov, 2011, p. 166-67). Cherciov came to the conclusion that “the levels of L1 attrition...[is] dependent on a combination of attitudinal and personal background variables” (2011, p. iii).

Cognitive control abilities does not dictate what you do rather how well you perform when you carry out certain tasks. Motivation, on the other hand, plays a bigger role in terms of how well a person maintain their already acquired language (Ben-Rafael & Schmid, 2007; Schmid, 2002). Environmental factors, especially the linguistic environment they are in, shapes cognitive control abilities in ways that support their daily language use the best (Hartanto & Yang, 2016; Yang et al., 2016).
When it comes to the influence of experience, especially the length of residence in the L2 environment, my finding becomes less clear. The results cannot be fully explained by length of residence in the L2 or the amount of L1 input. On the one hand, the long-term group showed greater deviation from the passive bilinguals in terms of their judgment of infelicitous *wh*-topicalizations. On the other hand, they are more accurate than both the short-term group and the passive-bilingual control group in the pronoun resolution of reflexive *ziji*. Results from the current study adds to the suspicion that LoR may not be a reliable measure for language use. Time is a linear construct, but people’s experience with time is not. In terms of linguistic experience, for example, the time elapsed since immigration to a L2 country does not necessarily equal the time spent using the L2 as a dominant language.

However, according to the current literature, even “language use” may not be a truthful reflection of the linguistic profile, depending on how it is measured. On the one hand, highly-frequent L1 use is generally associated with better language retention (Karayayla & Schmid, 2019; Schmid & Yılmaz, 2018). On the other hand, infrequent use might indicate less mixing, which in turn leads to less L2-induced L1 inhibition (Linck et al., 2009). It can also facilitates the L1 and L2 interplay under certain circumstances and accelerate L1 attrition process related to cross-language influence (Doris Stolberg and Alexandra Muñch, 2010; Schmid, 2010).

Results from the current study, albeit mixed, does highlight the significance of the context of language use. In both studies, the linguistic performance of the short-term and the long-term group were significantly different from one another, which could be partly attributed to the different contexts of language use. The active bilinguals in the short-term group were recruited from universities where their primary use of L2 is for academic purposes and thus discourages mixing. The active bilinguals in the long-term group were recruited from local communities, which can be further divided to two subgroups: young professionals who worked aboard, or immigrants who lived with their family. The young professionals, depending on their work requirements, could be either L1-dominant or L2-dominant in their workplace. While immigrants living in close quarters with their Chinese family, are more likely to be L1-dominant with frequent language mixing.

In summary, the role of language exposure in L1 attrition is more complicated than had been predicted previously. Under the “umbrella term” of language use is a collective of inter-related factors waiting to be disentangled: frequency,
recency, length of residence and more importantly, the contexts of language use. Future research should take a more fine-grained approach and quantify language exposure and language use from different contexts in order to capture the full picture.

6.4 Limitations and suggestions for future research

One of the limitations of the current study is the naturalistic, cross-section design which introduced multiple extraneous variables into the study, such as differences in attitudes, motivation, language use, processing strategies and cognitive control abilities. Despite that the majority of those extraneous variables have been recorded, most of them were not factored in the data analysis due to the large amount of missing data.

It has become evident that the future of L1 attrition research, or bilingualism research in general, lies in the quantity and quality of longitudinal studies, where one group of bilinguals is investigated and carefully monitored regarding their language use, changes in proficiency and processing, as well as cognitive control abilities.

Another limitation of the experimental design, which originated from the limitation of the field, is the lack of comprehensive cognitive control tasks. Without an unified cognitive control framework that applies to bilingual or multilingual speakers, the battery of cognitive tasks, however extensive, will not have a good concurrent validity or test-retest reliability.

It remains promising to compare interface structures with or without the discourse conditioning, as the results so far indicates that the processing of discourse information is distinct from the processing of other linguistic information. Future studies, with the help of sensitive measurements like fMRI or EEG/ERP, could further unveil the mechanism underlying discourse processing and its change during L1 attrition.
Chapter 7

Conclusions

This thesis investigates how sentence processing in the first language, especially with respect to complex syntactic structures, changes over time in the second language environment. It contributes to the field of L1 attrition, bilingualism and language processing in general by exploring some of the main factors that influence the performance of bilingual speakers, such as linguistic properties, bilingual experience and cognitive factors. Also, by investigating language attrition from both the linguistic and the cognitive perspectives, the thesis helps to integrate the two strands of research in the context of L1 attrition.

Based on the results of the two studies presented in the thesis, we can say that the driving force of L1 attrition among Mandarin-English speakers, at least in the sample tested, is the decreased efficiency in L1 processing due to a combined influence from decreased accessibility of L1 knowledge and increased cognitive demands posed by bilingualism. It is evident in both studies that real-time integration of linguistic knowledge and context information, rather than the knowledge itself, is the locus of L1 attrition in sentence processing.

L1 syntactic attrition, manifested through the judgment of wh-topicalization and the interpretation of reflexive pronouns, is a selective and subtle process, especially among late bilingual speakers whose onset of bilingualism occurs after puberty. It is unlikely for them to completely “lose” or “forget” the L1 grammars which have already been established and entrenched during early adolescence. Instead, they appear to be less efficient in accessing or integrating information from different domains in real-time language use. Additionally, during real-time language use, processing
factors such as structural complexity, task demands and cognitive control capacities can affect the outcome.

From the linguistic perspective, the results showed a trend of simplification or generalization that shift towards a simpler, default form that is functional in both L1 and L2 (sometimes less common in the L1) (see also, Gallo et al., 2021). From the cognitive perspective, the results reinforced the need for a unified cognitive control framework that applies to bilinguals and multilinguals, who, instead of monolinguals, are the norm of today’s world.
Appendix A

Personal background questionnaire

Name: __________________________

Code: __________________________

With this questionnaire I would like to get an impression of the personal background and language use of Chinese emigrants in the U.K. It consists of 50 items. It is important to note that not all items may apply to you personally. Should you think that a certain item does not apply to you (for example when you are asked about the language use of your children and you don’t have any children), you may cross out the number in front of that particular question and move on to the next. It is important that you answer these questions on your own, because I am interested in your language use. If you don’t understand a certain question, please do not hesitate to ask me. There are no right or wrong answers!
1. What is your date of birth: _______________

2. Are you:   □ Male   □ Female


4. Would you say that you spoke a variety of Mandarin while you lived in China or a dialect
   □ Standard mandarin
   □ Dialect: _______________

5. What is the highest level of education you have completed?
   □ primary School
   □ secondary school, level: _______________
   □ higher education, namely: _______________
   □ university, degree: _______________

6. How long have you been living in the U.K.? _______________

7. Why did you emigrate and why to the U.K. in particular? □ job □ partner’s job □ partner □ other, namely: _______________

8. Did you attend any English classes before coming to the U.K.? This has to be in an educational environment, like a school or some similar institution:
   □ No
   □ Yes, less than 1 year
   □ Yes, 1-3 years
   □ Yes, 4-6 years
   □ Yes, 6-9 years
   □ Yes, 9 years and above

9. What is your most recent TOEFL or IELTS test score?
   □ TOEFL: _______________
   □ IELTS: _______________

10. Have you pursued any further education while living in the U.K. (this does not have to be language-related)?
    □ Yes, for (number of months): _______________
    □ No
11. Have you attended Chinese heritage classes while living in the U.K.?
   □ Yes, for number of months: ______________________
   □ No

12. Have you ever been back to China since leaving for the U.K.?
   □ never
   □ seldom
   □ regularly, 1-2 times a year
   □ regularly, 3-5 times a year
   □ regularly, over 5 times a year

13. Do you ever go to church in the U.K.?
   □ no, never
   □ yes, sometimes
   □ yes, regularly

14. If you have indicated you go to church, could you please indicate in which language the services are held?
   □ English □ Chinese □ English & Chinese □ Other:

15. In general, how would you rate your English language proficiency before you moved to the U.K.?
   □ very bad □ bad □ sufficient □ good □ very good

16. In general, how would you rate your English language proficiency at present?
   □ very bad □ bad □ sufficient □ good □ very good

17. In general, how would you rate your Chinese language proficiency before you moved to the U.K.?
   □ very bad □ bad □ sufficient □ good □ very good

18. In general, how would you rate your Chinese language proficiency at present?
   □ very bad □ bad □ sufficient □ good □ very good

19. How often do you speak Mandarin?
   □ rarely □ a few times a year □ monthly □ weekly
   □ daily

20. Do you consider it important to maintain your Chinese?
   □ unimportant
   □ relatively unimportant
   □ not very important
21. Do you consider it important that your (future) children can speak and understand Chinese?
   □ unimportant
   □ relatively unimportant
   □ not very important
   □ important
   □ very important

22. In general, do you have more Chinese- or English-speaking friend?
   □ only English-speaking friends
   □ both, but mostly English-speaking friends
   □ as many Chinese- as English-speaking friends
   □ both, but mostly Chinese-speaking friends
   □ only Chinese-speaking friends

23. Do you feel more at home with Chinese or with English culture?
   □ with English culture
   □ with both, but more with English culture
   □ with both culture equally
   □ with both, but more with Chinese culture
   □ with Chinese culture

24. Do you feel more comfortable speaking Chinese or English? □ English □ Chinese
    □ No preference

25. Could you elaborate on your answer: why do you feel more comfortable speaking either Chinese or English or why don’t you have any preference?

