LEXICAL ACCESS IN BILINGUAL SPOKEN WORD PRODUCTION: EFFECTS OF LEXICAL INTERFERENCE

by

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ABSTRACT

When bilinguals decide to speak in one of their languages, parallel activation from both of their languages occurs. Selecting to speak in one language is therefore highly demanding since bilinguals have to constantly deal with the co-activation of translation equivalents in their other language, as well as interference from semantically related lexical representations in each language. Switching from one language to another poses the extra demand for a control mechanism to deal with cross-language activation. The aim of this thesis was to investigate the effects of semantic and cross-language interference on bilinguals' lexical retrieval. In addition, the effects of language similarity and bilingual language profile on cognitive control abilities in language selection and switching were examined. Two groups of highly proficient bilinguals completed a detailed bilingual profile questionnaire: a group of Arabic-English bilingual with unrelated languages and a group of German-English bilinguals with closely related languages. Language switching performance in both groups of bilinguals was investigated in a picture naming paradigm. Lexical selection demands were manipulated by integrating a semantic blocking paradigm so that pictures were named in semantically heterogeneous versus homogeneous lexical selection contexts. Both groups of bilinguals were slower in the homogeneous as compared to the heterogeneous contexts. Importantly, a significant interaction of semantic blocking and language switching was observed such that latencies were slowest in homogeneous context when switching into L1, but only for the Arabic-English bilinguals. This finding suggests that switching into L1 as compared to L2 is demanding in terms of lexical selection. In addition, the performance of Arabic bilinguals when switching into L1 under high lexical selection demands correlated with their response inhibition/selection ability, as measured by a Flanker task. This suggests that bilinguals' ability to resolve lexical competition is related to their domain-general response selection ability. This correlation was not observed for the German-English bilinguals, suggesting that similar languages may interfere less with each other. However, the analysis of bilingual language profile highlighted a number of subtle differences between the two groups of bilinguals, which might have contributed to the difference in their results. Taken together, the findings from this thesis have theoretical consequences for accounts of bilingual lexical processing and for the relationship of bilingualism to non-linguistic cognition.

DEDICATION

To the soul of my father who encouraged me to pursue my higher education,

To my mother who constantly prayed for me and supported me in all possible ways,

To my husband for always being by my side and for his ever-present encouragement,

To my two adorable sons for always being the source of my inspiration,

To my brothers and sisters for their sincere love, may God bless them all.

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INTRODUCTION AND OVERVIEW

Bilingualism does not only mean the ability to speak in two languages. It also involves both cognitive challenges and complex mechanisms that allow bilinguals to regulate the use of each language to match the language of an interlocutor and to switch between them. Over the last decade, bilingualism has become the norm as opposed to the exception, and an increasing focus for research. This thesis adds to the research on bilingualism and its influence on language performance, in particular those processes that underlie language selection in bilinguals.

In recent literature, one of the main observations about bilingualism is the finding that the bilingual's two languages are simultaneously active and potentially compete for selection in the bilingual mind, even when the task requires only one language to be active (Gollan & Silverberg, 2001; Kroll, Dussias, Bogulski &Valdes Kroff, 2012). For instance, research has shown that people with two languages are sensitive to the properties of a lexical representation of one language (i.e., semantics=meaning, orthography=letters, phonology=sounds) when processing target lexical representations in their other language (e.g., Van Heuven, Dijkstra & Grainger, 1998). As a consequence of this non-selective activation, it has been proposed that cognitive control and conflict resolution processes must be engaged at every level of language processing to help resolve potential cross-language interference (Coderre & van Heuven, 2014).

Models of bilingual language processing have proposed an inhibitory component as one mechanism to handle the parallel activation during bilingual speech production (e.g., Green, 1998; Meuter & Allport, 1999). Numerous language-switching studies have supported the inhibitory control account (e.g., Meuter & Allport, 1999; Kroll, Bobb, Misra & Guo, 2008; Guo, Liu, Misra & Kroll, 2011). Moreover, research suggests that the lifelong experience of negotiating two active languages is related to enhanced domain-general cognitive control abilities (e.g., Bialystok, 2010; Heij & Hommel, 2008), including several higher-order cognitive skills responsible for purposive activities – such as the inhibition of irrelevant rules, shifting between mental sets and updating information in working memory (e.g., Friedman & Miyake, 2004; Kaushanskaya, Gross & Buac, 2014). These advantages in bilinguals' cognitive control have been associated with improved performance on non-linguistic tasks that require interference suppression and conflict monitoring (e.g., Bialystok et al., 2004; Bialystok et al., 2008). Models of bilingual language control (BLC) therefore propose that language control is part of a domain general executive control system (EC) (e.g., Abutalebi & Green 2007, 2008; de Groot, 2011; Shao, Roelofs, & Meyer, 2012; Green & Abutalebi 2013) and that switching between languages is not different from other types of EC tasks that involve the selection of the target response and inhibition of distracting responses (Meuter & Allport, 1999), and should therefore be affected by cognitive load.

A growing body of research, including behavioural and neurocognitive studies, has used language switching paradigms in order to understand how bilinguals manage cross-language interference and restrict their lexical selection to the target language (e.g., Baus, Branzi, & Costa, 2015; Costa, Santesteban, & Ivanova, 2006). For example, in their seminal study, Meuter and Allport (1999) asked bilinguals to name lists of numerals in their first (L1) and second (L2) languages while switching back and forth between them. The results showed that switching into L1 resulted in longer naming latencies compared to switching into L2 (Meuter & Allport, 1999). Intuitively, switching into the dominant L1 should be easier and less demanding. Yet, the asymmetrical switching cost was taken as a support for the Inhibitory Control Model (ICM; Green, 1998). ICM suggests that naming in the L2 requires strong inhibition of the more dominant L1 by engaging a general executive system to prevent its intrusion into the weaker

L2. When switching back into the L1, additional time and cognitive effort is required to overcome the residual inhibition of the L1 (Green, 1998).

The theoretical bases of the ICM have been tested in several neuroimaging studies that have examined language switching costs and their neurological correlates. For instance, Branzi, Della Rosa, Canini, Costa, and Abutalebi (2016) found in their fMRI study that brain regions engage differently depending on the direction of the switch. In particular, they found that switching into L1 relies heavily on brain areas associated with response selection, while switching into L2 relies on attentional and monitoring brain areas (Branzi et al., 2016). This finding suggests that only switching into L1, not into L2, is demanding in terms of lexical selection as shown by the engagement of the domain-general response selection system. Therefore, a competition-inducing lexical context should strongly increase the demand on the lexical selection system when switching into L1, not L2, yielding slower and less accurate responses in this situation. This thesis extends this research by testing whether switch costs are modulated by the degree of lexical competition.

Most models of speech production proposed that lexical access starts with a concept, from which activation spreads not only to the target lexical representation but to several semantically similar lexical representations (e.g., Levelt, Roelofs, & Meyer, 1999). In monolinguals, lexical selection is therefore necessarily required to overcome the influence of competing lexical items that share semantic properties with the target lexical item. However, as for bilinguals, lexical selection requires that co-activation from both semantically related lexical representations as well as translation equivalents in another language must be resolved (De Bot, 1992). This makes language selection a cognitively demanding task for the bilingual mind, since the two languages are simultaneously active, even when the task or the context requires only one language to be active (e.g., Van Heuven et al., 1998; Spivey & Marian, 1999;

Costa et al. 2000). The experimental paradigm employed in this thesis combines, for the first time, the semantic blocking paradigm with the language switching paradigm in order to investigate the relationship between the language switching cost and the level of lexical semantic interference during lexical selection. Novel evidence is presented of the relationship between domain-general cognitive control, including inhibitory and shifting control abilities, and bilingual lexical production in a language switching task.

Findings that demonstrate improved domain general cognitive control in non-linguistic tasks mainly rely on group differences between bilinguals and monolinguals. However, cognitive control abilities generally vary from one individual to another and have been found to affect language performance (Shao, Roelofs & Meyer, 2012). Shao et al. examined the role of individual differences in cognitive control during object naming within monolinguals. Results demonstrated that individual differences in the speed of object naming were related to the monolinguals' updating and inhibition abilities as measured through their performances in the operation span and stop-signal tasks, respectively. This finding suggests that performance in language production tasks can vary with individual differences in cognitive control.

The available evidence that demonstrates the role of individual differences in modulating bilingual language performance is sparse. To the best of our knowledge, there are only few studies that have reported a direct connection between individual differences in cognitive control and word production in bilingual speakers. Linck, Schwieter, and Sunderman (2012) examined the relationship between inhibition, measured with a Simon task and a picture naming task. They found that individual differences within inhibitory control abilities play an important role in modulating language performance during lexical production tasks. Similarly, De Bruin, Roelofs, Dijkstra and FitzPatrick (2014) investigated the role of domain general inhibitory control on language switching performance. They found that both inhibitory control ability and language proficiency are key factors that affect switching efficiency. Taken together, it seems that individual differences in cognitive control are closely related to language processing. However, it should be noted that both aforementioned studies looked at individual differences within a sample of trilinguals, which is assumed to be different to bilingual populations in terms of lexical access. Therefore, in the studies described in this thesis we included the first direct investigation of the relationship between individuals who are bilinguals and non-linguistic executive functioning skills in language selection and switching.

In addition to cognitive control variables, several variables – such as language proficiency (e.g., Costa & Santesteban, 2004), age of L2 acquisition (e.g., Costa et al., 2006) and language exposure (e.g., Bonfieni, Branigan, Pickering & Soraca, 2019) – have all been found to play an important role in modulating the performance of bilinguals during language switching. However, most of studies that examined the effect of language control in lexical selection do not take the role of these multiple dimensions of the bilingual language experience into account.

In a recent examination of individual differences during language switching, Liu, Liang, Zhang, Lu and Chen (2015) claimed that both the proficiency levels of L1 and L2 in bilinguals and differences in cognitive control ability between bilinguals could modulate language switching performance. However, they only explored the role of inhibitory control ability by comparing a group of less and more proficient bilinguals, without controlling for the length of their language switching experience and other aspects of their bilingual language profile that might differently affect their pattern of performance. This thesis contributes to this issue by reporting an investigation of the effects of different aspects of bilingual language experience on bilinguals' ability to control their two languages. Detailed information for all participants was collected using the "Language Experience and Proficiency Questionnaire" (LEAP-Q) questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007) to assess the language profiles of our bilingual speakers in their first and second languages.

Concerning the bilingual experience, the degree of overlap between languages or language typology has received scant attention. Language typology can be defined as the commonalities in linguistic properties, such as the phonological, orthographic, lexical or syntactic similarity between languages. Bilinguals may know languages with a high degree of overlap in their linguistic properties (e.g., shared orthography, phonology and vocabulary) such as German and English, both of which are Germanic languages within the Indo-European family. Alternatively, bilinguals may know languages that share few properties, such as Arabic and English, which belong to different language families, with Arabic being a Semitic language. The finding that both languages of the bilingual speaker are automatically activated during speech production suggests that bilinguals have a shared mental lexicon for both of their languages (Kroll et al., 2012).

Importantly, given the well-established non-selective activation of the two languages in bilingual speakers, the amount of competition between the activated lexical representations has been found to vary according to the degree of overlap between the two languages (Dijkstra et al., 1999; Schwartz et al., 2007). If language coactivation and cross-linguistic interferences differ depending on the degree of similarity of the bilinguals' two languages, language similarity may therefore strongly influence the amount of cognitive control needed to produce L1 or L2 efficiently. There is a dearth of research examining if and how language similarity affects both bilinguals' cognitive control performance and their L1/L2 lexical retrieval. This thesis addresses this gap by conducting the first assessment of the effect of language similarity on cognitive control abilities in language selection and switching. It therefore examines whether lexical access and relationships to cognitive control vary in bilinguals with typologically related languages (L1 German and L2 English) as compared to bilinguals with typologically unrelated languages (L1 Arabic and L2 English).

In summary, this thesis investigates the effects of semantic interference and cross linguistic competition on lexical access by combining the semantic blocking and language switching paradigms. Additionally, the current study investigates how lexical competition is resolve under increased lexical competition demands. One final intention of the current study is to examine the effect of language similarity on the process of bilingual lexical selection within two groups of bilinguals; those with closely related languages (German-English) and those with relatively unrelated languages (Arabic-English).The structure of the thesis is described below.

Thesis structure

Chapter 1 of this thesis begins with a review of models of monolingual lexical selection processes, with a particular focus on the early stages involving the mapping between lexical concepts and lexical representations (e.g., Dell, 1986; Levelt, 1989; Roelofs, 1992, 1997; Caramazza, 1997; Levelt et al., 1999). There is evidence that during spoken word production, multiple semantically related words become activated and that the intended word is selected from amongst these alternatives (e.g., Dell, 1986; Caramazza, 1997; Levelt et al., 1999). The debate of whether lexical selection is a competitive process (e.g., Abdel-Rahman & Aristei, 2010; Belke, Meyer, & Damian, 2005) or not (e.g., Howard et al., 2006; Oppenheim et al., 2010) is introduced. In addition, lexical selection has been investigated with several experimental paradigms such as the semantic blocking paradigm (e.g., Kroll & Stewart, 1994; Damian, Vigliocco, & Levelt, 2001), and the cyclic version of the semantic blocking paradigm (Belke, Meyer, & Damian, 2005; Schnur et al., 2006), in which participants name pictures in either competitive or non-competitive lexical contexts. The effect of sematic similarity on lexical selection is discussed as well as the theories proposed to explain it.

Chapter 1 then turns to the issue of lexical selection in bilinguals. In particular, evidence for the parallel activation of bilinguals' two languages during production of a single language is discussed, and current theories of how bilinguals resolve this simultaneous activation of their languages are described. This research has primarily used language interference and language switching tasks to uncover the underlying language control mechanisms and to understand how lexical interference is resolved in bilinguals, and relevant studies are discussed (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006). The final section of this chapter reviews two studies demonstrating effects of language similarity on bilingual lexical selection (e.g., Van Heuven, Conklin, Coderre, Guo & Dijkstra, 2011; Boukadi, Davies & Wilson, 2015).

Chapter 2 compares and contrasts the two native languages of the participants tested in this thesis. The Arabic language is introduced in terms of its orthographical, phonological and semantic structure, with particular focus on how it differs from the Germanic languages (English and German), in all of its structural and functional features. In addition, key differences between these bilingual groups in terms of first language acquisition and second language learning and education are introduced.

Chapter 3 focuses on the divergent nature of bilinguals' language experience and language use (i.e., their bilingual language profile) and reviews the research that has highlighted the complex relationship between different aspects of bilinguals' language experience and their language performance. Studies investigating those characteristics of bilingual speakers that are associated with differences in language performance are reviewed (e.g., Costa & Santesteban, 2004; Bonfieni et al., 2019; Kastenbaum et al., 2019). Language profile data comes largely from self-report and a number of studies have examined the relationship between self-reported and objective measures of language performance (e.g., Flege, MacKay & Piske, 2002; Jia, Aaranson & Wu, 2002; Delgado, Guerrero, Goggin & Ellis, 1999). These studies are reviewed, with a particular focus on the questionnaire used in this study the “Language Experience and Proficiency Questionnaire” (LEAP-Q) questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007). We employ this questionnaire to assess the language profiles of our two groups of bilingual speakers in their first and second languages (Arabic-English and German-English). We factor analyse their responses to determine the principle components that capture the differences in the language status of these two groups of bilingual speakers.

In **Chapter 4** we report an experiment designed to investigate lexical-semantic retrieval in bilinguals with dissimilar typologies (i.e., Arabic-English bilinguals) during a language switching task. Under the assumption that switching into L1 relies heavily on brain areas associated with response selection as compared to switching into L2 (Branzi et al., 2016), we examined whether the same cognitive processes are involved when bilinguals switch into L1 as those involved in the switch to L2. We answer this question by using a cyclic semantic blocking task (Belke et al., 2005), where the level of lexical competition was manipulated, during language switching. We use the same participants as in Chapter 3 to assess competition resolution between languages with dissimilar typologies. The study demonstrates that only switching into L1, not L2, is demanding in terms of lexical selection as shown by its interaction with the degree of lexical selection difficulties. In addition, we used two non-linguistic tasks, including a Colour-shape shifting task (Miyake, Emerson, Padilla, & Ahn, 2004) and a Flanker task (Eriksen & Eriksen, 1974), to assess the individual differences in cognitive control in bilingual speakers, and to understand whether the individual differences in inhibitory control measured with non-verbal tasks influences language switching and language production in bilingual speakers. We demonstrate that bilinguals' performance when switching into L1 under high lexical selection demands correlated with their response inhibition/selection ability, measured by a Flanker task.

A second goal of this study was to examine the effect of the bilingual language profile in lexical selection process. We therefore included the individual factors from the LEAP-Q data to investigate the nature of their effects on lexical selection. We observed significant negative correlations between the homogeneity effect and the L2 proficiency and L2 exposure factors, but only for the switch into L1, not the switch into L2.