26. What is your current marital status? □ married □ separated/divorced □ widow/widower
    □ with partner □ single

27. With what language(s) was your (ex)partner brought up? □ Chinese □ English □ Other, namely: __________________________
28. If your (ex)partner was not born in the U.K., what were the reasons that he or she came to the U.K.? □ job □ partner’s job □ partner □ other, namely:

29. How long have your (ex)partner been living in the U.K. (months)? __________

30. What language or languages do you mostly use when talking to your (ex)partner?
   □ only English
   □ both Chinese and English, but mostly English
   □ both Chinese and English, without preference
   □ both Chinese and English, but mostly Chinese
   □ only Chinese

31. What language or languages does your (ex)partner mostly use when talking to you?
   □ only English
   □ both Chinese and English, but mostly English
   □ both Chinese and English, without preference
   □ both Chinese and English, but mostly Chinese
   □ only Chinese

32. Do you have children? □ No □ Yes, number: ________________

33. What language or languages do you mostly use when talking to your children?
   □ only English
   □ both Chinese and English, but mostly English
   □ both Chinese and English, without preference
   □ both Chinese and English, but mostly Chinese
   □ only Chinese

34. What language or languages do your children mostly use when talking to you?
   □ only English
   □ both Chinese and English, but mostly English
   □ both Chinese and English, without preference
   □ both Chinese and English, but mostly Chinese
   □ only Chinese
35. Are you in frequent contact with relatives and friends in China? □ very rarely □ rarely □ sometimes □ frequently □ all the time

36. How do you keep in touch with those relatives and friends in China? □ telephone □ letters □ emails □ other way, namely: __________________________

37. What language or languages do you mostly use to keep touch with relatives and friends in China?
   □ only English
   □ both Chinese and English, but mostly English
   □ both Chinese and English, without preference
   □ both Chinese and English, but mostly Chinese
   □ only Chinese

38. Have you made many new friends in the U.K.? □ yes □ no

39. What is the mother tongue of the majority of these people? □ English □ Chinese □ equal □ another language

40. How did you meet most of these people
   □ through a Chinese club or organization
   □ through mutual friends
   □ through work or the children’s school
   □ through another way, namely: __________________________

41. Could you, in the following scales, please indicate to what extent you use English and Chinese in the domains provided? You might simply tick the box. If an certain domain is not applicable to you (for example, you don’t have any pets), you may leave the box empty.

I speak Chinese...

   With relatives         very rarely □—□—□—□—□ all the time
   With friends          very rarely □—□—□—□—□ all the time
   To pets               very rarely □—□—□—□—□ all the time
   At work               very rarely □—□—□—□—□ all the time
   In church             very rarely □—□—□—□—□ all the time
   In shoptes            very rarely □—□—□—□—□ all the time
   At clubs or organizations very rarely □—□—□—□—□ all the time

I speak English...
With relatives  very rarely  all the time
With friends  very rarely  all the time
To pets  very rarely all the time
At work  very rarely all the time
In church  very rarely all the time
In shops  very rarely all the time
At clubs or organizations  very rarely all the time

42. Have you been a member of a Chinese club or organization in China? □ yes, namely (name of the organization and period of membership): __________________________ □ no

43. Have you been a member of an English club or organization in the U.K.? □ yes, namely (name of the organization and period of membership): __________________________ □ no

44. Do you ever get homesick in the sense of missing China? □ yes, what I then miss the most is/are: __________________________ □ no

45. Do you ever listen to Chinese songs? □ yes □ no

46. Do you ever watch Chinese television programmes? □ yes □ no □ I would love to, but I can’t get them

47. Do you ever listen to Chinese radio programmes? □ yes □ no □ I would love to, but I can’t get them

48. Do you ever read Chinese newspapers, books or magazines? □ yes □ no

49. Do you think your Chinese language proficiency changed since you moved to the U.K.?
□ yes, I think it has become worse
□ no
□ yes, I think it has become better

50. Do you use more or less Chinese since you moved to the U.K.?
□ yes, I think I use less Chinese
□ no
□ yes, I think I use more Chinese
Appendix B

*Wh*-topicalization stimuli (Chapter 4)

*Wh*-topicalization with complex *which* DP

*Which* bare

1. *Songjie juede youxie e-le, na-zhong mianbao Songjie xihuan chi?*
   Songjie feels a little hungry, which kind of bread does she like to eat?

2. *Youren qing yaoshu bangmang, na-zhong daima yaoshu jingchang jian?*
   Someone asked Yaoshu for help, which kind of code does Yaoshu often see?

3. *Caoping gen pengyou yi qi guangshangchang, na-ge paizi Caoping xihuan mai?*
   Caoping went shopping with friends, which brand does he like to buy?

4. *Luw en jintian you zai jiaban, na-ge fangan Luwen xiangyao yong?*
   Luwen worked overtime again today, which proposal did he want to use?

5. *Tuxi meitian gongzuo hen chang shijian, nazhong wenzhang Tuxi xihuan xie?*
   Tuxi works for a very long time everyday, which kind of article does she like to write?

6. *Yangyu jingchang qu tushuguan, na-ben mingzhu Yangyu xihuan du?*
   Yangyu goes to the library regularly, which type of classics does he like to read?

7. *Heyong guyong-le yixie sheyingshi, na-zhong dianying Heyong xihuan pai?*
   Heyong hired some cameramen, which type of film does Heyong like to make?

8. *Gesong zai xue huahua, nazhong fengge Gesong xihuan hua?*
   Gesong is learning to draw, which style does he like to paint?

9. *Mali jintian qu-le shangchang, na-ji an liwu Mali xiangyao tui?*
   Mali went to the mall today, which gift did she want to return?
10. Xiaochen jingchang qiaoke qu wangba, na-kuan youxi Xiaochen xihuan wan?
   Xiaochen often skips school and goes to the internet cafe, which game does he like to play?

11. Zhouwen qu-le xueziao bangqingshi, na-men ke zhouwen xiangyao xuan?
   Zhouwen went to the school office, which class did he want to choose?

12. Xiangyang zhunbei qu kan yanchanghui, na-jian yifu Xiangyang zhunbei chuan?
   Xiangyang plans to go to the concert, which outfit is he going to wear?

13. Luojing hen you yinyue tianfu, na-shou gequ Luojing xihuan ting?
   Luojing is very talented in music, which song does she like to listen to?

14. Lianghe benke xue-de shi sheji, na-ge huanjie Lianghe xianggao gai?
   Lianghe studied design in the undergraduate school, which design does she want to modify?

15. Zhongmei chi-wan wanfan jiu qu-le tushuguan, na-ben sanwen Zhongmei xihuan kan?
   Zhongmei went to the library after dinner, which prose does she like to read?

16. Luyan hen-you chuangyi, na-zhong shougong Luyan xihuan zuo?
   Luyan is very creative, which kind of craft does he like to do?

**Which + context**

1. Chunjie shoudao-de heli zhong, na-jian liwu Liuxue xiangyao tui?
   Among the gifts received during spring festival, which gift does Liuxue want to return?

2. Zhe ji-kuan zhuoyou dangzhong, na-kuan zhuoyou Xiaoazhang xihuan wan?
   Among these board games, which board game does Xiaozhang like to play?

3. Zhe xueqi de tongshike dangzhong, na-men kecheng Zhaolei xiangyao xuan?
   Among these semester’s optional courses, which course does Zhaolei want to choose?

4. Shangci mai-de yifu dangzhong, na-jian yifu Zhudan xihuan chuan?
   Among the clothes she bought last time, which outfit does Zhudan like to wear?

5. Xin chu-de zhanjji limian, na-shou gequ Zhengfan xihuan ting?
   In the newly-released album, which song does Zhengfan like to listen to?

6. Hanli caipai-de guocheng zhong, na-ge huanjie Chencheng xianggao gai?
   During the wedding rehearsal, which step does Chencheng want to change?

7. Zuijin mai-de shu dangzhong, na-ben xiaoshuo Cuijian xihuan kan?
   Among the recently bought books, which novel does Cuijian like to read?

8. Fengren, bianzhi he cixiu dangzhong, na-zhong shougong Fengjia xihuan zuo?
   Among sewing, wearing and embroidery, which craft does Fengjia like to do?
9. Changjian-de haichanpin limian, na-zhong haixian Xuxin xihuan chi?
   Among the common seafoods, which seafood does Xuxin like to eat?

10. Zai caikuan bangong chengxu limian, na-ge chengxu Hanchen jingchang jian?
    Among financial office programs, which program does Hanchen often see?

11. Xin chu-de kouhong yanse limian, na-ge yanse Dingli xihuan mai?
    Among the newly-released lipstick colors, which color does Dingli like to buy?

12. Zhuangxiu gongsi ti-de jitao fangan limain, na-ge fangan Xieyun xiangyao yong?
    Among the several proposals offered by the remodeling company, which proposal does Xieyun want to use?

13. Shiping lei-de wenzhang dangzhong, na-zhong wenzhang Wangziao xihuan xie?
    Among commentary articles, which type of articles does Wangxiao like to write?

14. Tushuguan shoucang-de waiguo mingzhu zhong, na-ben mingzhu Caohao xihuan du?
    Among the library foreign classics collection, which book does Caohao like to read?

15. Xiju, dongzuo he kehuanpian zhong, na-zhong dianying Zhaocong xihuan pai?
    Among drama, action and science-fiction, which genre does Zhaocong like to make?

16. Zai xieshipai he chouxiangpai zhijian, na-zhong fengge Chengjing xihuan hua?
    Between realism and abstract, which style does Chengjing like to paint?

Which + most

1. Xuexiao zuotian kai-le yanchanghui, na-shou gequ Fanxu zui ai ting?
   Xuexiao played a concert yesterday, which song does Fanxu like the most?

2. Gongcheng zhaobiao jiuyao kaishi-le, na-ge xiangmu Tangxin zui xiang tou?
   The public bidding is about to start, which project does Tangxin most want to submit?

3. Xin yiqi manhua jiuyao fashou-le, na-ben manhua Suyan zui ai kan?
   The latest issue of comic books is releasing soon, which comic book does Suyan most want to read?

4. Duchao shi moxing fashaoyou, na-zhong moxing Duchao zui ai zuo?
   Duchao is an enthusiastic model fan, which model does Duchao most like to build?

5. Shanxi cai zhong mianshi hen-duo, na-zhong mianshi Weixiang zui ai chi?
   Shanxi cuisine has a lot of pasta dish, which pasta does Weixiang most like to eat?

6. Shimian shang-de shadu ruanjian you hen-duo zhong, na-ge ruanjian Pengjie zui chang jian?
   There are a lot of antivirus softwares on the market, which software has Pengjie seen the most?
7. Tiantian shi yi-ge fuzhuang shejishi, na-zhong buliao Tiantian zui ai mai?
   Tiantian is a fashion designer, which fabric does Tiantian buy the most?

8. Shejishi tuandui tijiao-le zuizhong fangan, na-ge fangan Jinming zui xiang yong?
   The designer team submitted the final proposals, which proposal does Jinming most want to use?

9. Dukang shi yi-wei ziyou zhuangaoren, na-zhong wenzhang Dukang zui ai xie?
   Dukang is a freelancing writer, which type of article does Dukang most like to write?

10. Zhengyi reai yuedu he xiezuo, na-ben mingzhu Zhengyi zui ai du?
    Zhengyi loves to read and write, which classic does Zhengyi most like to read?

11. Zuowei dangxia zhishoukere-de daoyan, na-zhong dianying Liuchang zui ai pai?
    As the current most popular director, which type of movie does Liuchang most like to make?

12. Hanlin gang kaishi xuexi huihua, na-zhong fengge Hanlin zui ai hua?
    Hanlin just started learning to paint, Which style does Hanlin most like to paint?

13. Lilin shi-ge hen tiaoti-de ren, na-jian liwu Lilin zui xiang tui?
    Lilin is quite picky, which present does Lilin most want to return?

14. Huangping shi yi-wei zhiye dianjing xuanshou, na-kuan youxi Huangping zui ai wan?
    Huangping is a professional gamer, which game does Huangping most like to play?

15. Xin xueqi-de xuanke mashang jiuyao kaishi-le, na-men kecheng Sunming zui xiang xuan?
    Course enrollment for the new semester is beginning soon, which course does Sunming most want to choose?

16. Hejie-de pinwei hen-hao, na-jian yifu Hejie zui ai chuan?”
    Hejie has impeccable taste, which outfit does Hejie most like to wear?

In situ control

1. Weimin xihuan xie na-zhong wenzhang? Which type of article does Weimin like to write?
2. Zhangyue xihuan du na-ben mingzhu?
   Which classic does Zhangyue like to read?
3. Wangrui xihuan pai na-zhong dianying?
   Which type of movie does Wangrui like to watch?
4. Yandong xihuan hua na-zhong fengge?
   Which style does Yandong like to draw?
5. Xuhui xiangyao tui na-jian liwu?
   Which present does Xuhui want to return?
6. Wugang xihuan wan na-kuan zhuoyou? Which board game does Wugang like to play?
7. Mapeng xiangyao xuan na-men kecheng? Which course does Mapeng want to choose?
8. Gaoxin xihuan chuan na-jian yifu? Which outfit does Gaoxin like to wear?
9. Yeming xihuan ting na-shou gequ? Which song does Yeming like to listen to?
10. Dengqi xiangyao gai na-ge huanjie? Which step does Dengqi want to modify?
11. Zengying xihuan kan na-ben manhua? Which comic book does Zengying like to read?
12. Yuji xihuan zuo na-zhong shougong Which craft does Yuji like to make?
13. Jiangwei xihuan chi na-zhong haixian? Which kind of seafood does Jiangwei like to eat?
14. Tanlin jingchang yong na-ge chengxu? Which programme does Tanlin like to use?
15. Shenyan xihuan mai na-ge yanse? Which color does Shenyan like to buy?
16. Yuqing xiangyao yong na-ge fangan? Which proposal does Yuqing like to use?

**Ungrammatical control with *which* DP**

1. Na-ge pengyou Sunming zai xiang? *Which friend Sunming is missing?
2. Na-wei tongshi Xiangyang zai bang? *Which colleague Xiangyang is helping?
3. Na-ge xue-sheng Guochao zai dai? *Which student Guochao is teaching?
4. Na-ge jiaren Luojing qiangua-zhe? *Which family member Luojing is concerning?
5. Na-ge pengyou Hanlin danxin zhe? *Which friend Hanlin is worrying?
6. Na-chang biaoyan Fanxu zai kan?
   *Which performance Fanxu is seeing?

7. Na-wei tongshi Mapeng jian-guo?
   *Which colleague Mapeng has seen?

8. Na-wei xuesheng Zhudan jiao-guo?
   *Which student Zhudan has taught?

9. Na-jia gongsi Hejie hezuo-guo?
   *Which company Hejie has worked with?

10. Na-ge yuangong Gaoxin tixing-le?
    *Which employee Gaoxin notified?

11. Na-wei pengyou Lindi qipian-le?
    *Which friend Lindi cheated?

12. Na-wei xiashu Zhengfan tiba-le?
    *Which subordinate Zhengfan promoted?

13. Na-ge jieshi Luojing xiangxin-le?
    *Which explanation Luojing believed?

14. Na-ge qinqi Jiangxin bangzhu-le?
    *Which relative Jiangxin helped?

15. Na-wei bingren Yeming zhengjiu-le?
    *Which patient Yeming saved?

16. Na-ge xuesheng Dengqi chengfa-le?
    *Which student Dengqi punished?

**Wh-topicalization with simplex what NP**

**What bare**

1. Gesong shi ge ziyou zhuangao-ren, shenme Gesong xihuan xie?
   Gesong is a freelancing journalist, what does Gesong like to report?

2. Tuxi you hen-duo aihao, shenme Tuxi xihuan du?
   Tuxi has many hobbies, what does Tuxi like to do?

3. Yangyu mai-le danfan xiangji, shenme Yangyu xihuan pai?
   Yangyu bought a single lens reflex camera, what does Yangyu like to photograph?
4. Liuchang mai-le hen-duo yanliao, shenme Liuchang xihuan hua?
Liuchang bought a lot of paint, what does Liuchang like to draw?

5. Lilin jintian qi-de hen-zao, shenme Lilin xiangyao tui?
Lilin woke up early today, what does Lilin like to return?

6. Xiangyang shi ge da nanhai, shenme Xiangyang xihuan wan?
Xiangyang is a big boy, what does Xiangyang like to play?

7. Tangxin youxie youyubuding, shenme Tangxin xiangyao xuan?
Tangxin is a bit indecisive, what does Tangxin want to choose?

8. Zhouwen ganggang shuxi wanbi, shenme Zhouwen xiangyao chuan?
Zhouwen just freshened up, what does Zhouwen like to wear?