In **Chapter 5**, a study is reported which used the same experimental paradigm as Chapter 4 (i.e., the cyclic semantic blocking and language switching paradigm), but with a different group of participants. We tested the German-English bilingual group from Chapter 3 to assess the role of their similar languages on lexical access and to understand how this is modulated by their non-linguistic cognitive control. We again included the individual factors from the LEAP-Q data to analyse their effect on lexical selection processes. The study demonstrated similar effects of semantic blocking and language switching; however, no interaction was found between these conditions. No evidence of a relationship between level of lexical semantic interference during switching into L1 or L2 and bilinguals' performance in the Flanker task was found. The individual factors from the LEAP-Q data revealed only a marginally significant negative correlation between the L2 exposure factor and the homogeneity effect, but only for the switch into L2, not for the switch into L1.

In **Chapter 6**, detailed information about bilingual profile is collected in order to assess the effects of different aspects of language experience on language switching performance. In addition, two different groups of bilinguals are compared, in order to investigate the effects of bilingual language similarity on bilingual lexical selection process.

Finally, in the General Discussion in **Chapter 7**, the main findings of this thesis are summarised, and the limitations of the studies are addressed, including suggestions for further research. Together, the results of the studies reported in this thesis contribute to our understanding of the relationship between language selection and domain general cognitive controls in bilinguals, and further constrain models of language control and lexical competition resolution in bilingual speakers.

CHAPTER 1

BILINGUAL LEXICAL SELECTION

Models of spoken word production in monolingual speakers

Theories of spoken word production agree that uttering a single word requires several mental processes, starting with the activation of the conceptual information needed to access the intended word and ending with the articulation of its corresponding sounds. When a speaker wishes to convey a specific idea: they must access the lexical item that matches the intended concept. This process is called *lexical selection* (e.g., Dell, 1986; Levelt, 1989; Roelofs, 1992, 1997; Caramazza, 1997; Levelt, Roelofs, & Meyer, 1999). Current models of lexical selection differentiate between two processing stages during word production; the lexical-semantic stage which involves the selection of lexical units and the phonological stage which includes the selection of phonological forms that correspond to the lexical units (e.g., Roelofs,1997; Caramazza, 1997; Levelt et al., 1999). Both stages are equally crucial for word production; however, the focus of our study is the former stage; the mapping between semantic and lexical representations.

Several models have been proposed to explain lexical access during word production (e.g., Dell, 1986; Roelofs, 1992; Levelt et al., 1999). These models share a lot of their architecture but disagree on aspects of processing, which are discussed in more detail below. The most influential model of word production is Levelt et al.'s (1999) WEAVER++ model (also see Jescheniak & Levelt, 1994; Dell & O'Seaghdha, 1992). According to WEAVER++, speech production involves a sequence of mental processes and the output of each process provides the required information for the subsequent mental process. That is, conceptual processing leads to lexical selection followed by phonological encoding which leads to the motor preparation which enables articulation. The processing stages proposed by WEAVER++ are illustrated in Figure 1. Although the original model includes several intermediate stages, including morphological, phonological and phonetic encoding, our study mainly focuses on lexical selection; the process of mapping lexical concepts to lemmas (see Figure 1).

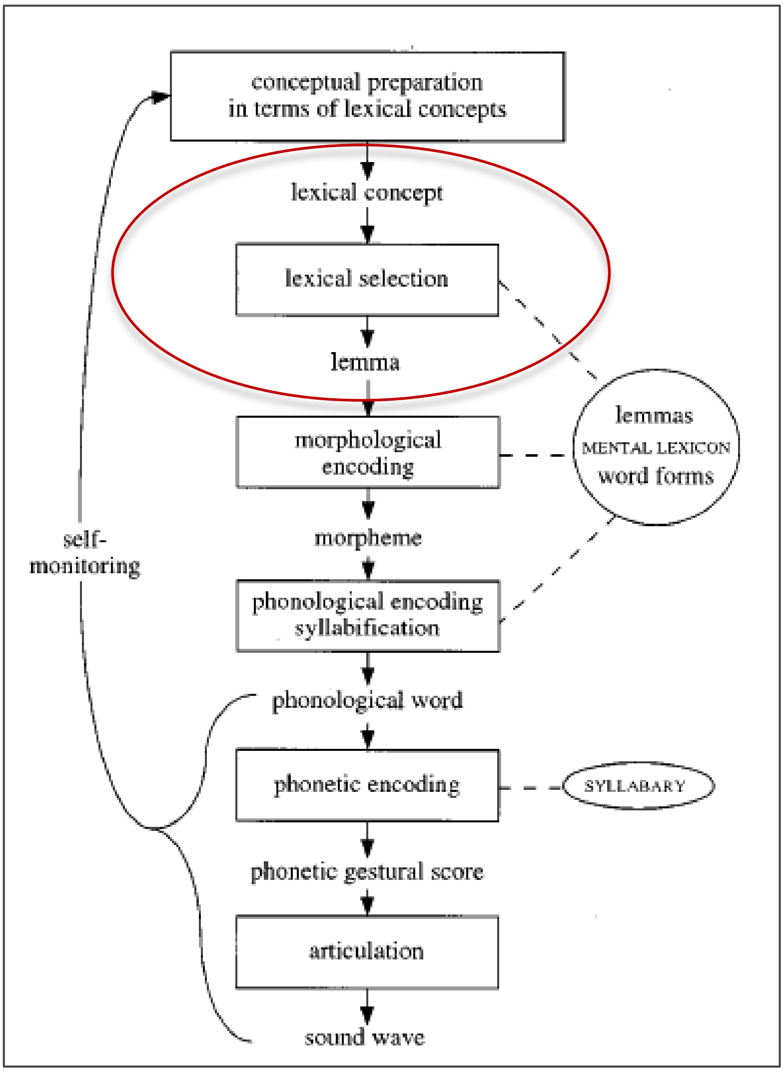


Figure 1-1 *The main stages of spoken word production: conceptual preparation, lexical selection and phonological encoding, before the actual articulation (Levelt et al., 1999, p. 3).*

Lexical concepts are non-linguistic representations for which a language has an actual linguistic form (e.g., the word *"mare"* for the lexical concept *female horse* in English; Traxler, 2011). This processing stage is necessary as some languages may require more than one term to express an idea (e.g., the lexical concept *female elephant* in English does not have a concept-to-word mapping, instead a combination of words is needed to express this idea) (ibid.). After a lexical concept is selected, the stage of lexical selection occurs with the retrieval of lemmas. Lemmas are defined as lexical nodes that provide lexical semantic and/or syntactic information such as grammatical class, subcategorization information and gender (Roelofs, Meyer, & Levelt, 1998). Lemmas do not contain phonological information. Hence, the corresponding phonological structure of the selected lemma is generated during a subsequent process of phonological encoding, and finally the articulatory motor system becomes ready for the actual production of the word (Levelt et al., 1999).

Importantly, the lexical selection stage is semantically driven, such that not only the target lexical representation is activated for selection, but rather a group of semantically related non-target lexical representations becomes activated as well (Dell, 1986; Caramazza, 1997; Levelt et al., 1999). This means that the activation of any intended concept at the conceptual level leads to the activation of semantically related conceptual representations along with their corresponding lexical representations at the lexical level. In most word production studies, pictures are usually used as stimuli for concept activation. So, for example, the retrieval of the word 'duck' leads to the activation of its corresponding semantic representation (i.e., lexical concept) (e.g., DUCK) and other related semantic representations are also activated (e.g., 'HEN, 'CHICK') (see Figure 2). Thus, the correlated lexical representation (i.e., lemma) also is activated (e.g., 'duck') amongst all the other activated lexical representations (e.g., 'hen', 'chick').

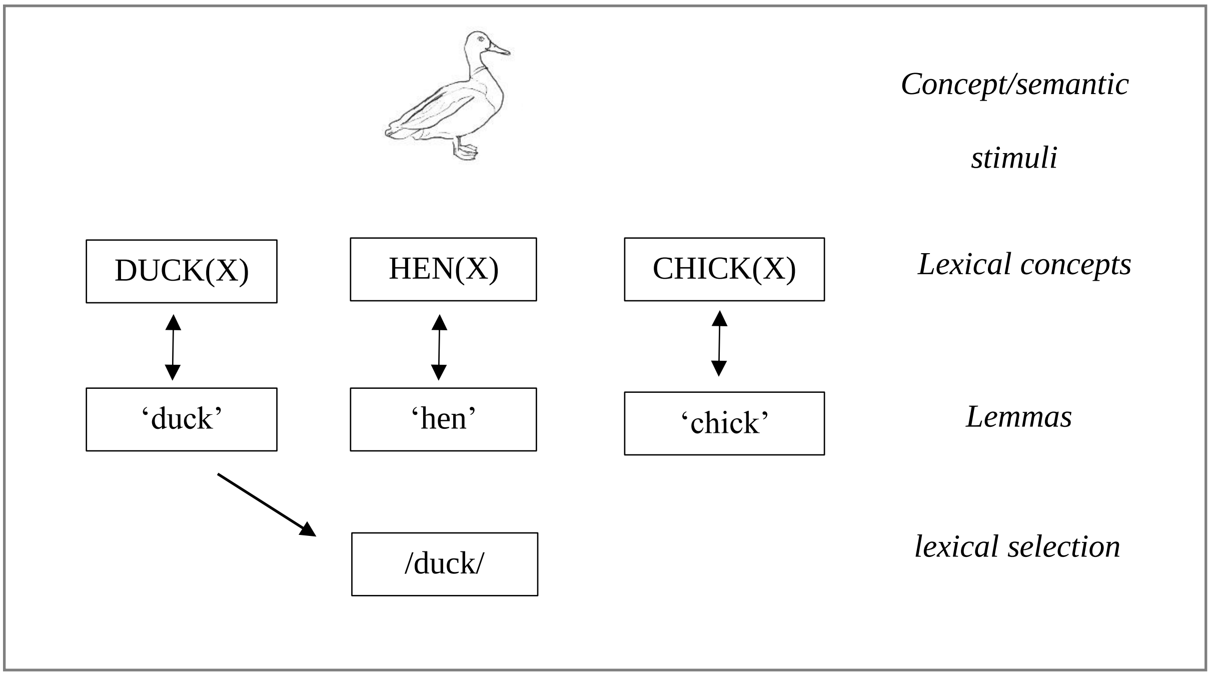


Figure 1-2 *a simple schematic of a semantic category (e.g., ‘duck’) in the WEAVER++ account. See text for explanation.*

This issue of how a target lexical representation is selected among several co-activated non-target candidates is a matter of heated debate. Although theories of language production share the same assumption that lexical selection is semantically guided, they differ in their mechanism of lexical selection. More precisely, whether lexical selection is based on the principle of competition or not (e.g., Mahon, Garcea, & Navarrete, 2012; Finkbeiner, Gollan & Caramazza, 2006; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007; Belke, Meyer & Damian, 2005; Caramazza, 1997; Schriefers, Meyer, & Levelt, 1990). We turn to this debate below.

Competition and non-competition-based theories of lexical access

As mentioned above, during lexical selection not only the target lexical node becomes activated for selection but also several semantically related lexical representations. A process of selection by competition has been integrated into some models of spoken word production, such as the WEAVER ++ (Levelt et al., 1999). According to this model, lexical selection is assumed to be a competitive process and for lexical selection to occur, the activation level for the target lexical representation must exceed the amount of activation of all its co-activated semantic competitors (Levelt et al., 1999). In other word, target lemma selection is determined by the activation level of the target lemma relative to the amount of activation of non-target lemmas; the higher the activation level of non-target lexical items, the harder the selection is for the target lexical item (Levelt et al., 1999). Thus, if target selection depends on the activation level of non-target alternatives, then target lexical selection should be slower in semantically related contexts where non-target alternatives are highly activated and strongly competing for lexical selection (e.g., Rahman & Aristei, 2010; Abdel Rahman & Melinger, 2009; Belke et al., 2005; Bloem & La Heij, 2003; Damian, Vigliocco, & Levelt, 2001).

Other lexical selection models assume that lexical selection can be accomplished without competition. For instance, Dell (1986) proposed that, at the time of selection, only the highest activated lexical representation is targeted irrespective of the activation level of other words. More recently, Oppenheim, Dell and Schwartz (2010) proposed a computational model to explain lexical selection without lexical competition. In their model, an incremental learning mechanism adjusts the semantic-to-lexical connection links. Their model assumes that every successful selection of a target word leads to the strengthening of the connection links between active semantic features and the target lexical representation (Howard, Nickels, Coltheart & Cole-Virtue, 2006; Oppenheim et al., 2010), while weakening the connection links between those same semantic features and other co-activated non-target words (Oppenheim et al., 2010). Thus, naming latencies should be increased with each subsequent naming trial because of incremental weakening of non-target lexical-semantic links. For example, naming a picture of a “dog” should strengthen the connections between the semantic representations of “dog” (e.g., has four legs) and the lexical representation of “dog”, while simultaneously weakening the connections between those same semantic representations and other co-activated semantically related non-selected words (e.g., cat, horse). Therefore, subsequently naming a picture of a “cat” should be slower due to the weakened connection from the semantics to the lexical representations of “cat” (Navarrete, Mahon, Caramazza, 2010).

To test the different views of lexical selection discussed so far, several experimental paradigms have investigated the mechanisms engaged in naming pictures for their pertinence to models of lexical access, such as the semantic blocking paradigms (e.g., Kroll & Stewart, 1994; Damian et al., 2001), and the cyclic version of the semantic blocking paradigms (Belke et al., 2005). These paradigms are of a particular interest to the issue of whether lexical selection is based on the principle of competition or not (e.g., Belke et al., 2005; Belke, 2008; Navarrete, Prato, Peressotti & Mahon, 2014), and are reviewed in the following section.

Semantic blocking paradigm

Lexical competition has been widely investigated using the semantic blocking paradigm. In the standard version of this paradigm, participants are required to name a set of pictures that are grouped together within a block either from the same semantic category (i.e., homogenous; e.g., all pictures are of animals), or from across different semantic categories (i.e., heterogeneous; pictures of animals, fruit, furniture etc.) (e.g., Kroll & Stewart, 1994; Damian et al., 2001). In the other variant of the semantic blocked paradigm (Belke et al., 2005), the set of pictures is presented cyclically in varying orders for several times within a block, and all pictures are named once within a cycle before the initial presentation of a new cycle either from the same semantic category (homogenous context; e.g., ‘duck’, ‘mouse’, ‘fish’, ‘snake’, ‘horse’) or from semantically unrelated categories (heterogeneous context; e.g., ‘bed’, ‘saw’, ‘cup’, ‘duck’, ‘train’) (see Figure 3).

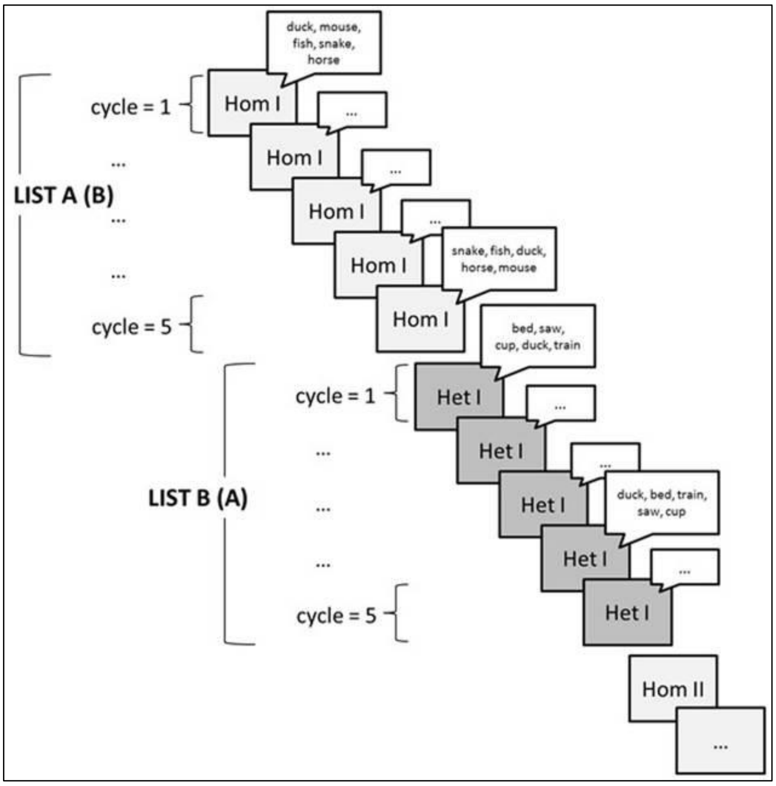


Figure 1-3 *Representation of a cyclic version of the semantic blocking paradigm in which a set of five pictures from semantically related categories (Hom), and from semantically unrelated categories (Het) are presented in succession multiple times (5 cycles) in which the pictures are ordered differently across these cycles, adopted from Belke (2017).*

The robust finding from the semantic blocking paradigm is that naming latencies are substantially longer during the retrieval of object names in homogenous contexts than in heterogeneous contexts (e.g., Kroll & Stewart, 1994; Damian et al., 2001; Belke et al., 2005; Belke & Stielow, 2013). This finding is referred to as the “semantic blocking effect”. The appearance of semantic blocking effect in the cyclic blocking naming task has been attributed to the spreading of activation within the semantic network when accessing a small set of semantically related lexical representations and their shared semantic features (e.g., Dell, 1986; Damian et al., 2001) repeatedly for several times (e.g., Belke et al., 2005).

While it is agreed that the longer naming latencies are due to the increased lexical retrieval difficulties within semantically related homogeneous context as compared to semantically unrelated heterogeneous context, the exact mechanism behind the interference effect is also still a matter of debate (e.g., Oppenheim et al., 2010; Belke et al., 2005; Roelofs, 2003; Damian et al., 2001; Levelt et al. 1999; Roelofs, 1992). A number of authors have proposed that the semantic blocking effect is caused by increased lexical-semantic competition (Belke et al., 2005; Damian et al., 2001). Therefore, if one assumes that the time needed for selecting a target picture depends on the activation level of the target lexical representation relative to the activation level of its competitors (Roelofs, 1992; Levelt et al., 1999), then one can explain the semantic blocking effect in terms of raised competitor activation due to the cyclical presentation of related stimuli, leading to the longer naming latencies in the homogeneous contexts (Belke et al., 2005). Lexical competition is therefore critical to this account of the semantic blocking effect.

However, an alternative view proposed by Oppenheim et al. (2010) accounts for the semantic interference effects without a lexical competition mechanism. According to this model, a learning mechanism modifies the semantic-to-lexical connection links at the end of each successful trial. Therefore, in a semantic blocking experiment, the connection links between active semantic features and other co-activated non-target members within a homogenous block are strongly reduced every time a target picture is named, while this is not the situation in the heterogeneous condition which thereby leads to the observed semantic blocking effect (Navarrete et al., 2014).

Although it is still debatable whether there is competition during lexical selection, a number of authors have agreed on the locus of the effect of semantic blocking. The semantic interference effect has been proposed to occur at the lexical level, at the level where the target lexical representation is selected for production (e.g., Levelt et al., 1999; Damian et al., 2001; Belke et al., 2005; Howard et al., 2006; Oppenheim et al., 2010; Belke, 2013). However, there is also evidence suggesting that the semantic interference effect may originate at the semantic level (Damian et al., 2001; Belke et al., 2005). This claim was supported by the finding that the semantic interference effect is not only restricted to the naming of a set of pictures from a certain semantic category, but it generalises to the naming of a new set of pictures from the same semantic category (Belke et al., 2005). In their study, participants were asked to name the same set of semantically related pictures in eight successive presentation cycles. They compared the resulting semantic blocking effect to that observed when participants named the same pictures only on the first four presentation cycles before naming a different set pictures from the same semantic category. They observed that the introduction of novel pictures on the fifth cycle led to a sharp increase of naming latencies, resulting in increased semantic interference.

Belke et al. (2005) proposed that the semantic interference effect results from “residual activation in the semantic system” (Belke et al, 2005, p. 687) which negatively interferes with the selection of a target lexical representation at the lemma level. This means that the slow selection of target lexical representations is due to the high activation level of the seman tic category node and its associated semantic features in the semantic system. This high level of activation extends its effect at the level of lexical-semantic processing during naming of other lexical items from the same category, leading to higher competitive lexical selection. For example, if the category is food, apple would produce a strong competitor with pear. As a result of naming apple, its lexical-semantic activation level is high and competes with the new word being presented.

To sum up, the semantic blocking paradigm demonstrates effects of the semantic relatedness of previously named pictures on the naming of subsequent pictures: naming pictures whilst naming semantically related ones is slower compared to naming pictures with semantically unrelated ones. Regardless of the current debate about the underlying processes of lexical selection (lexical selection by competition or not), our study is interested in investigating lexical selection during increased lexical-semantic activation. In what follows, I will use the term lexical competition to refer to lexical selection in the context of semantic alternatives rather than in reference to a particular underlying mechanism.

There is also a debate regarding language competition in bilingual word production during switching between languages (i.e., across-language lexical competition) and I turn to this in the following sections. Our study focuses on bilinguals' ability to resolve semantic competition by means of a semantic blocking paradigm. To the best of our knowledge, there are no studies assessing lexical-semantic selection using the blocked cyclic naming paradigm within bilingual population.

Lexical selection in bilingual speech production

In the case of bilingual speakers, who have two lexical representations for almost every concept they have, modelling the process of lexical selection is more complex compared to monolingual speakers. One of the key questions in bilingual lexical access is whether the two languages of bilinguals are activated during speech production or not. As we will review next, there is compelling evidence suggesting a parallel activation of the two languages in bilinguals during lexical access. Nevertheless, the nature of the mechanisms bilinguals apply to control lexical selection in speech production are still poorly understood, for instance whether the co-activated lexical representations compete for selection or not, as well as how bilinguals manage the co-activated languages, limit selection to the target language, and avoid intrusions from the non-target language.

Most bilingual lexical access models assume that when bilinguals plan to speak in one language, activation from the semantic system activates representations of both languages (e.g., Costa, Caramazza, & Sebastián-Gallés, 2000; Gollan & Kroll, 2001; Hermans, Bongaerts, De Bot & Schreuder, 1998). Evidence that supports the non-selective co-activation of bilinguals' two languages comes from several experimental paradigms investigating both language production and comprehension.

In terms of language production, the effect of cognate words has been widely studied to determine if the phonology of the nontarget language is active during the production of the target language (e.g., Christoffels, De Groot & Kroll, 2006; Costa et al., 2000). Cognates are those words that are pronounced similarly and largely overlap in meaning in two languages (e.g., English "bus"/Spanish "bus"; Costa et al. 2000). It has been observed that bilinguals are faster at naming cognate than non-cognate pictures, even in tasks that required bilinguals to use only one language. This effect has been called the cognate facilitation effect and has been interpreted as evidence for the co-activation of lexical representations of the two languages up to the phonological level (i.e., pronunciation) (Kroll, Dijkstra, Janssen & Schriefers, 2000).

In terms of language comprehension studies, it has been shown that the auditory perception of one language can activate similar candidates from the non-target language of bilinguals. Spivey and Marian (1999) employed eye-tracking technology to measure lexical interference from a non-target language during an auditory-visual task. Proficient Russian-English bilinguals were asked to move target objects displayed on a screen, in response to a spoken prompt. The visual display contained four objects, including an interlingual distractor object (e.g., a marker) that carried phonological similarity to the name of the object in the test language (e.g., *marku*, [stamp]). The other objects were control distractors, whose names were phonologically unrelated to the target word. It was observed that participants made more eye movements towards interlingual distractors than towards control distractors. This supports the hypothesis that phonemic input activates both languages simultaneously, even if the other language is not task relevant (Spivey & Marian,1999).

Interestingly, parallel activation has also been observed in languages with non-overlapping phonological systems, that is a spoken language and a sign language. Morford, Wilkinson, Villwock, Piñar, and Kroll (2011) showed that deaf bimodal bilinguals for whom American Sign Language (ASL) is the first language (L1) and English is the second language (L2) activated their ASL translations when reading words in their second language despite the absence of overlapping phonological and orthographic representations. In their experiment, the ASL/English bilinguals were asked to judge two sets of word pairs in English that were either semantically related (e.g., alligator/crocodile) or semantically unrelated (e.g., blood/bread). Crucially, these two sets were chosen to have equivalent numbers of phonologically related ASL translations.

Results revealed a significant interaction between semantics and phonology: bimodal bilinguals were faster to accept semantically related pairs with overlapping than with non-overlapping ASL translations, while the reverse pattern was seen for unrelated word pairs. This reaction time difference was mainly due to the parallel activation of the L1 (ASL) translation that occurred when processing L2. More specifically, these findings have been interpreted as evidence that bilinguals implicitly activate the translation in the language not in use, even when the two languages are structurally different (e.g., Morford et al., 2011).

The evidence reviewed above therefore demonstrates that there is a bidirectional influence between bilinguals' languages, even in monolingual contexts. This parallel activation requires a mechanism to select the appropriate language and to avoid interference from the other language. I turn to this issue in the following section.

Competition and non-competition-based theories of lexical access in bilinguals

Despite the evidence reviewed above of non-selective language activation during bilingual during lexical access, the mechanisms by which bilinguals manage language selection remain a matter for debate. In the next section, I will review the key research into bilingual language control as well as the models proposed to explain the underlying mechanisms.

Most models of bilingual lexical access propose that lexical selection is a competitive process (e.g., Green, 1998). That is, lexical representations from bilinguals' two languages compete for selection even when access to only one language is required. Following the logic that competition increases during lexical selection with the existence of semantic similarity between targets and their competitors during monolinguals' lexical selection, one would expect that competition should be maximal during lexical selection within bilinguals since the semantic system activates translation equivalent targets and their distractors equally.

For example, when an English/Spanish bilingual tries to produce a word in the target language English (e.g., 'dog'), its corresponding lexical representation in the non-target language (i.e., its translation equivalent in Spanish '*perro*'), becomes highly activated as well as other semantically related lexical representations in the two languages ('cat' and '*gato*'; Finkbeiner et al., 2006). This is because 'dog' and its Spanish equivalent '*perro*' share the same semantic representation, which ought to be even more closely related than semantically related lexical representations within a single language (e.g., dog and cat; Finkbeiner et al., 2006). Assuming that the semantically related lexical representations of both the target and non-target language and their translation equivalents are highly activated and compete for lexical selection, a mechanism must ensure the selection of the intended lexical node, i.e., of the concept to be named, and in the intended language. Two types of models have been proposed to account for bilingual lexical access, differing in whether the lexical representations of the two languages do or do not compete for selection.

One competitive model of bilingual lexical selection is the Inhibitory Control (IC) model by Green (1998). This model assumes that lexical selection is language non-specific and that lexical nodes in the bilingual's two languages are activated and strongly compete with each other to be selected (see also Green, 1986). This model entails an inhibitory mechanism that resolves cross-language competition. The target lexical node is selected by inhibiting/ suppressing the activation of lexical items in the non-intended language. As a result of this inhibitory selection mechanism, the activation level of the target lexical node (e.g., 'dog') is higher than the activation level of its translation equivalent ('*perro*') and will be selected (e.g., De Bot, 1993; Green, 1986, 1998).

An alternative model, which does not entail cross-language competition, assumes that language selection is "language specific" in the sense that lexical selection operates only on lexical representations in the intended language (e.g., Costa et al, 1999; Costa & Caramazza, 1999; Finkbeiner et al., 2006) irrespective of the activation level of the language not-in-use. Although lexical representations in bilinguals' both languages might indeed be co-activated, this model assumes that the activated lexical representations in the unselected language do not compete for selection (Finkbeiner et al., 2006). According to this view, bilinguals develop this ability to ignore any activation of lexical nodes from the non-target language and to selectively attend to the activated lexical nodes in the target one, without the need to suppress their activation (Costa et al., 1999; Finkbeiner et al., 2006). Thus, the selection mechanism only considers the target activated lexical node (e.g., 'dog'), while the activation of the non-target ('*perro*') will be ignored (Costa et al., 1999). The proposed language-specific model also assumes that only bilinguals who have L2 lexical representations which are as strong as L1 lexical representations (i.e., highly proficient bilinguals) can develop the ability to only focus on candidates in the target language (Costa & Santesteban, 2004).

The next section will review research conducted in the field of bilinguals' language selection models. More specifically, it will discuss the most salient experimental approaches that have been employed to examine language selection processes and to test the two accounts of bilinguals' language selection (language specific versus non-specific).

Experimental evidence for testing accounts of language selection

The picture-word interference paradigm

Three approaches have been adopted to test the predictions of the two models of lexical selection in speech production (i.e., the language-specific versus non-specific models). The first approach that has been heavily employed for studying the processes involved in bilinguals' lexical access is the picture-word interference (PWI) paradigm (e.g., Lupker, 1979; Schriefers et al., 1990). In this task, participants are asked to name a pictured object while ignoring a superimposed distractor word (e.g., Lupker, 1979). A robust finding within monolingual speakers is the semantic interference effects. That is, participants take longer to name a target picture when the superimposed distractor is semantically related to the target picture as compared to semantically unrelated (Finkbeiner et al., 2006). The semantic interference effect is assumed to arise because, unlike the semantically unrelated distractor, semantically related distractors are more highly activated because they receive additional activation due to overlap in the semantic system (Costa et al., 2000).

The same semantic interference effect has been obtained within a bilingual version of the paradigm when participants name a target picture in one language while the distractor word stems from the bilingual's other language (e.g., Costa, Miozzo & Caramazza, 1999; Hermans et al., 1998). The key finding of these studies is very similar to the semantic interference effect found in monolingual studies discussed above. For instance, for Catalan – Spanish bilinguals it takes longer time to name a target picture in Catalan (e.g., *taula* [table]) if it is presented with a semantically related Spanish distractor (*silla* [chair]) than if it co-occurs with a semantically unrelated Spanish distractor (*casa* [house]; Costa et al., 1999). This effect supports the hypothesis that lexical selection is language non-specific, since lexical representations in the bilinguals' two languages interfere with each other during lexical selection.

The selection by competition model also proposes that the interference effect reported in the picture-word interference paradigm should be greatest when pictures are presented with distractors that are translation equivalents (e.g., Catalan *taula* – Spanish *mesa* [both mean table]). For example, when Catalan-Spanish bilinguals name a picture of a table in Catalan (*taula*), the Spanish translation equivalent (*mesa*) should slow naming responses more than semantically related distractors (Green, 1998). However, Costa and colleagues (1999) showed that the naming of target pictures was actually facilitated when distractor words corresponded to the targets' translations (i.e., participants responded faster to translation equivalent distractors than semantically related ones). According to Costa and colleagues, the semantic representation of Spanish distractor *mesa* activates the lexical node of its Catalan translation *taula*; thus, the correct lexical node activates the correct phonological codes of the target picture (*taula* in Catalan) (Costa & Caramazza, 1999; Costa et al., 1999). This finding challenges the assumption that lexical selection is competitive across languages.

Proponents of a language non-specific selection mechanism, on the other hand, have failed to observe the facilitation effect observed in Costa and colleagues' study (e.g., Green, 1998; De Bot & Shreuder, 1993). Instead, they found that the simultaneous activation of Catalan – Spanish phonological representations (*taula* – *mesa*) led to competition. It is believed that the presentation of the translation distractor (*mesa*) causes the activation of both the Catalan and the Spanish phonological representations, and (*mesa*) in Spanish would compete with (*taula)* in Catalan leading to interference during the naming of the target picture (*mesa*). Further research is needed to understand the different results in these studies. It is important to last note that, although the paradigm provides a direct measure of a lexical-semantic competition processes, it does not separate the lexical-semantic retrieval effect from phonological retrieval effects.

Language switching

The pioneering study on bilinguals' language switching was conducted by Meuter and Allport (1999) who recruited unbalanced bilinguals (i.e., individuals who speak two languages but are more skilled in one language than in the other). Depending on the colour prompt, participants named numbers in either their dominant L1 or non-dominant L2. In addition, participants were asked to name numbers in the same language as the previous trial (L1/L1 or L2/L2; non-switch/repetition trials) or switch from one language to the other (L1/L2 or L2/L1; switch trials). Participants named the numbers faster in their stronger L1 than in their weaker L2 on non-switch trials. Surprisingly, the authors observed that switching from the weaker L2 to the stronger dominant L1 was slower and therefore seemingly more effortful than switching from L1 to the weaker non-dominant L2. This "paradoxical" result has been referred to as the "asymmetrical switch cost".

The asymmetrical switch cost reported in Meuter and Allport (1999) has been interpreted within the framework of the inhibitory account of bilingual language control (Green, 1998). According to this model, lexical items in the dominant language (L1) need to be strongly inhibited in order to name the target item successfully in L2, whereas switching from L2 to L1, bilinguals need to overcome the effect of the L1 inhibition applied during the previous trial. they therefore need more time to reactivate lexical items in L1 (Meuter & Allport, 1999). Since the bilinguals were unbalanced in Meuter and Allport's (1999) study, it was harder for them to switch into L1 than to switch into L2.

However, the asymmetrical switching cost has not always been observed in language switching studies. Costa and Santesteban (2004) employed a language-switching paradigm and discovered that balanced or high-proficient bilinguals switched to their dominant L1 as fast as to their weaker L3. They therefore exhibited a "symmetrical switch cost" between L1 and L3. This has led to the claim that bilinguals do not always resort to inhibition to regulate the co-activation of their two languages. However, the authors hypothesized that a language-specific selection mechanism operates to prevent cross-language interference (Costa et al., 1999). Costa, Santesteban and Ivanova (2006) argued that a language-specific mechanism has developed as a result of the bilinguals' high L2 proficiency, and that balanced bilinguals are found to employ a different switching mechanism compared to unbalanced bilinguals.