9. Luyan shi-ge erji fashaoyou, shenme Luyan xihuan ting?
Luyan is a headphone enthusiast, what does Luyan like to listen to?

10. Luojing shi-ge hen zixi-de ren, shenme Luojing xiangyao gai?
Luojing is very confident, what does Luojing want to change?

11. Heyong haoqixin hen zhong, shenme Heyong xiangyao kan?
Heyong has a curious mind, what does Heyong want to see?

12. Weixiang henkuai yao biye-le, shenme Weixiang xiangyao zuo?
Weixiang is graduating soon, what does Weixiang like to do?

13. Luwen jieshu-le yitian-de gongzuo, shenme Luwen xihuan chi?
Luwen finished a day’s work, what does Luwen want to eat?

14. Luojing shi-ge hen zixi-de ren, shenme Luojing xiangyao gai?
Luoqing is a big boy, what does Luoqing like to play?

15. Suyan you xuanze kunnan zheng, shenme Suyan xihuan mai? Suyan has a hard time making
decisions, what does Suyan want to buy?

16. Yaoshu shi-ge youyili-de ren, shenme Yaoshu jianchi yong?
Yaoshu is a resilient person, what does Yaoshu insistently use?

What + context

1. Ji-ge zhuyao yinyue liupai zhong, shenme Fengjia xihuan ting?
Among the major music genres, what does Fengjia like to listen to?

2. Xuesheng hui qizao-de xin zhangcheng zhong, shenme Zhengfan xiangyao gai?
Among the regulations newly drafted by the students’ committee, what does Zhengfan like to modify?
3. **Zuijin xin shangying-de dianying zhong, shenme Xiaochen xiangyao kan?**
   Among the newly-released movies, what does Xiaochen want to see?

4. **Shangsi anpai-de gongzuo dangzhong, shenme Xuxin xiangyao zuo?**
   Among the assignments arranged by his superior, what does Xuxin like to do?

5. **Shìtáng niányefán-de caidan zhōng, shenme Xieyun xǐhuan chí?**
   In the canteen’s New Year’s Eve dinner menu, what does Xieyun like to eat?

6. **Zai yewai guance shengwu de guocheng zhōng, shenme Dingli jīngchāng jiàn?**
   During the wildlife observation, what does Dingli often see?

7. **Zhè-ge pìn pái-de zhùdá chānpǐn zhōng, shenme Cuijian xǐhuan mǎi?**
   Among the staple products of this brand, what does Cuijian like to buy?

8. **Hufubao yáng lài chānpǐn zhōng, shenme Hanchen jīngchāng yòng?**
   Among skincare products, what does Hanchen regularly use?

9. **Meishi, jiànshen he gōuwú de shènghuo leì wénzhăng zhòng, shenme Chenjing xǐhuan xiě?**
   Among lifestyle articles like cooking, fitness and shopping, what does Chenjing like to write?

10. **Yínguó shìjiū shìjí de wénxué zuòpīn zhōng, shenme Wangxiáo xǐhuan du?**
    Among the British 19th century literature, what does Wangxiao like to read?

11. **Ziran, fēngguāng he rénxīăng de shèyǐng leixīng zhòng, shenme Caohao xǐhuan pāi?**
    Among photography types such as nature, scenery and portrait, what does Caohao like to photograph?

12. **Fénjǐng, rénwù hé jìngwù de huìhuà tīcài zhòng, shenme Zhaocong xǐhuan huà?**
    Among painting subjects like landscape, portrait and still life, what does Zhaocong like to draw?

13. **Yījīng xuànde kèchéng lǐmiàn, shenme Liuxue xiānyào tuì?**
    Among the selected courses, what does Liuxue want to drop?

14. **Jīxiàn tiàozhān yundòng lǐmiàn, shenme Mapeng xǐhuan wăn?**
    Among extreme sports, what does Mapeng like to participate?

15. **Kǎihuì fèngpī de shìhòu, shenme Chencheng xiāngyào zhuàn?**
    During the mission assignment, what does Chencheng like to pick?

16. **Jiéjiē liúxiàlái-de yífū lǐmiàn, shenme Xuhui xiāngyào chuàn?**
    Among the clothes left by her sister, what does Xuhui like to wear?
What + most

1. Jinming-de shengri kuai dao-le, shenme Jinming zui ai chi?
   Jinming's birthday is coming, what does Jinming most like to eat?

2. Caoping shi yi-wei lvshi, shenme Caoping zui chang jian?
   Caoping is a lawyer, what does Caoping witness most frequently?

3. Zengying zaoshang qu-le nongmao shichang, shenme Zengying zui ai mai?
   Zengying went to the farmers' market in the morning, what does Zengying most like to buy?

4. Danwei xin goumai-le hen-duo shebei, shenme Pengjie zui xiang yong?
   The department purchased many equipments, what does Pengjie most like to use?

5. Hanlin gei hen-duo zhuangao, shenme Hanlin zui ai xie?
   Hanlin writes for many columns, what does Hanlin most like to write?

6. Dukang jia caoshu fengfu, shenme Dukang zui ai du?
   Dukang has a large collection of books at home, what does Dukang most like to read?

7. Zhengyi ganggang jiaru sheying she, shenme Zhengyi zui ai pai?
   Zhengy just joined the photography club, what does Zhengying like to photograph the most?

8. Huihua neng tao ye qingcao, shenme Heyong zui ai hua?
   Painting can cultivate one's taste, what does Heyong most like to draw?

9. Shangci dianshi gouwu-de shangpin zhong, shenme Mali zui xiang tui?
   Among the products bought in the last TV shopping, what does Mali most like to return?

10. Qiulei yundong zhong, shenme Hejie zui ai wan?
    Among the ball games, what does Hejie most like to play?

11. Zai xuanze peicai de shihou, shenme Lianghe zui xiang xuan?
    When choosing side dishes, what does Lianghe most like to choose?

12. Qu canjia hongtan zouxiu de shihou, shenme Zhudan zui xiang chuan?
    During the red-carpet, what does Zhudan most like to wear?

13. Zai jueeshiyou, yaogunyue he minyao dangzhong, shenme Duchao zui ai ting?
    Among jazz, rock and country music, what does Duchao most like to hear?

14. Zai kanwan lunwen caogao hou, shenme Fanxu zui xiang gai?
    After reviewing the dissertation draft, what does Fanxu most like to edit?

15. Cici bowuguan zhanchu-de cangpin zhong, shenme Wugang zui xiang kan?
    Among the museum collection exhibited this time, what does Wugang most like to see?

16. Zhoumo fangjia zaijia de shihou, shenme Songjie zui xiang zuo?
    When staying at home for the weekends, what does Songjie most like to do?
In situ control

1. Xiaozhang xiāngyào tuí shénme?
   What does Xiaozhang like to return?

2. Lindi xǐhuàn wán shénme?
   What does Lindi like to play?

3. Dengqi xiāngyào xuǎn shénme?
   What does Dengqi want to choose?

4. Gaoxin xiāngyào chuān shénme?
   What does Gaoxin want to wear?

5. Yuji xǐhuàn tīng shénme?
   What does Yuji want to hear?

6. Yeming xiāngyào gāi shénme?
   What does Yeming want to change?

7. Zhaolei xiāngyào kàn shénme?
   What does Zhaolei want to see?

8. Jiangwei xiāngyào zuò shénme?
   What does Jiangwei want to do?

9. Yuqing xǐhuàn chī shénme?
   What does Yuqing like to eat?

10. Shenyan jīngchāng jiàn shénme?
    What does Shenyan often see?

11. Zhongmei xǐhuàn mǎi shénme?
    What does Zhongmei like to buy?

12. Tanlin xiāngyào yòng shénme?
    What does Tanlin want to use?

13. Yandong xǐhuàn xiě shénme?
    What does Yandong like to write?

14. Weimin xǐhuàn dú shénme?
    What does Weimin like to read?

15. Zhangyue xǐhuàn pài shénme?
    What does Zhangyue like to photograph?

16. Wangrui xǐhuàn huà shénme?
    What does Wangrui like to paint?
Ungrammatical control with *what* NP

1. *Shenme ren Liuxue zai deng?*
   *What person Liuxue is waiting for?*

2. *Shenme huo Mali zai zhunbei?*
   *What project Mali is preparing?*

3. *Shenme ge Wangfeng zai chang?*
   *What song Wangfeng is singing?*

4. *Shenme wu Xiaozhang zai tiao?*
   *What routine Xiaozhang is dancing?*

5. *Shenme fan Xiaochen dai-le?*
   *What food Xiaochen brought?*

6. *Shenme gongzuo Lilin zuo-le?*
   *What assignment Lilin finished?*

7. *Shenme jiqiao Huangping xue-le?*
   *What skill Huangping learned?*

8. *Shenme gushi Wugang jiang-le?*
   *What story Wugang told?*

9. *Shenme yinyue Heyong ting-guo?*
   *What music Heyong has heard?*

10. *Shenme ziliao Zhaoyong cha-guo?*
    *What information Zhaoyong has searched?*

11. *Shenme juese Zhouwen yan-guo?*
    *What role Zhouwen has played?*

12. *Shenme zhiwu Xuhui yang-guo?*
    *What plant Xuhui has grown?*

13. *Shenme cai Chengcheng zai chao?*
    *What dish Chengcheng is cooking?*

14. *Shenme jiyi Tangxin diu-le?*
    *What memory Tangxin lost?*

15. *Shenme zhanhui lvxing qu-le?*
    *What exhibition Lvxing went to?*

16. *Shenme zuoe Lianghe xie-le?*
    *What assignment Lianghe wrote?*
Appendix C

Reflexive \textit{ziji} stimuli (Chapter 5)

Syntax-discourse interface

Long-distance binding

1. \textit{Liuxue-de qiangfa bi Mali hao, Mali rang Liuxue baohu ziji}.  
   Liuxue’s marksmanship is better than Mali’s, Mali asks Liuxue to protect her.