Taken together, the results from Meuter and Allport (1999) and Costa and Santesteban (2004) indicate that switching into L1 is costly only for non-balanced bilinguals, and not for balanced bilinguals, and that bilingual language control is therefore dependent on the proficiency level of the bilinguals' two languages. Importantly, however, these findings are confounded by the effect of language similarity (i.e., similarity of task languages). That is, the impact of language similarity on bilinguals' language switching performance (if L1 is similar to or different than L2).

Costa, Santesteban and Ivanova (2006) carried out four experiments to assess language-switching performance of highly proficient bilinguals. In their first experiment, they investigated the effect of language similarity and L2 age of acquisition on bilinguals' speech production during language-switching tasks. They had two groups: highly proficient *early* bilinguals that switched between their dissimilar languages (Spanish/Basque), while the second group of highly proficient *late* bilinguals switched between more similar languages (Spanish/English). Results showed that there was no difference between bilinguals' switching performance when they switched between their similar and dissimilar languages. More specifically, Costa et al. (2006) found that the size of the switching costs was similar for the two groups, suggesting that neither the degree of similarity between task languages nor age of L2 acquisition affected the language switching performance of highly proficient bilinguals.

It should be noted though that Costa et al.'s (2006) study tested the performance of only highly proficient bilinguals. Cui and Shen (2016) questioned these results and raised the following question: "what will happen when bilinguals with different proficiency perform the switching task between one of their strong languages and an unskilled and dissimilar language?" (Cui & Shen, 2016, p. 488). To answer this question, Cui and Shen (2016) tested the performance of highly proficient bilinguals with dissimilar languages (Tibetan/Mandarin) switching between one of their proficient L1 or L2 and their less proficient and less similar L3 (English), with L1 being similar to L3 but different to L2. They found asymmetrical switching costs for switching between Mandarin/English and switching between Tibetan/English.

Cui and Shen's (2016) finding suggests that language similarity may have an effect on bilinguals' language switching performance. This result is not consistent with the idea that similarity between languages does not affect bilinguals' switching performance proposed by Costa et al.'s (2006) study, wherein highly proficient bilinguals showed symmetrical switching cost when switching between dissimilar languages (Spanish/Basque). Additionally, the symmetrical switching costs observed in Costa and Santesteban's study (2004) for proficient bilinguals performing the switching task between their proficient L1 (Spanish) and their similar/weaker L3 (English) is not consistent with those found in Cui and Shen's experiment (2016), in which asymmetrical switching costs were found for proficient bilinguals switching between their L1 (Tibetan) and their similar/unskilled L3(English).

Taken together, results from both Costa's studies and Cui and Shen's (2016) study showed how groups of proficient bilinguals performed differently under the same condition, wherein a symmetry pattern of switch cost was observed within some groups of bilinguals switching between their similar languages whereas others displayed an asymmetrical switching cost when switching between their dissimilar languages (i.e., switched between more-proficient and less-proficient languages).

Cui and Shen (2016) explained this contrasting pattern of results by proposing that highly proficient bilinguals switch between a more proficient and a less proficient dissimilar language could resort to inhibitory control as a lexical selection mechanism, just as highly proficient bilinguals make use of the language specific selection mechanism during language switching tasks. On the basis of these findings, they suggest that language similarity may affect which selection mechanism can be used by bilinguals.

The purpose of the present thesis was therefore to investigate the influence of language similarity on bilingual language switching performance, switching between two high-proficiency languages. Specifically, the present thesis examines the effect of language similarity on the nature of bilinguals' lexical selection mechanism under increased lexical competition within two groups of bilinguals, those with closely similar languages (L1 German and L2 English) and those with dissimilar languages (L1 Arabic and L2 English). The question arises, will the performance of our two bilingual groups be affected by language similarity (Cui & Shen, 2016) or will it not be affected by language similarity (Costa et el., 2006)?

Table 1-1 presents an overview of key findings from studies of bilinguals' language switching performance. As shown in Table 1-1, previous studies have used several experimental conditions to investigate the effects of language similarity on bilinguals' switching performance. Beside language similarity, several variables have been found to play an important role in modulating the performance of bilinguals during language switching – such as the age of L2 acquisition (e.g., Costa et al., 2006) and individual differences in cognitive control ability between bilinguals (e.g., Liu, Liang, Zhang, Lu & Chen, 2015). The effect of these variables on lexical selection will be discussed in detail in the experimental chapters of this thesis.

Examining the role of the variables aforementioned in bilinguals' language switching performance, Table 1-1 presents results from earlier studies in which a symmetrical switching cost was found between L1 and L2 for highly proficient bilinguals (e.g., Costa et al., 2006; Calabria et al., 2012; Cui & Shen, 2016), whereas an asymmetrical switching costs was evident for L2 learners (e.g., Costa & Santesteban, 2004; Philipp et al. ,2007). Intriguingly, symmetrical switching costs were also observed for highly proficient bilinguals when they switched between L1 and their much weaker L3, regardless of the linguistic similarities between languages (e.g., Costa et al., 2006), whilst asymmetrical switching costs were present when bilinguals switched between their proficient L1 and less proficient dissimilar L3 (Cui & Shen, 2016).

Table 1-1 Summary of key task-switching studies examining bilingual language switching costs reported in this thesis

Study	Participants	Level of proficiency	Task	Task-switching outcome
Meuter & Allport (1999)	▪ English/French ▪ English/German ▪ English/Italian ▪ English/Portuguese ▪ English/Spanish	L1 dominant L2 proficient	a digit naming switching task	▪ asymmetrical switching cost when switching from weaker L2 to stronger L1
Costa & Santesteban (2004)	▪ Spanish/Catalan ▪ Korean/Spanish ▪ highly proficient Spanish/Catalan bilinguals	L2 learners: Spanish learners of Catalan Korean learners of Spanish weaker in: (L3 English)	a picture naming language-switching task	▪ asymmetrical switching cost (switching from L2 into L1 was harder than vice versa) ▪ symmetrical switching cost (when switching between two dominant languages OR switching from L1 into L3)
Costa et al. (2006)	▪ Spanish/Basque ▪ Spanish/English ▪ Spanish/Catalan/ English ▪ Catalan/Spanish /English/ French ▪ Spanish/Catalan	highly proficient *early* bilinguals in their two dominant languages highly proficient *late* bilinguals in their two dominant languages highly proficient *early* bilinguals in their (L2; Catalan) but having a weak L3 (English) highly proficient *early* bilinguals with weak (L3; English) and even weaker L4 (French) highly proficient *early* bilinguals in (L1; Spanish) and learning (New-L)	a picture naming language-switching task	▪ symmetrical switching costs regardless of the similarities of the 2 languages and AoA ▪ symmetrical switching costs (when one of the languages is very weak (i.e., an L3, L4 OR a recently learned language)

Philipp et al. (2007)	▪ German (asL1): ▪ German/English/French ▪ German/French/English	L2 learners: at least for 7 years and longer than learning L3 L3 learners: at least for 4 years	a digit naming switching task	▪ asymmetric shift cost when switching between L1 and L2, between L1 and L3, or between L2 and L3
Verhoef et al. (2009)	▪ Dutch/English	unbalanced bilinguals	overt picture naming in L1and L2	▪ asymmetrical switch costs on short intervals ▪ symmetrical on long intervals
Calabria et al. (2012)	▪ Catalan/Spanish	highly proficient bilinguals	a picture naming language-switching task	▪ symmetrical switch costs when switching between L1 and L2 or between L1 and L3
Liu et al. (2015)	▪ Chinese/English	low-proficient bilinguals	a picture naming switching task	▪ symmetrical switching costs for bilinguals with high inhibitory control ability ▪ asymmetrical switching costs for bilinguals with low inhibitory control ability
Cui & Shen (2016)	▪ Tibetan/Mandarin ▪ Tibetan/English ▪ Mandarin/English	highly proficient bilinguals in their two dominant languages (L1 and L2) with unskilled (L3)	a picture naming language-switching task	▪ symmetrical switching costs ▪ asymmetrical switching cost (when switching between proficient L1 or L2 and less proficient L3)

The effect of language-specific properties

A third resource of evidence about bilingual lexical production comes from studies that manipulate language-specific properties, such as phonology and/or orthography, to find out whether the unintended language is active or not during the planning of an utterance. Findings that support the parallel activation of bilinguals' languages show that bilinguals' two languages are active to the level of phonology and/or orthography (e.g., Guo & Peng, 2005; Hoshino, 2006; Thierry & Wu, 2007; Hoshino & Kroll, 2008). This is found for bilinguals whose two languages share the same script (e.g., Costa et al., 2000), as well as when features of the bilinguals' two languages are distinctly dissimilar, as in the case of two languages that use different written scripts (Hoshino & Kroll, 2008).

Hoshino and Kroll (2008) found that Japanese-English bilinguals showed a cognate facilitation effect during picture naming in L2. As previously noted, the cognate facilitation effect refers to the faster naming latencies for translation pairs that have very similar phonological or orthographical lexical features than translation pairs that are dissimilar. Hoshino and Kroll's (2008) finding is equivalent to the cognate facilitation effect reported in Costa et al. (2000) for Spanish–English bilinguals. However, their results demonstrated parallel activation of lexical candidates of the non-target language during the planning of speech of the target language, even when the non-target language has a different written script than the target language. Thus, these results indicate that languages that do not share the same script yield the same cognate facilitation effect as same-script bilinguals (Costa et al., 2012). Critically, this study shows that bilinguals with different-script languages cannot easily use specific-language properties to attain early language selection, which means that a bilingual's two languages are simultaneously active during picture naming, thereby indicating that bilinguals have to overcome the co-activation that occurs within and between their languages (Gollan & Silverberg, 2001).

The occurrence of cross-language activation for different-script bilinguals in Hoshino and Kroll's study (2008) does not reveal the nature of the selection mechanism that bilinguals apply to restrict their production to the target language; it only demonstrates cross-language interactions. In addition, the bilinguals recruited in their study were all proficient in their second language (i.e., English). Thus, it is unclear whether high L2 proficiency is necessary in order to observe a cognate effect in different-script languages. Thus, further assessment of the effects of language proficiency and language similarity with different/similar-script languages should be conducted.

To our knowledge, there are only few studies that have directly investigated the role of language similarity in cross-language activation during lexical access. Van Heuven, Conklin, Coderre, Guo, and Dijkstra, (2011) investigated the effect of language similarity on cross-language activation, using a Stroop task. They found that trilinguals whose languages are distinctly dissimilar in their written-scripts (i.e., Uyghur, Chinese, and English) showed a smaller Stroop interference effect than same-script trilinguals (i.e., German-English-Dutch). This result suggests that language similarity plays an important role in controlling the degree of enrolment of cognitive control mechanisms during bilingual language processing.

Boukadi, Davies and Wilson (2015) used a picture-word interference task to explore lexical selection in bilinguals with different-script languages. They asked Tunisian Arabic-French bilinguals, who are proficient in French, to name pictures in their L2 while ignoring auditory distractors that were either phonologically or semantically similar to the picture names or dissimilar. Naming occurred in two different contexts (i.e., monolingual and bilingual contexts). Results showed that when the context was monolingual (same-language distractors), only phonological similarity affected naming latencies, suggesting that lexical selection functioned in a specific manner. However, in the bilingual context (cross-language distractors), a phono-translation effect as well as phonological and semantic effects were found, suggesting that lexical selection is non-specific. These results indicate that cross-language competition occurs only in a bilingual context as seen by the phono-translation interference effect observed in the bilingual context while bilingual lexical selection operated in a language specific way in the monolingual context, as observed in the phonological facilitation effect. Boukadi et al. (2015) suggest that bilingual lexical selection is a dynamic process that depends on factors such as the experimental language context (i.e., whether it is monolingual or bilingual) and the degree of activation of both languages (i.e., whether lexical selection functions in a language non-specific or in a language-specific manner). Taken together, the results show that it is not only proficiency that modulates the bilingual lexical selection process, but rather its interaction with other variables, such as language context and language similarity.

As seen in the studies discussed above, differences in bilinguals' linguistic backgrounds seem to have a profound impact on the nature of the mechanism bilinguals use to control their two languages. However, the majority of studies on bilingual lexical selection control have examined related languages such as English, German, Dutch and other Indo-European languages, while relatively little attention has been paid to language control in bilinguals with unrelated languages such as Arabic and other Semitic languages. Studies on cross-linguistic activation in bilinguals have been conducted with various language pairs, for instance Spanish/Catalan and Dutch/English (e.g., Kroll, Dussias, Bogulski & Valdes Kroff, 2012), which all share the Roman alphabet. Schiller (2018) pointed out that most of the work on cross-linguistic influences on bilingual lexical production/perception has been conducted with language pairs from the same writing system (e.g., 68% Germanic languages: English, German, Dutch and Danish; and 13% Roman languages: Spanish, French, Italian and Romanian) and most belong to the Indo-European language family (see Figure 1-4).

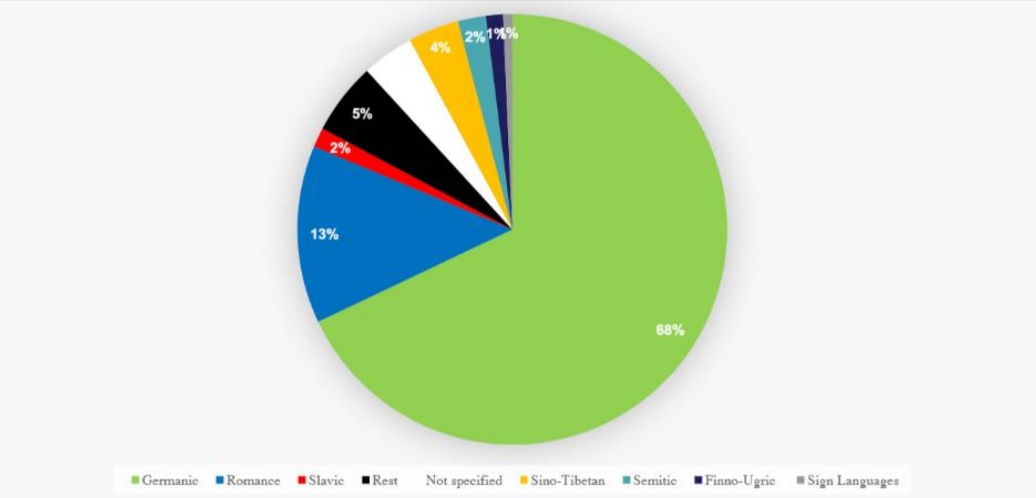


Figure 1-4 *The average of languages investigated in papers studying cross-language acquisition that are published between 2000-2015 in Journal of Memory and Language (JML), Languages and Cultures for Professions (LCP) and Journal of Neuropsychology (JN) according to different language groups (Schiller, 2018).*

In summary, this Chapter reports a series of studies designed to examine lexical retrieval in bilingual spoken word production. These studies include experimental paradigms such as picture-word interference paradigm, language switching paradigm and semantic blocking paradigm which have been heavily employed to understand the underlying mechanism of lexical selection that bilinguals apply to resolve simultaneous language activation.

This Chapter has also discussed current theories of how bilinguals resolve this simultaneous activation of their languages. One mechanism called the Inhibitory Control model posits an inhibitory selection mechanism, which can prevent the competition of lexical representations from the non-intended language by inhibiting the activation of lexical items in the non-response language (Linck, 2012; Abutalebi & Green, 2007; Green, 1998). Another model called the language specific selection model (Giezen & Emmorey, 2016; Costa et al.,

1999) assumes that the selection mechanism is only sensitive to those lexical representations belonging to the intended language.

Several factors that could affect bilinguals' language selection mechanism have been discussed in this Chapter such as the effects of the level of L2 proficiency and the effects of lexical semantic interference on bilingual lexical selection. Despite the large body of literature on how such variables could modulate bilinguals' language control, there has been limited investigation into how language similarity impacts the language selection mechanism of bilinguals. This thesis therefore investigates the effects of bilingual language similarity on the bilingual lexical selection process. It examines the effect of language similarity on the nature of bilinguals' lexical selection mechanism within two groups of bilinguals, those with closely similar languages (German/English) and those with dissimilar languages (Arabic-English).

The Present thesis

One of the main aims in this thesis is to investigate the nature of the mechanism bilinguals use to control their two languages. A second purpose of this thesis is to test whether bilinguals' reported advantages in non-linguistic tasks, including inhibitory and shifting controls have an impact on the way they control and switch between their two languages. Since most studies reviewed above on bilingualism and cognitive advantages have been mainly based on the comparison between the performances of bilinguals as a group relative to monolinguals, there is a need to consider whether bilinguals' individual abilities to perform on executive function tasks have an effect on the way they control production and switch between their two languages.