2. \textit{Xiaozhang shi Xiaochen-de qianren guzhu, Xiaochen rang Xiaozhang tuqian ziji}.  
   Xiaozhang was Xiaochen’s previous employer, Xiaochen asks Xiaozhang to recommend him.

3. \textit{Sunming sichu biandi Manan-de qiyi, Manan rang Sunming tiaozhan ziji}.  
   Sunming constantly undermines Manan’s chess skills, Manan asks Sunming to challenge her.

4. \textit{Zhengfan yizhi bu ba zhongyao-de gongzuo jiaogei Luojing, Luojing xiwang Zhengfan Zhongshi ziji}.  
   Zhengfan never hands important work over to Luojing, Luojing hopes Zhengfan can value her.

5. \textit{Chengcheng youzie huaiyi Yeming, Yeming rang Chengcheng xiangxin ziji}.  
   Chengcheng is a bit suspicious of Yeming, Yeming asks Chengcheng to trust him.

6. \textit{Yaoshu juede Panxiao-de yaoqiu guoyu keke, Yaoshu rang Panxiao buyao nanwei ziji}.
Yaoshu feels that Panxiao’s requests are too strict, Yaoshu asks Panxiao not to press him.

7. Dingli bei Caoping bangjia dao jiaoqu, Dingli rang Caoping buyao nuepai ziji. Dingli was kidnapped to the suburb by Caoping, Dingli begged Caoping not to abuse her.

8. Shenyan fuxi rang yisheng Caoyun faxian-le, Shenyan rang Caoyun buyao fangqi ziji. Shenyan’s relapse was caught by Doctor Caoyun, Shenyan asks Caoyun not to give up on her.

9. Jinming renwei shangsi Yuqing-de tiaotiaokuangkuang tai duo, Jinming rang Yuqing buyao xianzhi ziji. Jinming thinks her superior Yuqing has too many rules, Jinming asks Yuqing not to restrict her.

10. Tuxi zong chouchu shijian zhaogu shoushang-de Weimin, Tuxi rang Weimin buyao biaoyang ziji. Tuxi always makes time to take care of Weimin’s injury, Tuxi asks Weimin not to praise her.

11. Lianghe bei Dengqi hen bu limao, Dengqi rang Lianghe zunzhong ziji. Lianghe is very rude to Dengqi, Dengqi tells Lianghe to respect her.

12. Zhongmei-de mimi bei Renjing xielou-le chuqu, Renjing rang Zhongmei yuanliang ziji. Zhongmei’s secret was leaked by Renjing, Renjing asks Zhongmei to forgive her.

13. Luyan shi Wanghai-de xingxiang guwen, Wanghai rang Luyan daban ziji. Luyan is Wanghai’s image consultant, Wanghai asks Luyan to dress him up.

14. Jingjiren Xuxin-de xuanchuan celue Weixiang bu tongqi, Weixiang rang Xuxin buyao chaozuo ziji. Weixiang does not agree with his Agent Xuxin’s promotion strategy, Weixiang asks Xuxin not to exploit him.

15. Liuchang na dao weixie Zhaocong, Zhaocong rang Liuchang buyao shanghai ziji. Liuchang is threatening Zhaocong with a knife, Zhaocong asks Liuchang not to harm him.
16. Yangyu-de fangan bei Zhangyue baibantiaoti, Yangyu, rang Zhangyue, buyao zhemo ziji।\(^1\)

Yangyu’s proposal was nitpicked by Zhangyue, Yangyu asks Zhangyue not to give him a hard time.

17. Chenjing bei Hanlin qingshi zixunxin shoucuo, Chenjing, rang Hanlin, buyao qingshi ziji।\(^1\).

Chenjing’s self-esteem was frustrated by Hanlin’s contempt, Chenjing asks Hanlin not to look down upon her.

18. Tangmeng pingqing Gaosi zuo jingjiren, Tangmeng, rang Gaosi, xuanchuan ziji।\(^1\).

Tangmeng hired Gaosi as her agent, Tangmeng asks Gaosi to promote her.

19. Tangjia buxihuan Xiangyang zong shijidan -limian-tiao-gutou, Tangjia, rang Xiangyang, buyao shuluoziji।\(^1\).

Tangjia dislikes that Xiangyang always nitpick, Tangjia asks Xiangyang not to reproach her.

20. Xiaoyan ba Xiaoqian-de xingli nongdu-le, Xiaoyan, rang Xiaoqian, buyao zebei ziji।\(^1\).

Xiaoyan lost Xiaoqian’s luggage, Xiaoyan asks Xiaoqian not to blame him.

21. Jiangwei faxian Hanchen zai maoling buzhujin, Hanchen, rang Jiangwei, buyao piping ziji।\(^1\).

Jiangwei caught Hanchen falsely claim financial aid, Hanchen asks Jiangwei not to criticize him.

22. Pengjie-de shiqing rang Tanlin zuoyou weinan, Tanlin, rang Pengjie, buyao zheteng ziji।\(^1\).

Pengjie’s affairs put Tanlin in a dilemma, Tanlin asks Pengjie not to torment him.

23. Dongyan xihuan gei Tiantian jiang gui gushi, Tiantian, rang Dongyan, buyao xiahu ziji।\(^1\).

Dongyan likes to tell ghost stories to Tiantian, Tiantian asks Dongyan not to scare her.

24. Luwen xiang la-zhe Yuanli yiqi taoke, Yuanli, rang Luwen, buyao danwu ziji।\(^1\).

Luwen wants to drag Yuanli to skip school together, Yuanli asks Luwen not to hold her back.
25. Dukang buxihuan Wangxiao-de faxing, Wangxiao rang Dukang buyao gaibian ziji. Dukang doesn’t like Wangxiao’s hairdo, Wangxiao asks Dukang not to change her.


27. Heqiang yinwei Lilin luoxia-le canji, Heqiang rang Lilin yanghuo ziji. Heqiang was injured because of Lilin, Heqiang asks Lilin to support him.

28. Zhouwen zuowan-le Xuhui buzhi-de zuoye, Zhouwen rang Xuhui jiancha ziji. Zhouwen finished the homework Xuhui assigned him, Zhouwen asks Xuhui to check his work.

29. Gaoxin juede zuzhang Lindi guoyu yanli, Gaoxin xiwang Lindi guli ziji. Gaoxin thinks the group leader-Lindi is overly critical, Gaoxin hopes Lindi can encourage him.

30. Jiangxin yizhi hen chongbai fanxu, Jiangxin xiwang Fanxu renshi ziji. Jiangxin always admires Fanxu, Jiangxin hopes that Fanxu know her.

31. Tangxin-de xiaozu lingdao shi Lvxing, Tangxin xiwang Lvxing kending ziji. Tangxin’s group leader is Lvxing, Tangxin hopes that Lvxing can give him affirmation.

32. Cuijian-de buzaichang zhengren shi Suyan, Cuijian rang Suyan zhengming ziji. Cuijian’s alibi witness is Suyan, Cuijian asks Suyan to testify for him.

33. Zengying gei Fengjia-de gongcheng bang-le bushao mang, Zengying xiwang Fengjia renke ziji. Zengying helped a lot with Fengjia’s project, Zengying hopes that Fengjia can acknowledge her.

34. Duchao buxihuan bei Yuji cui-de tai jin, Duchao rang Yuji buyao mianqiang ziji. Duchao hates to be rushed by Yuji, Duchao asks Yuji not to force him.

35. Xiaoxiao shi Songjie-de muhou gongzuorenyuan, Xiaoxiao bu xiwang Songjie hushi ziji. Xiaoxiao is Songjie’s colleague, Xiaoxiao wants Songjie to acknowledge her.
Xiaoxiao is Songjie’s staff behind the scenes, Xiaoxiao doesn’t want Songjie to ignore her.

36. Caohao dai Zhengyi qu jian ta-de fumu, Zhengyi rang Caohao jieshao ziji. Caohao is taking Zhengyi to meet his parents, Zhengyi asks Caohao to introduce her.

37. Heyong duoci quan Wangrui yao zhuyi shenti, Wangrui rang Heyong buyao danxin ziji. Heyong advises Wangrui that he should look after his health multiple times, Wangrui told Heyong not to worry about him.

38. Gesong buken gei Yandong zuozheng, Yandong juede Gesong hai-le ziji. Gesong won’t testify for Yandong, Yandong thinks that Gesong ruined him.


40. Wanzhe fuze gei Gongrui jinxing tineng xunlian, Gongrui rang Wanzhe molian ziji. Wanzhe is responsible for Gongrui’s physical training, Gongrui asks Wanzhe to chasten him.

Local binding

1. Dengqi juede Lianghe bu zizhong, Dengqi rang Lianghe zunzhong ziji. Dengqi thinks Lianghe lacks self-respect, Dengqi asked Lianghe to respect herself.

2. Renjing zhidao Zhongmei yinwei xingdong shibai hen zize, Renjing rang Zhongmei yuanliang ziji. Renjing knew Zhongmei self-blames a lot for the mission failure, Renjing asks Zhongmei not to blame herself.

3. Wanghai juede Luyan tai buxiubianfu, Wanghai rang Luyan daban ziji. Wanghai thinks Luyan is too slovenly, Wanghai asks Luyan to dress up himself.

4. Weiyang xiwang Xuxin yuanli meiti, Weiyang buyuan Xuxin chaozuozu ziji. Weiyang hopes Xuxin can stay away from the media, Weiyang hates it when Xuxin exploit himself.
Sentence processing in first language attrition

5. Zhaocong kandao Liuchang zhan-zai wuding shang, Zhaocong, rang Liuchang, buyao shanghai ziji.
Zhaocong sees Liuchang standing on the rooftop, Zhaocong asks Liuchang not to hurt himself.

6. Zhangyue jieshi-de tongku Yangyu kanzai yanli, Yangyu, rang Zhangyue, buyao zhemo ziji.
Yangyu see the misery Zhangyue is in during diet, Yangyu asks Zhangyue not to abuse herself.

7. Hanlin-de wangzifeibo Chenjing hen bu zantong, Chenjing, rang Hanlin, buyao digu ziji.
Chenjing doesn’t approve of Hanlin’s self-deprecation at all, Chenjing asks Hanlin not to underestimate himself.

8. Gaosi-de bushan jiaoji rang Tangmeng hen kunrao, Tangmeng, rang Gaosi, xu-anchuan ziji.
Gaosi’s poor social skills concern Tangmeng a lot, Tangmeng asks Tangmeng to promote herself.

9. Xiangyang zize-de yangzi bei Tangjia kan-zai yanli, Tangjia, rang Xiangyang, buyao shuluo ziji.
Tangjia sees Xiangyang’s look of self-blame, Tangjia asks Xiangyang not to reproach himself.

10. Xiaoqian hen aohui ba Xiaoyan-de dizhi xie cuo-le, Xiaoyan, rang Xiaoqian, buyao zebei ziji.
Xiaoqian greatly regretted mixing-up Xiaoyan’s address, Xiaoqian asks Xiaoqian not to blame himself.

11. Mali hen-danxin Liuxue-de anquan, Mali, rang Liuxue, baohu ziji.
Mali is very concerned about Liuxue’s safety, Mali asks Liuxue to protect herself.

12. Xiaochen zhida Xiaozhang xiang jingxuan huizhang, Xiaochen, rang Xiaozhang, tuijian ziji.
Xiaochen knows that Xiaozhang wants to run for chairman, Xiaochen asks Xiaozhang to recommend himself.
13. Manan faxian Sunming yudao kunnan jiu zhibubqian, Manan, rang Sunming, tiaozhan ziji/\textsubscript{i}/j.
Manan found that Sunming finches at any difficulties, Manan, asks Sunming, to challenge himself\textsubscript{i}/j.

14. Luojing zhiao Zhengfan weile gongzuo nongkua-le shenti, Luojing, rang Zhengfan, zhongshi ziji/\textsubscript{i}/j.
Luojing knows that Zhengfan ruined his health for work, Luojing, asks Zhengfan, to pay attention to himself\textsubscript{i}/j.

15. Yeming jiaolian kanchu Chengcheng hen bu zixin, Yeming, rang Chengcheng, xiangxin ziji/\textsubscript{i}/j.
Coach Yeming finds that Chencheng lacks confidence, Yeming, asks Chengcheng, believe in himself\textsubscript{i}/j.

16. Panxiao yanyulvji-de zuofeng Yaoshu hen liaojiej, Yaoshu, rang Paoxiao, buyao nanwei ziji/\textsubscript{i}/j.
Yashu is well aware of Paoxiao’s strict self-discipline, Yaoshu, asks Panxiao, not to be too hard on himself\textsubscript{i}/j.

17. Caoping-de chaofuhe gongzuo rang Dingli hen youlv, Dingli, rang Caoping, buyao nuedai ziji/\textsubscript{i}/j.
Caoping’s excess workload worries Dingli, Dingli, asks Caoping, not to abuse himself\textsubscript{i}/j.

18. Xieyun xiang yisheng Shenyan biaoda-le fangqi-de xiangfa, Shenyan, rang Xieyun, buyao paoqi ziji/\textsubscript{i}/j.
Xieyun express to Doctor Shenyan that she wants to give up, Shenyan, tells Xieyun, not to give up on herself\textsubscript{i}/j.

19. Yuqing-de suoshousuojiao rang jinming henbu zantong, Jinming, rang Yuqing, buyao shufu ziji/\textsubscript{i}/j.
Jinming does not approve of Yuqing’s timidness, Jinming, asks Yuqing, not to limit himself\textsubscript{i}/j.

20. Weimin zichuizilei-de maobing Tuxi bu xihuan, Tuxi, rang Weimin, buyao biaoyang ziji/\textsubscript{i}/j.
Tuxi dislikes that Weimin always blows her own horn, Tuxi, tells Weimin, not to praise boast herself\textsubscript{i}/j.
Zhengyi is Caohao’s interviewer, Zhengyi_i asks Caohao_j to introduce himself_i/j.

22. Wangruizi zhidaohai ping bi caiyuan, Wangruizi rang Heyong buyao danzini_j.
Wangruizi knows that Heyong is afraid to be laid off, Wangruizi tells Heyong_j not to worry about himself_i/j.

23. Yandong faxian Gesong zai sidu, Yandong_j juede Gesong_j hai-le ziji_i/j.
Yandong caught Gesong doing drugs, Yandong thinks Gesong_j has ruined himself_i/j.

24. Linjun kandaoguokai ziquan haozhe tongxin, Linjun_j juede Guokai_j hui-le ziji_i/j.
It pains Linjun to see Guokai letting himself go, Linjun_j feels Guokai_j has jeopardized himself_i/j.

25. Gongruidui xuesheng Wanzhe de jiaoyu hen yange, Gongruizi rang Wanzhe_j molian ziji_i/j.
Gongrui is very strict with his student Wanzhe, Gongruizi asks Wanzhe_j to chasten himself_i/j.

26. Lvxing-de youxiu T angxin kan-zai yanli, T angxin_j xiwang Lvxing_j kending ziji_i/j.
T angxin has recognized Lvxing’s outstanding performance, T angxin_j hopes that Lvxing_j can acknowledge himself_i/j.

27. Suyantichu Cuijian-de lilun you loudong, Cuijian_i qing Suyan_j Zhengming ziji_i/j.
Suyan claimed that Cuijian’s theory has a loophole, Cuijian_i asks Suyan_j to prove himself_i/j.

28. Fengjia-de bu zixin rang Zengying hen danyou, Zengying_j xiwang Fengjia_j renke ziji_i/j.
Zengying is concerned about Fengjia’s lack of confidence, Zengying_j hopes Fengjia_j can recognize herself_i/j.

29. Yuji bu yuanyi bangmang Duchao hen lijie, Duchao_i rang Yuji_j buyao manqiang ziji_i/j.
Duchao understands Yuji’s reluctance to help, Duchao_i tells Yuji_j not to force himself_i/j.

30. Songjie-de juda qianli bei Xiaoxiao faxian-le, Xiaoxiao_i bu xiwang Songjie_j hushi ziji_i/j.
Xiaoxiao discovered huge potential in Songjie, Xiaoxiao doesn’t want Songjie to ignore herself?

31. Guzhun-de zichuizilei rang Heqiang hen kanbuguan, Heqiang rang Guzhun buyao chuípeng ziji?
   Heqiang dislikes Guzhun’s self-boasting, Heqiang tells Guzhun not to flatter himself?