The current thesis therefore takes an individual differences approach and looks for a direct relationship between executive function and first language/second language lexical retrieval in bilinguals. In doing so, the thesis uses non-linguistic tasks of executive function, including a Colour-shape shifting task and a Flanker task, to assess bilinguals' individual differences in executive control ability.

A final issue to be addressed in this thesis is the effect of language similarity on both linguistic competition resolution and executive functions in bilinguals with closely related languages compared to bilinguals with relatively unrelated languages. This research combines a semantic blocking paradigm and a language switching paradigm to assess the impact of language similarity on lexical access and to understand the underlying language control mechanisms bilinguals apply to resolve lexical semantic interference during lexical selection.

The next section will look at how Arabic is different from German when compared to English at every linguistic level (e.g., phonology, morphology and orthography) and how those differences might affect bilingual lexical selection.

CHAPTER 2

COMPARISON AND CONTRASTS BETWEEN INDO-EUROPEAN AND SEMITIC LANGUAGES

Introduction

The current research examines lexical access in two bilingual participant groups, one with same-script languages (German-English) and one with different-script languages (Arabic-English). The aim is to understand the effect of language similarity on lexical selection mechanisms. Bilinguals with the language pair Arabic-English combine two unrelated language families (Semitic/Indo-European), which greatly differ at every aspect of linguistic structure (e.g., phonology, morphology, orthography, etc), while bilinguals with the language pair German-English combine two languages from one language sub-family, namely Germanic languages (Moulton & Buccini, 2018).

More specifically, German and English belong to the Indo-European family. Germanic languages are spoken in most of northern Europe, and some areas of European settlement. They can be divided into three main groups: West Germanic, including English, German, and Netherlandic (Dutch); North Germanic, including Swedish, Icelandic, Danish, Faroese and Norwegian; and East Germanic, including only Gothic and a few other tribal languages which are now extinct (Buccini & Moulton, 2018). In contrast, the Semitic language family is a branch of the Afro-Asiatic language family, which includes Modern Hebrew, Amharic, Ugaritic, Tigre, Tigrinya, Syriac and Arabic (Watson, 2011).

A general view of linguistic structure in Semitic and Indo-European languages

The two language families differ in terms of their phonology, morphology, and orthography. In terms of phonology, Semitic languages are marked by a rich consonantal system and a limited vocalic system, whereas there are only three basic vowels (with a short and long form of each vowel /a/, /i/, /u/). In addition, Semitic languages are marked by a rich set of guttural consonantal sounds, such as the pharyngeal /ʔˤ/, the laryngeals /ʔ/, /ħ/ and the uvular /s/, /χ/ and /ʁ/, sounds that do not exist in the Germanic consonant sound system (Watson, 2011). In contrast, the vowel systems of Indo-European languages contain a large number of vowels. For instance, West Germanic languages (i.e., English and German) have nearly 20 distinct vowel phonemes each. English has around 12 vowels in most dialects, while standard German has even more vowels than English (Johnson, 2002).

Differences in the number of vowels between Semitic and West Germanic languages mean that there are certain vowels in the Germanic languages that do not exist in the Semitic languages (Ashour, 2017). For example, vowels like /ə/, /ɔ/, and /ʌ/ are not present in the Arabic language, Arabic speakers may find it therefore difficult to map these English vowels to their Arabic ones, resulting in a slower lexical processing during language production (Ivanova & Costa, 2008).

On the other hand, cross-language similarity in phonology has been observed to facilitate the production of the target language (Flege, 1981). Since English and German are closely related, both being Germanic languages, certain similarities between these two languages can enhance the perception and production of an L2 (Schultheiss, 2008). For instance, words like *Apfel* and *Fisch* in German are equivalent to “apple” and “fish” in English respectively. Such lexical similarity between English and German makes it easier for L2 learners to correctly perceive and produce an L2 (Llach, Fontecha & Espinosa, 2005). However, enough differences do exist between these two languages that can hinder the acquisition of an L2. For example, the German language has several vowels, /œ/, /Y/, /ø:/ and /y:/ that do not exist in the English language (Schultheiss, 2008), which might be a problem for the German speakers, resulting in cross-language pronunciation errors (Parker & Riley, 2000). It is important to say though that these dissimilarities between the German and English languages are considered to be minor compared to the major differences between the Arabic and English languages, each has its own linguistic system. That is, each language has its own phonology, morphology and orthography.

In terms of morphology, there are also critical differences between Semitic and Germanic languages. A striking feature of Semitic languages is their system of root-pattern morphology that is based on discontinuous morphemes. The root system is extremely complex but organised. Arabic words comprise of two morphemes, namely a consonantal root and a vowel pattern, that must be used together and cannot exist independently. Roots and vowel patterns are abstract mental representations that convey a specific and essential meaning (Ryding, 2005).

The Arabic consonantal root is the essential component of the word that carries its meaning. It is a “discontinuous” morpheme because vowels can be inserted between the consonants in a certain pattern. The consonants in an Arabic root must always be present in the same order, e.g., first */k/*, then */t/*, then */b/* for the three-consonant root */k-t-b/*, meaning ‘write’ (Ryding, 2005). An intercalated vowel pattern marks the grammatical category of the word, such as singular or plural for nouns, and voice (active or passive) for verbs (McCarthy & Prince, 1990). For example, words that are associated with the meaning of “write” are derived from the three-consonant root */k-t-b/* by manipulating the patterns of vowels. The masculine active form “he wrote” is formed by inserting the vowel “a” *katab-a*, which shares the root with *katib* (*writer*), *ketab* (*book*), etc. For more examples of other root-pattern combinations for the root */k-t-b/* see Table 2-1.

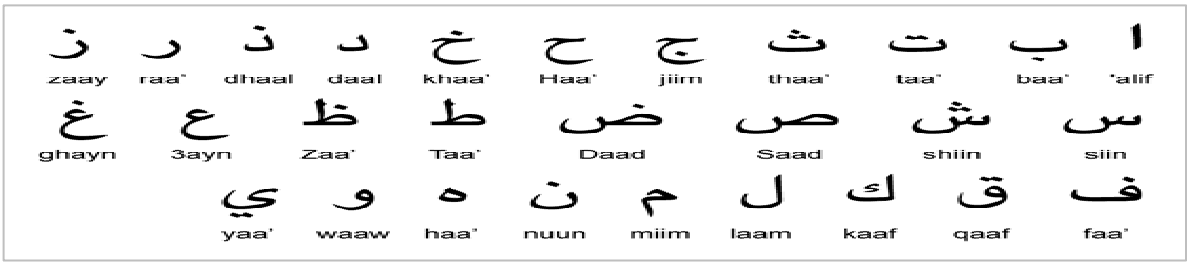
Table 2-1 Examples of root-pattern combinations for the root /k-t-b/ ‘write’. All examples that hold the meaning of ‘write’ contain the consonants k-t-b, always in that same sequence, whereas the grammatical categories tense, person, voice, gender, number and case are marked by the vowels.

he wrote	*katab-a* (v.)	كَتَبَ
he corresponded	*kaatab-a* (v.)	كاتَبَ
it was written	*kutib-a* (v.)	كُتِبَ
book	*kitaab* (n.)	كِتاب
books	*kutub* (n.)	كُتُب
writer; (adj.) writing	*kaatib* (n.)	كاتِب
writers	*kuttaab* (n.)	كُتّاب
write! (2 m.s.)	*uktub!* (v.)	أُكْتُبْ!

The consonantal roots are important for the lexical system of the Arabic language, because they contain the lexical meaning of words and signify a semantic field in Semitic languages (Ryding, 2005). It is therefore not surprising that Arabic dictionaries are organised by lexical roots and not by spellings of words, as done, for instance, for English and German. The most basic semantic meaning of the lexical root and all words that are associated with the meaning of that lexical root are listed first, then follow all the derivatives of the root (Watson, 2011).

The Arabic root system is completely different from the inflectional morphological system of English or other Indo-European languages. Those have a linear and comparatively simple morphological system in which words are formed by connecting morphological affixes (e.g., *-ness*) to stem morphemes (e.g., happy) in a linear manner (e.g., happiness) (Haspelmath, 2002). Most English words therefore consist of two morphemes. For example, the noun *writer* is made up of two morphemes: the root/stem *write* and the nominal suffix *–er*. Importantly, most roots can be used as independent words, which is not the case for roots and vowel patterns.

Finally, the two language families also differ in their orthographic system. The phonetic script of Semitic languages is read from right to left in a cursive script, while the script of Germanic languages is read from left to right. In addition, Arabic often does not represent most vowel letters and uses diacritic marks above or below the consonants before the vowel (e.g., Wright, 1995). West Germanic languages use the Roman alphabet (a modern version from a western variety of the Latin alphabet), whereas the Arabic alphabet is originally derived from Aramaic script which was later modified to accommodate the consonantal root system (Saiegh-Haddad, Henkin, 2014) (see Figure 2-1).



Symbol	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	V	X	Z
Latin name of letter:	ā	bē	kē	dē	ē	ef	gē	hā	ī	kā	el	em	en	ō	pē	qū	er	es	tē	ū	ex	zēta
Latin name (IPA):	[aː]	[beː]	[keː]	[deː]	[eː]	[ɛf]	[geː]	[haː]	[iː]	[kaː]	[ɛl]	[ɛm]	[ɛn]	[oː]	[peː]	[kuː]	[ɛr]	[ɛs]	[teː]	[uː]	[ɛks]	[ˈzeːta]

Figure 2-1 *The difference between the Arabic and the Germanic languages alphabetic writing system*

The Arabic alphabet is thus considered a consonantal alphabet, a type of writing system where each symbol stands for a consonant, and the proper vowels are provided by the reader. This system is best suited to the root-pattern morphological structure, where the meaning of the lexical root is carried by the consonantal root and the vowel information is derived from the vocalic pattern (Saiegh-Haddad & Henkin, 2014).

As evidenced in the above descriptions of Semitic and Indo-European languages, these two language families are different in many aspects. Since one of the aims of this thesis is to examine the effect of language similarity on bilingual lexical access, German-English bilinguals and Arabic-English bilinguals are therefore ideal candidate participant groups. Furthermore, Arabic-English bilinguals also provide an opportunity to investigate the role of language similarity in a group that has been included in relatively few studies to date (but see Liepmann & Saegert, 1974; Coderre & Van Heuven, 2014; Boukadi et al., 2015). Having said this, in order to comprehend the nature of lexical selection by a group of bilinguals who have different scripts as well as different morphological structures, a further review of the Arabic language and its dialects as well as the German language is needed.

The Arabic Language

Arabic is one of the most widely spoken languages in the world. It ranks fourth based on the total number of its speakers, with roughly 315 million native speakers (Gordon, 2005). Arabic belongs to the Semitic language family, and it is the most widely used of all the Semitic languages including Amharic, Tigrinya, and Hebrew (Thompson, 2017). Arabic is the official language of about 25 countries, including African countries such as Egypt, Sudan, Algeria, Libya, Morocco, Tunisia, Mauritania, Mali, Chad, Ethiopia, Niger and Somalia, and is also commonly spoken in Djibouti and Eritrea. It is the main language of all the countries of the Middle East (e.g., Saudia Arabia, Kuwait, Oman, Bahrain, United Arab Emirates, Qatar, Iraq, Yemen, Jordan, Lebanon).

The Arabic language has two main forms namely Modern Standard Arabic (MSA), a formal modern form of the old Classical Arabic and Dialectal Arabic (DA), a non-formal spoken form of the language. A significant percentage of Arabic speakers can speak and understand MSA, as it is the official language of all Arabic-speaking countries and is considered the formal language of education, mass media and the only written form of Arabic taught at all levels of education (e.g., Grimes, 1996). Most MSA speakers learn it through formal schooling (Thompson, 2017).

Dialectal Arabic, on the other hand, includes impressively diverse colloquial dialects (Owens, 1998). Each individual colloquial dialect has its own distinctive features (i.e., differences in pronunciation or/and vocabulary), which are acquired by children in their early years of life as their first language (Thompson, 2017). Differences between some dialects, however, are such that they remain largely mutually intelligible so that Arabs of different nationalities are able to understand one another very well (Rubin, 2017). On the other hand, some North African dialects spoken in Morocco are uniquely different in their vocabulary and structure which can challenge mutual understanding with Arabs of the Middle East. Some scholars even argued that such a variety of the Arabic language may be better considered separate languages (e.g., Kaye & Rosenhouse, 1997).

The usage of Arabic language is therefore characterized by diglossia, meaning that its speakers have proficiency in two varieties of the same language, a colloquial variety and MSA ("Diglossia | linguistics", 2016). As a result of the differences between colloquial dialects, there has been a huge reliance on MSA, especially in education, literature and media. MSA has become the universal language across the Arab world that serves as a language for communication among speakers of various colloquial dialects, many of whom may otherwise have barriers to communicate with one another.

The Arabic speakers that we tested for the present thesis stemmed from the Middle East, mainly from Saudi Arabia. All the people across Saudi Arabia understand each other, with only the exception of a few words. However, the official language of the country is MSA, which, as mentioned above, is used in education, social media, news, books and many other forms of more formal communication. Children start to study MSA officially at school at an early age (i.e., from age 6), and throughout their years of formal education. They learn the rules of Arabic grammar, lexicon and the rules of word formations. Although students read and write in MSA at school, they communicate among themselves with their own dialects. This indicates that DA differs from MSA in terms of phonology, morphology and syntax.

Regarding their learning and exposure to English, Arabic speakers typically start to learn English at schools after the age of 12 which, according to the critical period hypothesis, is considered to be a late age of acquiring a new language. As the critical period holds language acquisition must occur before the age of 12, otherwise speaking that language will be difficult and native-like proficiency will not be achieved (Hensch, 2004). Arabic speakers are less exposed to the English language due to the limited media resources. Even in formal schools, the exposure to English is limited: less than 5 hours a week.

The German Language

German is a West Germanic language that is mainly spoken in Central Europe. It is the official language of Germany, Austria, the German-speaking community of Belgium, Liechtenstein and it is one of the official languages in the German-speaking area of Switzerland (Nielsen, 1989). German is the native language of more than 100 million speakers worldwide, and is the second most widely spoken Germanic language, after English ("Europeans and their Languages," 2012).

As a written language, German is considered to be a uniform language that derives the majority of its vocabulary from the Indo-European language family, such as ancient Latin and Greek (Nielsen, 1989). Some other vocabularies are borrowed from English or French, such as *babysitten* “to babysit” from English and *fein* “fine” from French (Onysko, 2007). As a spoken language, German has many dialectal groups existing in Europe and other parts of the world. These dialectal variations are typically divided into High German and Low German. The main difference between these two dialectal groups is the sound system, mainly the consonants (Waterman,1966).

High German is divided into Central and Upper German. The Modern Standard German or “*Hochdeutsch*” is based on the Central and Upper German, which is the language used for administration, literature, higher education and the mass media (Nielsen, 1989). Modern standard High German is the official language of Germany and it is widely spoken in the central and southern highlands of Germany, Austria, and Switzerland (Waterman,1966). On the other hand, Low German dialects “*Plattdeutsch” o*r “*Niederdeutsch*” are still widespread among older people in northern Germany (Waterman, 1966).

Although Modern standard German is the official language of Germany, over 65% of the population of Germany speaks at least one foreign language and about 27% can speak two foreign languages (Sen Nag, 2018). Within the variety of languages in Germany, English is the most important foreign language and is taught early in German schools. The German speakers that we tested for the present thesis all came from Germany where English is spoken as a foreign language. In Germany, learning a foreign language is obligatory, and English is one of the more common choices, besides Ancient Greek, Spanish and French.

According to a study by the European Commission's education network, *Eurydice*, about 60% of German students take English as a foreign language ("The local Germany", 2008). The study has also confirmed that English is the most-studied language in Germany. However, the age at what students begin learning a foreign language differs from one state to another. In some states, foreign language education starts in the first year of primary school, while in other states it starts in the third year of primary school. In general, the average age for German pupils to start learning English is at the age of 9, which is quite an early age to learn a second language. Regarding exposure to English, German speakers have several resources to learn English. First and foremost, geographically, Germany is very close to English speaking countries like the UK which facilitates exposure to English. Moreover, fast growth in media technology, including progress in internet access for instance, has helped to develop early experiences with the English language.

In summary, this chapter compared two language families, Indo-European and Semitic language families. It specifically described how Arabic language is different from the German language. It showed that Arabic and German greatly differ at every aspect of linguistic structure important for lexical representation (e.g., phonology, morphology and orthography). In addition, Arabic speakers are diglossic, learning two representational systems for their first language. In both Germany and Saudi Arabia English is a common second language. However, in Germany children typically start to learn English before the age of 10 and are often exposed to the language in the media (music, films etc.). In contrast, Arabic speakers start to learn English later in their lives, after the age of 12 and are less exposed to the English language. These differences in learning and exposure to English between both counties is relevant for the interpretation of the LEAP-Q factors in the next chapter.