32. Lilin zongshi xiang Wangfeng jie qian, Wangfeng rang Lilin yanghuo ziji?
   Lilin always borrow money from Wangfeng, Wangfeng tells Lilin to support himself?

33. Xuhui yunsuan zhong de cuowu rang Zhouwen faxian-le, Zhouwen rang Xuhui jiancha ziji?
   Zhouwen found a arithmetical error in Xuhui’s work, Zhouwen asks Xuhui to check herself?

34. Lindi-de bu zixin Gaoxin kan-zai yanli, Gaoxin xiwang Lindi guli ziji?
   Gaoxin sees that Lindi lacks self-confidence, Gaoxin wants Lindi to encourage herself?

35. Fanxu-de guihua zai Jiangxin kanlai hen bu mingque, Jiangxin xiwang Fanxu renshi ziji?
   Jiangxin thinks Fanxu’s planning is very unclear, Jiangxin wants Fanxu to know himself?

36. Hanchen juede zhe-jian shi bushi Jiangwei-de cuo, Hanchen rang Jiangwei buyao zeguai ziji?
   Hanchen thinks this incident is not Jiangwei’s fault, Hanchen asks Jiangwei not to blame himself?

37. Tanlin kan-zhe Pengjie ao-le hao ji-ge tongxiao, Tanlin rang Pengjie buyao zheteng ziji?
   Tanlin knew that Pengjie pulled several all-nighters in a row, Tanlin asks Pengjie not to torment himself?

38. Tiantian faxian Dongyan rongyi yishenyigui-de, Tiantian rang Dongyan buyao xiahu ziji?
   Tiantian finds Dongyan to be very paranoid, Tiantian tells Dongyan not to scare herself?
39. Yuanli juede Luwen tianfu ji-gao dan bu gou qinfen, Yuanli_i rang Luwen_j buyao danwu ziji_i/j.

Yuanli thinks Luwen is very talented but not so diligent, Yuanli_i asks Luwen_j not to hold himself_i/j back.

40. Wangxiao juede Dukang rongyi zai yali xia qufu, Wangxiao_i rang Dukang_j buyao gaibian zi_i/j.

Wangxiao thinks Dukang gives in very quickly under pressure, Wangxiao_i asks Dukang_j not to change himself_i/j.

Syntax-semantics interface

Long-distance binding

1. Lianghe gei Gongrui da-le hen-duo dianhua, Gongrui_i Lianghe_j buyao saorao ziji_i/sj.
   Lianghe has called Gongrui many times, Gongrui_i asks Lianghe_j not to harass him_i/sj.

2. Fengyuan tou na-le Luolin-de zhengjian, Luolin_i rang Fengyuan_j buyao maochong ziji_i/sj.
   Fengyuan stole Luolin’s credentials, Luolin_i tells Fengyuan_j not to impersonate her_i/sj.

3. Caijun renwei Lvwei-de jihua tai maoxian, Lvwei_i rang Caijun_j buyao ganshe ziji_i/sj.
   Caijun thinks Lvwei’s plan is too risky, Lvwei_i asks Caijun_j not to interfere with her_i/sj.

4. Sunyan shi Zhenglan jue-se-de tibuyanyuan, Zhenglan_i bu yuanyi Sunyan_j tidai ziji_i/sj.
   Suyan is Zhenglan’s backup actress, Zhenglan_i doesn’t want Suyan_j to replace her_i/sj.

5. Wangrui zai anjiankou gen Houxiang gaobie, Wangrui_i rang Houxiang_j buyao wanliu ziji_i/sj.
   Wangrui is saying goodbye to Houxiang at the security checkpoint, Wangrui_i asks Houxiang_j not to persuade him_i/sj to stay.
6. Xiaoxiao zai bangongshi meiyou zhaodao Mali, Xiaoxiao rang Mali lianxi ziji_i/s_j.
Xiaoxiao didn’t find Mali at her office, Xiaoxiao tells Mali to contact her_i/s_j.

7. Leiming-de xinzhi koukui maofan-le Zhudan, Leiming rang Zhudan buyao wuhui ziji_i/s_j.
Leiming’s outspokenness offended Zhudan, Leiming asks Zhudan not to misunderstand him_i/s_j.

8. Yandong dao Xiaochuang-de jiaxiang lyou, Yandong xiwang Xiaochuang huanying ziji_i/s_j.
Yandong traveled to Xiaochuang’s home town, Yandong wants Xiaochuang to welcome him_i/s_j.

9. Yujie zhishouhua jiao rang Tangyan hen bu gaoxing, Tangyan xiwang Yujie buyao shihuan ziji_i/s_j.
Tangyan doesn’t like Yujie being bossy, Tangyan hopes Yujie won’t order her_i/s_j around.

10. Tanlin-de xuanpiao dui Gesong hen guanjian, Gesong xiwang Tanlin zhichi ziji_i/s_j.
Tanlin’s vote is crucial to Gesong, Gesong hopes Tanlin can support him_i/s_j.

11. Hejie na qiang weixie Zhaocong, Zhaocong rang Hejie buyao kajin ziji_i/s_j.
Hejie threatens Zhaocong with a gun, Zhaocong tells Hejie not to come near him_i/s_j.

12. Duanhai zong ai kai Tuxi-de W anxiao, Tuxi xiwang Duanhai buyao jidui ziji_i/s_j.
Duanhai always makes fun of Tuxi, Tuxi wants Duanhai to stop teasing her_i/s_j.

13. Wangfeng dezhi Manan yao juban shengda de paodui, Wangfeng xiwang Manan yangqing ziji_i/s_j.
Wangfeng heard about Manan’s grand party, Wangfeng hopes Manan will invite him_i/s_j.

14. Xuhui huikuan hou lianxi bushang Zhoutai le, Xuhui faxian Zhoutai liyong ziji_i/s_j.
Xuhui can’t reach Zhoutai after wiring him money, Xuhui discovered that Zhoutai used her_i/s_j.

15. Heyong-de chezi bei Caohao guaceng-le, Heyong yaoqiu Caohao peichang ziji_i/s_j.
Heyong’s car was scratched by Caohao, Heyong asks Caohao to compensate him_i/s_j.
16. Suyan shoudao-le Zhuyang jilai-de xin, Suyan zhidao Zhuyangj zai xiangnian ziji i/sj.
   Suyan has received Zhuyang’s letter, Suyan knows that Zhuyangj misses her i/sj.

17. Weimin duoci yaoqing Yaoqin zuo yi-qi zhuanfang, Yaoqin bu yuanyi Weiminj caifang ziji/sj.
   Weimin has invited Yaoqin for an interview multiple times, Yaoqin doesn’t want Weiminj to interview her i/sj.

18. Xiangyang meitian dou song Zhengyi huijia, Zhengyi jude Xiangyangj zai zhuiqiu ziji/sj.
   Xiangyang walks Zhengyi home everyday, Zhengyi thinks Xiangyangj is courting her i/sj.

19. Linfeng jijiang jieren Gaoxin-de zhiwei, Gaoxin buyuan Linfengj qudai ziji/sj.
   Linfeng will take over Gaoxin’s position, Gaoxin doesn’t want Linfengj to replace him i/sj.

20. Su jinguan zhuazhu Cuian paqie, Cuian xiwang Su jingguanj buyao kouliu ziji/sj.
    Officer Su caught Cuian pick-pocketing, Cuian hopes Officer Suj won’t detain him i/sj.

21. Xiaoqian zhengzai shenli Xiaoyan tijiao-de anzi, Xiaoqian yaoqiu Xiaoyan jiezhu ziji/sj.
    Xiaoqian is reviewing the case submitted by Xiaoyan, Xiaoqian tells Xiaoyanj to assist him i/sj.

22. Panxiang he Yuqing hezuo yi-ge xiangmu, Panxiao, rang Yuqingj lianluo ziji/sj.
    Panxiao is cooperating with Yuqing on a project, Panxiao tells Yuqingj to contact him i/sj.

23. Zhouwen zhidao Wangzhi zong shuo ziji-de huaihua, Zhouwenr renwei Wangzhij jidu ziji/sj.
    Zhouwen knows Wangzhi always speak ill of him behind his back, Zhouwenr thinks Wangzhij envies him i/sj.

    Renwei called Yetao after the plane landed, Renweir asks Yetaoj to pick him i/sj up.
25. Renjing dui Zouyuan-de wuhui hai meiyou xiaochu, Renjing_i bu xiwang Zouyuan_j yudao ziji_i/BJ.

Renjing’s suspicion of Zouyuan hasn’t cleared up, Renjing_i doesn’t want Zouyuan_j to run into her_i/BJ.

26. Jinming gei Fangda kaichu-le gaoe ticheng, Fangda_i juede Jinming_j zai youhuo ziji_i/BJ.

Jinming proposed a lucrative cut to Fangda, Fangda_i thinks Jinming_j is bribing him_i/BJ.