CHAPTER 3

ASSESSING LANGUAGE PROFILES IN TYPOLOGICALLY-DIFFERENT BILINGUALS

Introduction

Bilingualism can be defined differently from different viewpoints (Romaine, 1989). The variation in the definition of bilingualism is a result of the huge differences in bilinguals' language experience, including the age at which the second language is acquired, the ways in which both languages are used, and the different levels of proficiency, dominance and preference in both languages. These differences in bilinguals' language experience or profile have led to an increasing interest in studies that examine the effects of the different aspects of bilingual profile on bilinguals' language processing (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Li, Wang & Lin, 2017; Bonfieni et al., 2019; Kastenbaum et al., 2019). Many of these studies have considered individual aspects of bilingual profile such as age of second language acquisition (e.g., Costa et al., 2006), proficiency (e.g., Costa & Santesteban, 2004) and language exposure (e.g., Bonfieni et al., 2019). However, a complex relationship exists between the different facets of bilingual language experience and use.

Therefore, further research with a multifaceted bilingualism perspective is needed, that can capture the multidimensional nature of bilingualism and its influence on language performance. This thesis has a specific focus on the role of bilingual language profile on the bilinguals' ability to control their two languages. The goal of the study reported in this chapter is therefore to collect and analyse language proficiency questionnaire data from two groups of bilingual speakers, with typologically different languages, in order to efficiently investigate the contribution of their profile in each langue to their language performance. The questionnaire data was collected from all the bilinguals that participated in the semantic blocking experiment: the Arabic/English bilinguals (in Chapter 4) and the German-English bilinguals (in Chapter 5). The data was analysed using factor analysis in order to determine the factors that best explained these two different samples of bilingual speakers' underlying language experience and proficiency constructs.

In the sections below, we first elaborate on the concept of bilingualism, and discuss those characteristics of bilingual speakers that have been associated with difference in language performance. We then review previous studies which examined the association between self-ratings of bilingual language proficiency and behavioural measures of language performance to prove the reliability of these self-rating measures in assessing bilinguals' language proficiency and experience (e.g., Delgado, Guerrero, Goggin & Ellis,1999; Bahrick, Hall, Goggin, Bahrick & Berger,1994; Jia, Aaranson & Wu, 2002). Many studies have however used differing bilingual language profile and performance measures, making it difficult to generalise across their findings. It is clearly important to develop a language proficiency measure that can capture the different aspects of the bilingual language experience. This was the aim of the Language Experience and Proficiency Questionnaire (LEAP-Q), developed by Marian, Blumenfeld and Kaushanskaya (2007) which was used in the present study as an assessment instrument. The LEAP-Q will be discussed in detail before the present study is reported.

Types of bilinguals

Linguists such as Bloomfield define bilingual speakers as those individuals who can converse in two different linguistic settings, having "native-like control of two languages" (Bloomfield, 1933, p.56). Haugen (1953), on the other hand, states that bilinguals should be able to produce “complete and meaningful utterances in the second language” (Haugen, 1953, p.6). Such definitions are strictly exclusive and ignore most of the world’s population who are bilinguals (Grosjean, 1982). Bilinguals are not a group of homogeneous speakers, they differ from each other depending on many factors, such as the age during which they acquired their second language (e.g., simultaneous or late), the acquisition context of their two languages (e.g., compound or coordinate) and the relative strength of each language (e.g., balanced or unbalanced). In compound bilinguals, individuals learn the two languages in the same context/environment (e.g., home); therefore, the linguistic representations of their two languages are associated to the same concept. While coordinate bilinguals learn their two languages in separate contexts (e.g., home and school); thus, the linguistic representations of both languages can be more separate with each having its independently related concepts (Diller, 1970). Compound bilinguals usually become balanced bilinguals as they acquire both of their languages before the age of ten (i.e., simultaneous bilinguals) (e.g., Diller, 1970; Chiswick & Miller, 2002). On the other hand, bilinguals who did not learn their second language at an early stage of their lives are defined as late or unbalanced bilinguals. Quite often, second languages are learnt for an explicit purpose, such as for professional, academic, or other purposes (Graddol, 1997).

Such a diversity in bilinguals’ linguistic backgrounds, with large differences in their language experiences, has often led to variations in findings in research investigating bilingual language processes (e.g., Grosjean, 2004). For instance, the participants in studies of bilingual lexical processing (e.g., Kroll, Sumutka & Schwartz, 2005; Costa, 2005) and bilingual lexical selection mechanisms (e.g., Green, 1998; Costa et al., 1999) have been found to differ in their age of acquisition, their proficiency in the L2 and the degree of their language dominance. Such divergence in bilinguals’ linguistic backgrounds makes it difficult to identify which aspect of bilingualism is important for particular bilingual language behaviours. These variations in the findings are further increased by the absence of a valid and uniform assessment measure within bilingualism research. For example, Roseberry-McKibbin, Brice and O'Hanlon, (2005) observed that working with bilinguals whose languages do not match with the researchers' languages is taxing and stands in the way of achieving the intended outcomes.

Previous self-rating studies

In bilingual research, questionnaires are broadly used as an approach to assess language proficiency and other aspects of bilingual language status, including age of acquisition, language dominance and preference. In these questionnaires, bilinguals are often asked to self-rate their linguistic abilities in each of their languages and report their language history (e.g., Gollan & Acenas, 2004; Gollan & Silverberg, 2001). Earlier research suggests that self-reported language measures are particularly important tools for determining bilinguals' linguistic ability and assessing their linguistic proficiency (e.g., Flege, MacKay, & Piske, 2002; Flege, Yeni-Komishian, & Liu,1999). For instance, Flege et al. (2002) examined how language dominance can affect both bilinguals' grammatical ability and their degree of foreign accent. They applied a language history questionnaire that included questions related to participants' L2 immersion factors, such as age of arrival in the L2 speaking country, duration of L2 immersion and degree of L2 exposure. Flege et al. (2002) found that participants' self-reported language history correlated with their degree of foreign accent in L2 and their performance on a grammaticality judgment task. However, an important question is how accurate these self-ratings are as a measure of bilinguals' language proficiency and experience.

There is evidence for a relationship between self-reported ratings of language proficiency and more objective, behavioural measures of language performance (i.e., tests that are used to measure basic skills in listening, speaking, reading, writing, and understanding). For instance, Delgado, Guerrero, Goggin and Ellis (1999) found a relationship between self-assessed proficiency and language performance for a group of Spanish/English bilinguals. They found that bilinguals' self-reported proficiency in their two languages correlated with a standardized behavioural measure of language, namely the Woodcock–Muñoz Language Survey (Woodcock & Muñoz-Sandoval, 1993). Bahrick, Hall, Goggin, Bahrick and Berger (1994) have also found that self-reported language dominance strongly correlated with performance on some language performance tasks, such as vocabulary recognition and category generation, but correlated less strongly with performance on other tasks, namely the oral comprehension task. Jia, Aaranson and Wu (2002) found that self-assessed proficiency positively correlated with behavioural measures of grammatical ability. They used a questionnaire with 32-items to assess four different language variables of 112 Mandarin-L1/ English-L2 bilinguals. These variables included age of L2 acquisition and arrival in the L2 environments, frequency of speaking L2 (e.g., at home and in the workplace), self-consciousness and language preference and finally self-evaluation of proficiency in both of their languages in in speaking, reading, and writing. Participants self-reported their proficiency and their language history. They were also tested on a grammaticality judgment task, using 256 sentences to assess their L2 proficiency in listening and reading. The results yielded strong positive correlations between self-reported ratings of language proficiency and performance on the grammaticality judgment task.

Taken together the evidence suggests that self-reported measures of language proficiency appear to be reliable because they highly correlate with behavioural measures of language performance, suggesting that bilingual speakers are able to assess their own language proficiency in a manner that is consistent with their behavioural performance (e.g., Chincotta & Underwood, 1998; Jia et al., 2002).

Measuring bilingual language status and proficiency

Although previous self-ratings studies have found correlations between self-rating and objective behavioural language measures, there were some inconsistencies in various aspects of these studies. First, the relationship between self-reported proficiency measures and behavioural measures of language performance differ across bilinguals' two languages. For instance, in the Delgado et al. (1999) study, participants were more accurate in assessing their proficiency in their first language than they were for their second language. That is, the Woodcock–Muñoz scores correlated with all the self-assessed ratings of their first language proficiency (i.e., listening, speaking, reading, writing, and understanding skills) but only with some of the self-reported measures of their second language, namely reading and writing. Moreover, the number of behavioural tasks used to validate self-reported measures are often limited. This was exemplified in a Jia et al. (2002) study which only used one behavioural task (e.g., grammaticality judgment) instead of using a variety of behavioural tasks for questionnaire validation. Thus, more reliable findings might have been attained if the range of behavioural tasks had been wider.

Adding to the inconsistency in the previous self-rating studies is the absence of a uniform procedure for determining bilinguals' language proficiency and dominance. Some researchers have used separate measures of language performance to describe bilingual language proficiency and dominance, while others have used the same measure to define both proficiency and dominance (e.g., Flege et al., 2002; Vaid & Menon, 2000). For example, Chincotta & Underwood (1998) have used bilinguals' history-related variables, such as early language exposure and current language use as a measurement of language dominance, whereas Talamas, Kroll and Dufour (1999) have determined language dominance by relying on the experimenter's personal judgment. Similarly, while some researchers have measured bilinguals' self-reported proficiency in reading, writing, speaking and comprehending (e.g., Vaid & Menon, 2000), others have assessed only some areas of bilingual language proficiency, such as their self-ratings in speaking, reading, and writing, but not measured their proficiency in comprehending (e.g., Jia et al., 2002). Using such data as language performance measures to determine bilinguals' language dominance or proficiency has created confusion in bilingualism research (e.g., Marian & Neisser, 2000).

Finally, inconsistencies were also found in the questions and scales used across the previous studies. For instance, while Vaid and Menon (2000) used a 7-point rating scale for their questions, Jia et al. (2002) applied a 4- or 5-point scale. Thus, cross-experimental comparisons have been difficult to do due to the application of distinct rating scales to index bilingual language proficiency. Taken together, the absence of uniform assessment instruments in bilingual research has contributed to the problem of inconsistency across studies, which makes it hard to do cross-experimental comparisons. Therefore, a more comprehensive and valid self-assessment tool that combines appropriate measures of bilingual language experience and proficiency into a single instrument is needed for assessing the language profiles of bilingual speakers and to better understand existing findings and to make generalisations across bilingual language studies (Marian et al., 2007). As a result, the present study used "The Language Experience and Proficiency Questionnaire" (LEAP-Q), a detailed self-reported measure for assessing bilinguals' language profile.

The LEAP-Q is a comprehensive questionnaire that combines relevant proficiency and language experience variables. It provides detailed questions relating to language acquisition, language history, demographic information in each language group as well as self-reported proficiency data. Such self-assessed proficiency measures have been found to correlate significantly with behavioural measures of language performance and to produce more valid and reliable results that are widely used in bilingual research (e.g., Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012; Marian et al., 2007).

The Language Experience and Proficiency Questionnaire (LEAP-Q)

The LEAP-Q (Marian et. al., 2007) was constructed to assess the language status of healthy bilingual populations in their first and second languages across a wide range of experimental settings. The questions in the LEAP-Q are based on similar types of questions that have been used in previous questionnaires measuring bilinguals' proficiency and language history (e.g., Jia et al., 2002; Vaid & Menon, 2000; Marian & Spivey, 2003). The questions were constructed within the context of bilingualism theories to capture factors that have been identified as significant contributors to bilingual language status, such as language competence; age of language acquisition; previous language exposure and current language use.

The three different measures of bilingual language competence (including language proficiency, dominance and preference) are measured separately in the LEAP-Q in order to make the process of data interpretation easier for questionnaire users. Consistent with previous bilingual self-assessment studies, the LEAP-Q probes proficiency ratings in reading, writing, listening and speaking (e.g., Vaid & Menon, 2000; Jia et al., 2002). However, unlike previous questionnaires, proficiency ratings are analysed separately instead of collapsing them into a cumulative score (e.g., Flege et al., 2002) to yield distinct information about these different language skills.

Questions regarding language dominance are constructed to indicate the order of dominance for the languages participants speak, while the questions targeting language preference probed specific questions, such as preference of reading a text in both languages instead of asking general questions about the overall preferred language (Marian et al., 2007). In addition to language competence, age of language acquisition, prior and current language exposure have been shown to influence research findings. Age of acquisition has been found to be strongly associated to language learning and to predict bilinguals' performance on their behavioural tasks (e.g., Hyltenstam & Abrahamsson, 2003). Therefore, the LEAP-Q assesses age-of-acquisition for each of the bilinguals' languages in four measures (e.g., age of initial language learning and age of achieved fluency). Prior language exposure has also been found to influence bilinguals' performance (e.g., MacKay & Flege, 2004; Birdsong, 2005). Consequently, the LEAP-Q probes language exposure across different settings, including at home, at school, and at work. Moreover, the degree of ongoing language use also influences proficiency achievement. For instance, Jia at al. (2002) found that bilinguals who use L2 more frequently than L1 were better at pronunciation than those who used L1 more than L2. As a result, the LEAP-Q measures bilinguals' current exposure to their languages in different environments, including interaction with family, exposure during watching TV, and listening to the radio, in addition to exposure through self-instruction (Marian et al., 2007).

As already mentioned above, the LEAP-Q is a valid, efficient and reliable tool for assessing bilingual language experience and proficiency profiles in their first and second languages. To establish its internal validity, Marian et al. (2007) conducted a study and analysed responses of 52 Spanish-English bilinguals by using factor analysis. Factor analysis is a statistical technique utilized in the social and behavioural sciences to model variables that cannot be directly measured (Cudeck & MacCallum, 2007). It has been commonly used as a data reduction method to determine a set of variables/factors that share variance patterns in the data set and are expected to assess the same underlying construct (Taherdoost, Sahibuddin & Jalaliyoon, 2014).

Results from Marian and colleagues' (2007) factor analysis revealed groupings of variables that accounted for more than half of the variance in bilinguals' self-reported data, with variables that clustered together measuring the same underlying construct. The clusters of variables that emerged reflected the underlying language construct of bilingualism, which suggest that the questions on the LEAP-Q are comprehensive enough to capture variability in the bilingual population that was sampled in this study (e.g., Marian et al., 2007) and many other bilingualism studies (e.g., Blumenfeld, Bobb & Marian, 2016; Kastenbaum et al., 2019).

Study 1: Language profile factors for typologically different Bilinguals

The goal of this study is to determine key factors that capture the differences in the language status of the two groups of bilingual speakers who participated in the semantic blocking studies reported in Chapters 4 and 5. To describe our bilinguals' language profile (i.e., their two languages status which primarily depends on several linguistic factors such as age of acquisition, language proficiency, and language dominance), we used the LEAP-Q by Marian et al., (2007), with some minor alterations (detailed below). Factor analysis was then conducted on the responses of each group of the participants, the German-English bilinguals (Study 1a) and the Arabic-English bilinguals (Study 1b), to yield factors to relate to their L1 and L2 proficiency and to show how the different patterns of their language experiences related to underlying language experience and proficiency constructs in the self-report data.

The LEAP-Q study by Marian et al. (2007) that was constructed to assess the languages' status of bilingual populations tested two groups of highly proficient Spanish-English bilinguals; the present study however, tests two groups of bilinguals with different linguistic backgrounds (i.e., different first language). Therefore, interesting differences in the underlying factors are expected to be seen in this study, due to the diverse levels of proficiency and linguistic backgrounds of the bilingual populations that were sampled in this study. In addition, different groupings of variables are predicted during factor analysis to show distinct patterns for each language group, such as differences in age of second language acquisition, the language contexts, the amount of language exposure, and the frequency of language use.

We expected both the native Arabic and German speakers to be highly fluent in their English as we recruited educated participants, with a fairly advanced level of proficiency in English. In comparison to the Arabic speakers, German speakers are expected to have higher daily exposure to English and different life experience with English. The two groups are also expected to differ in the degree of switching frequency, with German speakers switching more than the Arabic speakers who are expected to have quite context-dependent language use. In terms of age of second language acquisition, the German speakers are expected to have a somewhat earlier experience with English as they can start learning English at school around the age of 9, compared to the Arabic speakers who usually start learning English after the age of 12. In the sections below, the LEAP-Q data collection and analysis will be described, and the results will be discussed.

Method

Participants and procedure

A total of 88 participants self-reported their proficiency and language use experiences in both of their languages. Participants included right-handed bilingual individuals between the ages of 19 and 35. Inclusion criteria for participation required participants to have no history of learning difficulties and no vision or hearing problems. Arabic or German had to be their first or native language (i.e., a language that an individual has been exposed at an early stage of life).

The categorization of participants by language similarity is as follows: 44 German-English speakers and 44 Arabic-English speakers. For the German-English bilinguals, participants were mostly undergraduate and postgraduate students at the University of Birmingham in the United Kingdom (n=27) and participated either for course credits or £10 cash. The remaining German- English participants were recruited from The Ruhr-University Bochum in Germany and were paid € 11 cash for their participation (n=17). The Arabic-English bilingual participants were mostly undergraduate students from the departments of English and Translation Studies at the University of King Abdulaziz in Jeddah, Saudi Arabia. The rest of the participants were postgraduate students from the University of Birmingham in the United Kingdom who all participated voluntarily, as payment of these participants would be against their cultural customs.

All participants were given an informed consent form which they signed to show their approval for participation in the current study. Participants completed the questionnaires either in the laboratory or in their own time and chosen environment and then sent them electronically via email before their performance on the other parts of the study (i.e., semantic blocking, non-linguistic experiments). Participants reported that they completed the given questionnaire in about 20-25 minutes.

Materials and design

All participants completed the language experience and proficiency questionnaire (Marian et al., 2007; see Appendix 1). The first part of the LEAP-Q was kept the same as in the Marian et al. (2007) LEAP-Q study. Some questions were deleted that were not relevant for the current participants' linguistic background. For example, questions regarding immigration to the United States were deleted as all of our participants were either from Europe or the Middle East. A question asking, "how much of a foreign accent do you have in Language", was also deleted because this question has caused difficulties in comprehending it, especially for the Arabic-English bilinguals who have a standard language and a dialectal language, and the foreign accent part of the question was understood as what dialect do you have.

As shown in appendix 1, the questionnaire can be broken up into the following sections: the first section of the LEAP-Q included general questions about participants' demographic information. In this section, participants were required to answer some questions about themselves such as age, gender and level of education. Participants also reported their country of origin, residence, handedness and any vision or learning disability such as dyslexia.

The second section comprised general questions about participants' language acquisition history (same questions of their first language (L1) and their second language (L2) acquisition were included). Participants were asked to state their native language and the language(s) of their parents or primary caretaker to ensure that either Arabic or German is their native language. Then, they were asked to list the languages they can speak, the approximate order in which they acquired/mastered these languages and they provided estimates of overall level of proficiency of these languages. This was followed by queries about their language dominance, such as questions concerning their current two languages exposure (both outside/inside and on average). In addition, they were asked to name the language in which they received instruction at school for each of their educational levels.

The third section contained language proficiency questions in which participants were asked to self-rate their language ability in speaking, understanding, reading, and writing. Participants provided rating of their linguistic skills for both languages on a scale between 1 to

7, with a 7 reflecting excellent ability and 1 meaning poor ability. In addition, participants were asked to estimate the percentage of factors that contributed to their language learning, such as interacting with family, watching TV, self-instruction and listening to music. These questions were asked for both their first and further languages.

The last part of the questionnaire comprised questions about the frequency of language use and the rate of switching between languages. These questions were added to the LEAP-Q from a Silverberg and Samuel (2004) study which gathered information about participants' rate of switching between their languages. Participants were asked to report if they ever mix words or sentences from the two or more languages they speak. They were also asked about the frequency of mixing of the languages they speak and the direction of that switch (first language to second and the other way around). The extent to which the first language intrudes when speaking another one was also queried. In addition, in this last part, participants specified their current language use pattern (e.g., using mainly one language or using more than one language in different settings; Silverberg & Samuel, 2004). All information from the questionnaire was self-reported by the participants themselves.

Study 1a. The bilingual profile of the German-English bilinguals

Results

The questionnaire was given to 44 participants (average age = 24 yrs., SD = 5.1; 34 women, 10 men). Most of the participants were born in Germany except for four who were born in Austria, Nigeria, South Africa, or Switzerland. The majority of the participants, about 86.36%, had German parents. Only six had a parent who spoke a language other than German (Turkish (n=3), Dutch (n=1), Vietnamese (n=1) and English (n=1)).

All participants were first language German speakers. Most spoke German as their first language and reported that they began acquiring their L1 from birth; however, six of them grew up with other languages as their first. These languages are Turkish (n=3), Dutch (n=1), Vietnamese (n=1) and English (n=1). Apart from the participant who grew up with German and English, all reported that English was their second language which was acquired at the average age of 9.5 years. All participants reported that they were German dominant, and only 6 of them reported that they were balanced in German and the other language they spoke.

Of the 44 participants, 30 reported that they had some experience in at least one other language, including French, Dutch, Italian, Swedish, Spanish, Greek, Latin, Turkish, Kurdish, Portuguese, African, Vietnamese, Thai and Chinese. About 32% of the participants reported having some experience with two languages, 40% reported three languages, 18% four languages and 9% five languages.

Participants' self-reported language history and proficiency measures can be found in Table 3-1. When asked to report proficiency in L1, all the participants reported very high proficiency skills, but maximum scores only in understanding speech. With regards to their L2 proficiency, they reported somewhat lower scores, with higher proficiency for understanding speech and reading than for speaking and writing. Ages of L2 acquisition ranged from 1 to 15 years, indicating both simultaneous and late bilinguals. The average age for speaking fluency in L1 was estimated at the age of 6 years, whereas the average age for speaking fluency for L2 was estimated at almost 18 years.

Table 3-1 Self -reported language history and proficiency for German/English participants. Range: 0 (none) to 7 (perfect), c. Range: 0 (not a contributor) to 10 (most important contributor).

	German L1 history			English L2 history		
Language history measures	M	SD	Range	M	SD	Range
a. Self-reported proficiency						
Understanding	7.0	0.0	-	6.1	0.8	4-7
Speaking	6.9	0.2	-	5.5	1.1	3-7
Reading	6.9	0.2	-	6.1	0.9	3-7
Writing	6.9	0.2	-	5.5	1.0	3-7
b. Age milestones(years)						
Began acquiring	0.0	0.0	-	9.5	3.0	1-14
Speaking fluency	6.1	1.2	4-12	17.7	5.1	4-30
c. Contribution to language learning						
From family	10.0	0.0	-	2	3.3	0-10
From school	8.3	1.5	5-10	9.4	0.8	7-10
From TV	4.2	2.4	0-10	8.0	1.5	4-10
From music	3.5	2.1	0-10	7.5	1.9	4-10
From self -instruction	4.4	2.2	1-10	7.1	2.5	0-10
From living abroad	1.7	3.8	0-10	5.5	4.4	0-10

All participants were educated but varied in their educational level, with about 59% having completed A-levels or equivalents, 27% having gained a Bachelor degree, 9% with Masters Degrees (MD) and 1% holding a PhD. Participants reported on the different factors that contributed to their language learning. They reported that family was by far the greatest contributor to their L1, while the school environment came second (see Table 1). This was followed by watching TV and self-instruction in equal measure, followed by listening to music and from living abroad. In contrast, when it came to their English acquisition, participants reported that they mainly learned from school, followed by watching TV, listening to music, self-instruction, and living abroad. Communication with family members came last.

In terms of language preference, 63.6% of the participants preferred using both languages, German and English, but in two different settings (i.e., one at home and one at school, one with friends and one with family, etc.). The remaining 36% mainly chose to speak German, although they later reported that they would switch into English but only if they needed to. Almost all of the participants stated that they were frequent switchers between their languages if they were with other bilinguals, as it enabled them to express themselves better, especially if they cannot find a word in the target language. 56.8% of the participants stated that they may also produce unwanted mixing or switching between their languages in a context that requires only the use of one language. In general, intrusions from L1 into L2 were reported to be more frequent than the other way around.

Principal component analysis for the German-English Bilinguals data

Factor analysis was conducted to compare the clustering of variables that were expected to measure the same underlying construct and to best explain language experience and proficiency of bilinguals' self-reported data. Before the commencement of factor analysis, we removed any data that showed no variation across participants. For instance, all German-English bilinguals spoke their first language (German) since birth. Thus, there was no variation in first language acquisition and the data about the age acquiring L1 (German) was removed. The same was the case for variables that contributed to L1 acquisition, such as communication with family, the age at which L1 was mastered (age 1) and L1 understanding proficiency (score 7 out of 7).

Factor analysis includes a sequence of statistical analysis steps. First, a correlation matrix was calculated for the whole data set. Only those variables that had at least one correlation of 0.3 with another variable were included in the principle component analysis

(PCA) which we performed as an extraction method. However, highly correlated variables with a correlation coefficient above 0.8 were removed from the analysis as they were measuring the same process and these variables could distort the PCA. For example, percentage of participants' proficiency in writing correlated highly only with percentage of L1 proficiency in reading (0.80), while correlating less than (0.25) with all other variables. We therefore deleted percentage of L1 proficiency in writing as it was not informative and retained percentage of L1 proficiency in reading.

In addition, the age participants began to learn L2 was highly correlated with the age they mastered L2 (0.80). Therefore, the age they mastered L2 was removed from the analysis and the age at which they began learning L2 was retained in the analysis because this was one of our measures of interest. Unsurprisingly, percentage of L1 home exposure has a strong negative correlation with percentage of L2 home exposure (-0.98). Percentage of L1 outside home exposure and percentage of L2 outside home exposure also negatively correlated with each other and also correlated highly with percentage of L1 overall exposure (0.94) and percentage of L2 overall exposure (0.84). Since all these variables showed high correlations with each other, we retained L2 (English) home exposure in the analysis as it was potentially most relevant to explain performance in our English picture naming task.

The second step of the factor analysis was to test for adequacy of the collected sample. A Kaiser-Meyer-Olkin (KMO) Test (Kaiser 1970) was used to measure whether the data is suitable for factor analysis by evaluating the degree of correlation between the remaining variables in the correlation matrix. Netemeyer, Bearden and Sharma (2003) stated that a KMO correlation between 0.60 - 0.70 is considered suitable for factor analysis, when the cases to variable ratio are less than 1:5 (ranges from 0 to 1). We obtained a KMO correlation of 0.60 confirming that our sample data was suitable for factor analysis.

After determining that the data were suitable for factor analysis, the data were submitted to a PCA, with the main goal of reducing and grouping the number of the observed variables into underlying components (i.e., factors) that can explain most of the variance in the data. To accomplish this, the remaining 22 variables were entered into the PCA. After extracting the factors, factor rotation method was applied in order to simplify and clarify the results of the factor loadings (Osborne, 2015). There are a variety of methods of factor rotation, such as orthogonal (e.g., varimax) and oblique (e.g., oblimin) rotations (Brown, 2009). The correlation matrix of factor rotations showed no or a very low correlation, with correlation coefficient less than .32. Since none of the correlations exceeds the Tabachnick and Fiddell (2007) cut off point of .32 correlation coefficient, then “the solution remains nearly orthogonal.” Tabachnick & Fiddell (2007, p. 646). Thus, we applied the orthogonal varimax rotation.

The next step is to determine the number of factors to retain. There are different approaches that can be used to decide the optimal number of factors that can capture the variance in the data set, such as Kaiser’s eigenvalue-greater-than-one rule, Horn’s Parallel Analysis and Cattell’s Scree test (Ledesma & Valero-Mora, 2007).

Kaiser’s rule proposed by Kaiser (1960) suggests eigenvalues greater than one rule. The eigenvalue is a measure of how much of the variance of the observed variables a factor explains (Courtney, 2013). Kaiser’s criterion postulates that the retained factors should explain more variance than the original variables do, and the logic is that only factors that explain at least the same amount of variance as an original variable is worth keeping (Courtney, 2013). Horn (1965) proposes parallel analysis (PA) as a modification of Kaiser’s rule. PA has been one of the most assessment methods used to determine the number of components to keep in a principal component analysis (Garrido, Abad, & Ponsoda, 2013).

Cattell's scree test (Cattell, 1966) provides a different way to determine the number of components based on the graphical representation of the eigenvalues. The rule for interpreting the scree plot is to retain the number of components above the scree (i.e., elbow point). The justification for this test is based on the idea that only a few but main factors will account for the most variance, resulting in a "cliff", followed by a shallow "scree" representing the small and relatively shallow error variance defined by minor factors (Courtney, 2013). A non-graphical approach came afterward to modify Cattell's scree test to accurately specify the location of the scree by developing a numerical solution for determining the number of factors to retain, namely, the acceleration factor approach and the optimal coordinates approach (Raîche, Walls, Magis, Riopel & Blais, 2013).

The analysis of the data showed seven factors with eigenvalues above the mean of 1 (See Figure 3-1), which means seven factors should be retained according to Kaiser's eigenvalue greater than one rule (Kaiser 1960). On the other hand, Horn's parallel analysis suggested that the number of factors to retain is six. The optimal coordinates approach suggested that six factors should be retained, while the acceleration factor approach suggested that the number of factors to retain is only one.

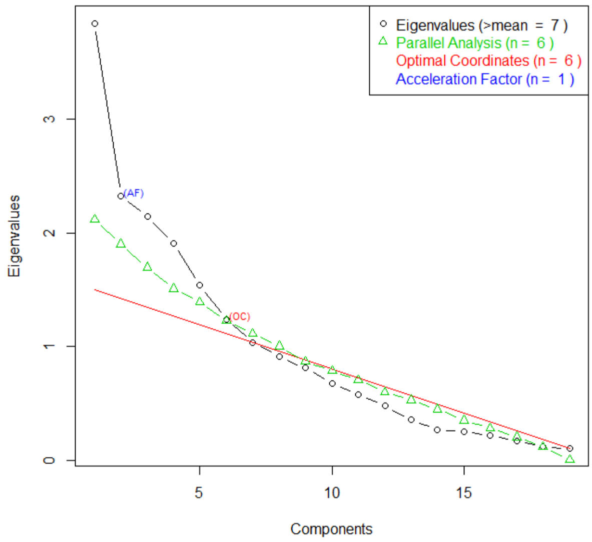


Figure 3-1 *the scree plot determining the optimal number of factors: The plot shows the number of Eigenvalues, Parallel Analysis, Optimal Coordinates and the Acceleration Factor to determine the optimal number of factors to retain.*

The question is how to determine the number of factors to retain in factor analysis if there are several approaches that can be applied to capture the variance in the data set. Several studies have pointed out that Kaiser's eigenvalue greater than one rule is the best choice for researchers and the most used one in practice (e.g., Fabrigar, Wegener, MacCallum & Strahan, 1999). Other researchers pointed out that Parallel Analysis is the most appropriate method to determine how many factors to retain (e.g., Glorfeld, 1995). Nonetheless, it is not a widely used method (Zwick & Velicer, 1986). Zwick and Velicer (1986) demonstrated in their simulation study that the Scree test can be more accurate and less variable than the Kaiser's eigenvalue greater than one rule, suggesting that the Scree test works the best with strong factors (Zwick & Velicer, 1986). We therefore used the Scree plot to decide on the number of factors to retain. The Scree plot suggests that factors with eigenvalues above the slopped curve should be retained, which are six factors in our data, which is also visible in the Scree plot (see Figure 1). These 6 factors explained 68% of the variance in the whole data.

The six factors were then examined in terms of the variables that loaded onto them. Based on these loadings, each construct was given a name according to their component variables. These constructs and their loading factors are listed in Table 3-2 in order of the variance described. Factors include variables with positive and negative loadings or both, with positive loadings yielding inclusionary criteria that define the underlying construct reflected by the factor, while negative loadings yielding exclusionary criteria that show an opposite relationship to the underlying construct reflected by the factor.

Table 3-2 PCA results of the Questionnaire data from the German/English bilinguals, resulting in the six factors shown, along with their component variables and the associated loading factors.

Factor 1: L2 proficiency	Loading values	**Factor 2:** L2 exposure	Loading values
L2 proficiency reading	0.83	L2 living abroad	0.82
L2 % of overall proficiency	0.83	L2 % of overall exposure	0.81
L2 learning family	0.64	L2 % of home exposure	0.72
L2 age begin learning	-0.39	L1 learning school	0.36
L1 into L2 intrusions	-0.34	L1 learning self-instruction	0.32
L2 % of home exposure	0.32		
L2 % of overall exposure	0.31		
% Variance	0.13		0.13
Cumulative variance	0.13		0.26

Factor 3: L1 learning	Loading values	**Factor 4:** L2 informal learning	Loading values
L1 learning music	0.84	L2 learning music	0.82
L1 learning tv	0.84	L2 learning tv	0.57
L1 learning self-instruction	0.56	L2 % of home exposure	-0.38
L1 learning school	0.42	L2 learning self-instruction	0.34
L2 into L1 intrusions	0.37		
L2 learning family	0.31		
L1 age mastered	0.31		
% Variance	0.12		0.10
Cumulative variance	0.38		0.48

Factor 5: L2 age of acquisition	Loading values	**Factor 6:** Language competition	Loading values
Age	0.77	L1-L2 rate mixing	0.83
L2 learning self-instruction	0.67	L1 into L2 intrusions	0.66
L2 age begin learning	0.66	L1 age mastered	0.45
L2 learning family	-0.35	L2 age begin learning	0.38
L2 into L1 intrusions	-0.33		
% Variance	0.10		0.10
Cumulative variance	0.59		0.68

Description of factors

As mentioned earlier, factor analysis produced factor groupings that contributed to the underlying constructs defining the bilingual language status. These factors account for most of the discrepancy in bilinguals' self-reported data. Importantly, when naming the factors, one should consider the variables that loaded most into those factors as well as the direction of loading for all variables.