27. Tangxin haipa ba liugan chuanran-gei Huangping, Tangxin_i burang Huangping_j jiejin ziji_i/BJ.

Tangxin doesn’t want to infect Huangping, Tangxin_i asks Huangping_j not to get near him_i/BJ.

28. Linjun zongshi foujue Linmiao-de tiyi, Linmiao_i juede Linjun_j zai paiji ziji_i/BJ.

Linjun always vetoes Linmiao_i’s proposal, Linmiao_i thinks Linjun_j is pushing him_i/BJ out.

29. Shenyan shoudao-le Yaoshu jilai-de weixie youjian, Shenyan_i zhidao Yaoshu_j xiang lesuo ziji_i/BJ.

Shenyan received a threatening email from Yaoshu, Shenyan_i knows Yaoshu is blackmailing her_i/BJ.

30. Dengqi yueguo Zhengfan gen shangji jianmian, Zhengfan_i zhidao Dengqi_j xiang suanjji ziji_i/BJ.

Dengqi went over Zhengfan_i’s head and met with a superior, Zhengfan_i knows Dengqi_j tries to dig a pit for him_i/BJ.

31. Xiayue yao likai Duchao chuguo liuxue, Xiaoyue_i xiwang Duchao_j dengdai ziji_i/BJ.

Xiayue is leaving Duchao to study abroad, Xiaoyue_i hopes Duchao_j to wait for her_i/BJ.

32. Yinwen zongshi huibi Gaoyuan-de tiwen, Gaoyuan_i rang Yinwen_j huida ziji_i/BJ.

Yinwen always avoid Gaoyuan_i’s questions, Gaoyuan_i asks Yinwen_j to answer him_i/BJ.

Local binding

1. Xueling ba Yinwen jiao-dao bangongshi, Xueling_i rang Yinwen_j tanbai ziji_i/BJ
Xueling called Yinwen to the office, Xueling asks Yinwen to confess himself.

2. Furui bu xiang guoyu yanli-de piping Weixing, Furui xiwang Weixing fanxing ziji. Furui doesn’t want to overly criticize Weixing, Furui asks Weixing to reflect on himself.

3. Wangzhi zhidaol Luyan duzi dapin bu rongyi, Wangzhi xiwang Luyan zhenzhong ziji. Wangzhi knows Luyan has a hard time facing the world alone, Wangzhi hopes Luyan can treasure himself.

4. Shenlian ba Renwei dangzuo zuihao-de pengyou, Shenlian rang Renwei buyao weizhuang ziji. Shenlian takes Renwei as his best friend, Shenlian asks Renwei not to disguise himself.

5. Lijiang-de pidouhui you Shiming zhuchi, Shiming yaoqiu Lijiang jiantao ziji. Shiming leads Lijiang’s internal investigation, Shiming asks Lijiang to introspect himself.

6. Qinxin-de xingwei Xionglin hen bu renke, Xionglin rang Qinxin fanxing ziji. Xionglin does not approve of Qinxin’s behaviors, Xionglin asks Qinxin to reflect on himself.

7. Xiayue zai dianhua-zhong gen Jiasi gaobie, Jiasi rang Xiayue baozhong ziji. Xiayue says farewell to Jiasi on the phone, Jiasi asks Xiayue to take care of herself.

8. Tanxing zai Zhongxiao mianqian buting-de xuanyao, Zhongxiao juede Tanxing zai mainong ziji. Tanxing can’t stop bragging in front of Zhongxiao, Zhongxiao thinks Tanxing is showing off himself.


10. Yetao bu mingbai Yujie-de zhenshi yitu, Yetao xiwang Yujie buyao zheyang ziji. Yetao doesn’t understand Yejie’s real intention, Yetao hopes Yujie stop covering himself.
11. Tianjun bu xihuan Xiaochuang-de aimuxu–r, Tianjun_i rang Xiaochuang_j buyao xianbai ziji_i/j.
Tianjun doesn’t like how vain Xiaochuang is, Tianjun_i asks Xiaochuang_j to stop showing off himself_i/j.

12. Xuchang faxian Tangyan-de shenti meikuangyuxia, Xuchang_i xiwang Tangyan_j fangsong ziji_i/j.
Xichang finds that Tangyan’s health is getting worse, Xuchang_i hopes Tangyan_j to relax herself_i/j.

13. Dingyong yikandao Lvwei jiu dui-qi xialian, Lvwei_i juede Dingyong_j zai yanshi ziji_i/j.
Dingyong puts up a smile in front of Lvwei, Lvwei_i thinks Dingyong_j is concealing himself_i/j.

Caijun is working under Jiangping as an apprentice, Jiangping_i tells Caijun_j not to indulge himself_i/j.

15. Zenghong-de pengyou Denglan xiang bang ta zou-chu yinying, Denglan_i rang Zenghong_j buyao fengbi ziji_i/j.
Zenghong’s friend Denglan wants to help her overcome the trauma, Denglan_i asks Zenghong_j not to isolate herself_i/j.

16. Gaoyuan shuo-de hua Lixiang bu tai xiangxin, Lixiang_i zhidao Gaoyuan_j zai chuixu ziji_i/j.
Liuxiang doesn’t believe Gaoyuan’s stories, Liuxiang_i knows that Gaoyuan is boasting herself_i/j.

17. Houxiang luguo Leiming-de bangongshi, Houxiang_i tingdao Leiming_j zai jiantao ziji_i/j.
Houxiang passed by Leiming’s office, Houxiang_i overhead Leiming_j introspecting himself_i/j.

18. Zouyuan yanli-de piping-le Menghao-de chaoxi xingwei, Zouyuan_i rang Menghao_j fanxing ziji_i/j.
Zouyuan sternly criticized Menghao’s plagiarism, Zouyuan_i tells Menghao_j to reflect on himself_i/j.
19. Liaoyong liaojie Shigang buguanbugu-de xingzi, Liaoyong xiwang Shigang baozhong ziji.
   Liaoyong is well aware of Shigang’s stubbornness, Liaoyong wants Shigang to preserve himself.

20. Cuian hen fangan Jianghe-de xingwei, Cuian rang Jianghe buyao mainong ziji.
   Cuian was put off by Jianghe’s behavior, Cuian tells Jianghe not to flatter himself.

   Duanhai asks his friend Yanli for advice, Yanli wants Duanhai to confess himself.

22. Baiyan-de xingwei shanghai-le Fangda he qitaren, Fangda rang Baiyan fansi ziji.
   Baiyan’s behavior hurt Fangda and others, Fangda asks Baiyan to reflect on himself.

23. Jinqiao hen shebude gen Fanyu gaobie, Fanyu rang Jinqiao zhenzhong ziji.
   Jinqiao is reluctant to say goodbye to Fanyu, Fanyu asks Jinqiao to take care of herself.

24. Lujing hen-shao gen Yaoqin tulu xinsheng, Yaoqin gandao Lujing zai weizhuang ziji.
   Lujing rarely confides in Yaoqin, Yaoqin feels Lujing disguises herself.

25. Dulv zhenshi-de yangzi Chengye geng xinshang, Chengye rang Dulv buyao zheyan ziji.
   Chengyu appreciate Dulv’s true self more, Chengyu asks Dulv not to conceal himself.

   Weiying knows Sujin is putting on a strong face, Weiying thinks Sujin is hiding herself.

27. Yumiao kandao Pande zhuozi-shang dui man-le kong jiuping, Yumiao zhidao Pande zai fangzong ziji.
   Yumiao saw beer bottles piled on Pande’s desk, Yumiao knows Pande is letting himself go.
28. Yuanli zong gen Dongqin ti ziji-de mingpai baobao, Dongqin, renwei Yuanli zai xianbai ziji

Yuanli always mentioned her luxury brand purse, Dongqin, thinks Yuanli is showing off herself.

29. Fengyuan quan Hanjin duo chumen guang jiao pengyou, Fengyuan bu xiwang Hanjin fengbi ziji

Fengyuan persuaded Hanjin to go out and socialize with others, Fengyuan doesn’t want Hanjin to isolate himself.

30. Songxue-de sheji Xiejia bushi hen manyi, Xiejia rang Songxue jingu ziji

Xiejia is not satisfied with Songxue’s design, Xiejia asks Songxue not to limit herself.

31. Luolin du Linfeng-de kuakuaqita buxieyigu, Luolin zhidao Linfeng zai chuixu ziji

Luolin disdained Linfeng’s boastfulness, Luolin knows that Linfeng is bragging about himself.

32. Huangxin xiang Wubing baoyuan gongzuo yali taida, Wubing yao Huangxin fangsong ziji

Huangxin complains to Wubing about the stress at work, Wubing asks Huangxin to relax himself.
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