The 6 factors were given construct names suggestive of their components and were listed in order of variance accounted for, as well as the direction of loading for all variables. The first factor that accounted for the most variance in the data set (0.13%) included L2 proficiency reading; L2 percentage of overall proficiency; L2 learning family; L2 age begin learning; L1into L2 intrusions; L2 percentage of home exposure; L2 percentage of overall exposure. Two of these variables, L2 proficiency reading and L2 percentage of overall proficiency, accounted for more than half of the variance 84% and were proficiency variables. The positive loadings of L2 proficiency variables together with the negative loadings of L1into L2 intrusions and age begin learning L2 suggested that this factor was an index of *L2 proficiency.*

The second factor included variables related to time exposed to L2, such as the percentage of overall exposure to L2; L2 percentage of home exposure and the time living abroad where the L2 (English) was spoken, all organised in order from the highest positive loading to the lowest one. Yet, the three variables had very high loading values compared to the low loading values of the L1 learning at school and L1 learning from self-instruction variables, possibly reflecting measure of L2 exposure with the duration of time spent living abroad and the amount of time being exposed to L2 are all suggestive of L2 exposure measures. Therefore, this clustering of variables was interpreted as an *L2 exposure* factor.

The third factor was named *L1 learning* as it related to the kinds of input that contributed to participants' learning of their first language. This factor included L1 learning from music and TV with the highest loading values, followed by L1 self-instruction learning, L1 learning at school and L1 age mastered L1, which had the lowest loading value. All loading values were positive. Most of these factors were related to learning from formal and informal sources of learning L1.

The fourth factor was named *L2 informal learning*, as it incorporates variables related to learning L2 outside the home and from exposure from the media. There are two variables in L2 with positive loading values; these variables are L2 learning from music with a high loading value, followed by L2 learning from TV and L2 learning from self-instruction. However, there is only one factor in L2 with a negative loading value which is percentage of L2 home exposure. The negative covariance resulted from the opposite relationship between percentage of L2 home exposure and L2 language learning outside the home. That is, the more home exposure those participants had the less informal learning they had. German L1 bilinguals reported that they learned English from resources like TV, music, and what they have taught themselves, but not from home exposure, which had a negative loading value onto this factor.

The fifth factor included 3 variables that were related to participants' age, L2 learning from self-instruction and L2 age begin learning and all had the highest positive loading values into this factor, while L2 learning from family and L2 onto L1 intrusions were loaded negatively. This factor therefore related to the age participants acquired their L2 and how that was related to their L2 proficiency (i.e., the older they were, the less L2 they had and the weaker their L2 was, which also meant less L2 learning from family and fewer L2 into L1 intrusions). Together, these variables were interpreted as indexing *L2 age of acquisition.*

The sixth and final factor was named *Language competition* because the rate of mixing languages loaded very strongly onto this factor, as well as frequency of L1 intrusions into their L2, followed by the age they mastered their first language and the age they began learning their second language, which both load positively. Thus, the longer participants took to master their L1 and the older they were when they began to learn their second language correlated positively with the rate, they mixed both languages. In other words, if they learned L2 later and mastered their L1 later, they mixed more.

Study 1b: The bilingual profile of the Arabic-English bilinguals

Results

Our Arabic-English participants were much more uniform in their language experience than our German-English bilinguals. For all participants, Arabic was their first language, and all were born and raised in Saudi Arabia (average age = 26 yrs., SD = 5.9) where Arabic is the official language of the country. All participants had English as their second language, only one had some experience with French as a third language. Given this background, participants reported that Arabic was their most dominant language and English came second (M= 11.3).

Only one participant was a balanced Arabic-English bilingual and started learning English at the age of 5.

In terms of language preference, participants who were tested in the UK reported using both languages but in two different settings (i.e., at home versus at school), while those who were tested in Saudi Arabia chose to speak mainly in Arabic, though they also reported that they switch into English but only if it was required. Almost all of the participants who were tested in the UK reported that they are frequent switchers between their two languages, while those who were tested in Saudi Arabia reported that they were infrequent switchers. They also reported that intrusions from L1 into L2 were more frequent than from L2 into L1.

Participants' self-reported language history and proficiency measures can be found in Table 3-3. When asked to report proficiency in L1, all the participants reported maximum proficiency in all of their language skills. In their L2 proficiency, they reported a higher proficiency level for the receptive language skills understanding speech and reading, while they reported an intermediate level of proficiency for the productive language skills, speaking and writing. Participants also reported that they began acquiring L1 from birth. By contrast, L2 acquisition began at around 12 years of age. The age for speaking fluency in L1 was estimated at 6 years of age, whereas the age for speaking fluency for L2 was at 21.7 years of age.

Participants reported that different factors contributed to their language status for both their first and second language. They reported that family was the greatest contributing input into their L1, followed by school and watching TV in an equal measure. Self-instruction and listening to music came second. However, when it came to their L2 acquisition, participants reported that learning English came from the schooling context, followed by self-instruction, then watching TV and listening to music, which contributed equally to L2 input. Living abroad came last and communication with family members had no effect on their L2 input.

Table 3-3 Self -reported language history and proficiency for Arabic/English participants. Range: 0 (none) to 7 (perfect), c. Range: 0 (not a contributor) to 10 (most important contributor).

	Arabic L1 history			English L2 history		
Language history measures	M	SD	Range	M	SD	Range
a. Self-reported proficiency						
Understanding	7.0	0.0	-	5.6	0.9	4-7
Speaking	7.0	0.0	-	4.7	1.1	3-7
Reading	7.0	0.0	-	5.1	1.1	3-7
Writing	7.0	0.0	-	4.5	1.1	3-7
b. Age milestones(years)						
Began acquiring	0.0	0.0	-	11.3	1.7	5-12
Speaking fluency	6.2	0.6	4-7	21.7	5.2	12-35
c. Contribution to language learning						
From family	10.0	0.0	-	0	0	-
From school	9.3	1.0	8-10	7.4	1.7	7-10
From TV	9.0	1.0	7-10	5.8	3.8	2-10
From music	4.0	2.6	2-10	5.8	3.8	2-10
From self -instruction	6.5	2.2	1-10	6.4	2.7	1-10
From living abroad	0	0	-	4.4	4.9	0-10

Principal component analysis for the Arabic-English Bilinguals data

As for the German-English bilinguals, the Arabic-English data was submitted to a PCA. Then an oblimin rotation method was applied. Although varimax was used in the previous PCA, we used oblimin rotation as the component correlation showed a coefficient above .32 (Fidell & Tabachnick, 2003).

The analysis revealed that the first six eigenvalues were greater than 1, which means that According to Kaiser's rule six factors should be retained (See Figure 3-2). In contrast, Horn's parallel analysis suggested that a different number of eigenvalues, namely two, should be retained. The optimal coordinate approach suggested that two factors should suffice, while the acceleration factor approach suggested that only one factor should be retained. Considering the different conclusions from Kaiser's rule, Horn's parallel analysis and the disagreement in the nongraphic solution for Cattell's scree test, we decided to use the Scree plot to decide on the number of factors. Four factors explained 67% of the variance in the whole data. This is also visible in the Scree plot (see Figure 3-2). So, it is reasonable to drop the remaining factors without losing much of the original variability.

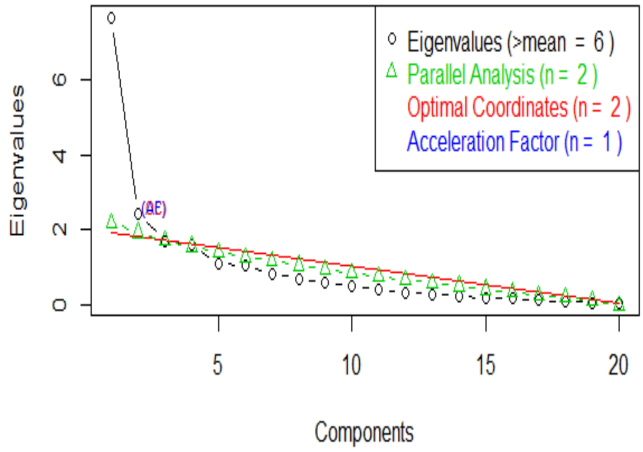


Figure 3-2 *The scree plot determining the optimal number of factors*

Additionally, the analysis with four factors was more interpretable than the other options and the amount of variability explained was similar to the German data set. As for the Arabic data, the four factors were then examined in terms of the variables that loaded onto them. Based on these loadings, each construct was given a name according to their component variables. These constructs and their loading factors are listed in order of the variance that they describe in Table 3-4.

Table 3-4 The result of the PCA of the Questionnaire data from the Arabic/English bilingual, resulting in four factors shown along with their component variables and the associated loading factors.

Factor 1: L2 proficiency	Loading values	**Factor 2:** L2 exposure	Loading values
L2 proficiency reading	0.91	L2 learning living abroad	0.85
L1-L2 code switching	0.84	L2 learning self-instruction	0.84
L2 proficiency understanding	0.82	L2 % of home exposure	0.66
L2 proficiency speaking	0.80	L2 % of overall exposure	0.61
L2 proficiency writing	0.77	L2 % of outside exposure	0.59
L2 age begin learning	-0.66	age	0.44
L2 % of overall exposure	0.60	L2 into L1 intrusions	0.36
L2 learning tv	0.59	L2 proficiency speaking	0.35
L2 % of home exposure	0.49	L2 proficiency writing	0.33
L2 % of outside exposure	0.48		
age	0.39		
L1 into L2 intrusions	-0.38		
L2 into L1 intrusions	0.35		
% Variance	0.28		0.18
Cumulative variance	0.28		0.46

Factor 3: language competition	Loading values	**Factor 4:** L1 learning	Loading values
L1-L2 rate mixing	0.84	L2 learning school	-0.81
L2 learning tv	0.59	L1 learning school	0.64
L1 learning school	-0.50	L1 learning music	0.50
L2 into L1 intrusions	0.45	L2 age begin learning	0.43
L1 into L2 intrusions	0.33	L1 into L2 intrusions	0.33
% Variance	0.10		0.10
Cumulative variance	0.57		0.67

Description of factors

The first factor, which accounted for the most variance in the Arabic data was labelled as *L2 proficiency* and included 13 variables, with five of the highest loading values being strongly related to aspects of L2 language proficiency (L2 proficiency reading, L1-L2 code switching, L2 proficiency understanding, L2 proficiency speaking and L2 proficiency writing).

The rest of the variables were also L2 proficiency related variables but had low loading values, including L2 percentage of overall exposure, L2 learning from TV, L2 percentage of home exposure, L2 percentage of outside exposure and L2 into L1 intrusions. However, age begin learning L2 and L1into L2 intrusions variables were negatively loaded onto the factor. The positive loadings of L2 proficiency variables together with the negative loadings of age begin learning L2 and L1into L2 intrusions suggested that the lower L2 proficiency was associated with later L2 acquisition which resulted in more L1into L2 intrusions.

The second factor included (in order of variance accounted for) L2 learning from living abroad, L2 learning from self-instruction, L2 percentage of home exposure, L2 percentage of overall exposure, percentage of outside exposure, age, L2 into L1 intrusions, L2 proficiency speaking, L2 proficiency writing (all positive loadings). These variables were mainly related to aspects of L2 learning and exposure from home and outside. The clustering of these variables suggested that exposure to L2 via learning from living abroad and from self-instruction led to better speaking and writing abilities in L2; thus, this factor was interpreted as a measure of *L2 exposure*.

The third factor was interpreted as *Language competition* since the rate of L1-L2 mixing was the highest loading variable next to intrusions of L1 into L2 and vice versa (all positive loadings). The negative loading of L1 learning at school suggested that the less time spent learning L1 at school, the higher the language competition.

The fourth factor was associated with L1 learning variables and was labelled as *L1 learning*, for which the two highest positively loading variables were L1 learning variables (L1 learning at school and L1 learning from music). This factor also had a highly negative loading variable of L2 learning at school suggesting that the underlying construct of this factor was specific to just one language, namely L1 learning.

Summary and discussion

The questionnaire data demonstrated that our two groups of bilinguals (Arabic-English & German-English) vary in several ways. One significant difference is that all of our Arabic-English participants grew up knowing only one language (i.e., Arabic) while living in the Arabic environment which constitutes their L1 environment, and L2 English came later in life (M=12). This means that they had experience with only two languages. In contrast, many of our German-English participants had experience with more than two languages (n=30), which constituted 76% of the participants. Also, they were exposed to English as their L2 somewhat earlier than the Arabic-English group (M=9.5).

Secondly, the German-English participants had a higher self-rated L2 language proficiency than the Arabic-English participants. While both groups reported higher receptive proficiency than productive proficiency, all measures were lower in the Arabic population than in the German population. Our German-English participants reported a high proficiency measure for understanding speech (M=6.1 out of 7) and reading (M=6.1 out of 7), followed by speaking (M=5.5) and writing (M=5.5). However, our Arabic-English group reported a higher proficiency level for the receptive language skills, understanding speech (M=5.6) and reading (M=5.1), while they reported an intermediate level of proficiency for the productive language skills, speaking (M=4.7) and writing (M=4.5). Also, German-English participants estimated the age at which they mastered speaking in L2 as on average 17 years (SD=5.1), while Arabic-English bilinguals estimated this as on average 21.7 years (SD=5.7).

Another critical difference is that the Arabic-English group were all diglossic in their L1 (i.e., using two distinct varieties of one language but in different social environments, such as a formal variety at school and informal one at home). This means that speakers of Arabic learn a local dialect but also learn an academic Arabic at school and media. These participants reported that school and watching TV contributed equally to learning their L1, which means that the way Arabic-English bilinguals learn their first language is very different compared to the German-English bilingual group, where both formal and informal learning variables grouped together as a factor of learning L1. This might have an effect on the way Arabic speakers learned their English as Arabic speakers have to learn two representational systems for their first language. Thus, any second language may be somewhat equivalent to a third language for Arabic speakers. This may have an effect on English lexical access as Arabic speakers have to manage their two L1 representational systems while accessing the L2 translation equivalent.

The differences in language experience between the German and Arabic bilinguals described were reflected in the output of the PCA analyses which show a number of differences. First, the PCA for the Arabic-English bilinguals data resulted in a different number of factors compared to the German-English bilinguals' data, with six factors for the German-English bilinguals (including *L2 proficiency, L2 exposure, L1 learning, L2 informal learning, L2 age of acquisition* and *language competition*) and four factors for the Arabic-English bilinguals (including *L2 proficiency, L2 exposure, language competition* and *L1 learning*). This is most likely due to the greater diversity of language background of the German-English bilinguals, compared to the similarity of language background of the Arabic-English bilinguals.

L2 age of acquisition and *L2 informal learning* were factors that were only appeared in the German group but not in the Arabic group. The explanation for this is based on the fact that all the German-English participants had mastered their L2 in an early stage of their lives compared to the Arabic-English participants who mastered their L2 later in their lives. In addition, German bilinguals had a different life experience with English, and were primarily exposed to L2 in their daily life with variables such as family and media-based L2 learning mainly contributing to their L2 learning. Also, the appearance of the *L2 informal learning* factor in the German group suggested that the German-English participants have used several informal available sources to learn their L2 and have not been dependent only on the formal sources of learning their second language.

As can be seen, although the analysis resulted in a different number of factors between the two samples of the bilingual speakers, there are a number of similarities in how the component variables grouped between these different sample of bilingual participants. First of all, the results of the PCA analysis concluded four types of factors that are similar in both groups, namely *L2 proficiency*, *L2 exposure*, *L1 learning* and *language competition.* This means we have clear L1 and L2 factors that look relatively equivalent. Yet, the Arabic first factor *L2 proficiency* accounted for much more variance (n=13) compared to the number of variance in the *L2 proficiency* factor for the German analysis (n=7) and showed both positive and negative loadings for both groups. The second factor, *L2 exposure*, which deals with the age of becoming proficient in speaking and writing L2, learning L2 abroad as well as the percentage of L2 overall exposure and home exposure, also accounted for much more variance in the Arabic data (n=8) compared to the number of variance in the German data (n=5), again this is likely due to the homogeneous sample of Arabic-English bilinguals.

Interestingly, our variables revealed a new factor that did not appear in other studies (e.g., Marian et al. study, 2007), namely a *language competition* factor. This was mainly due to the fact that we added additional measures of participants' rate of switching between their languages, the degree of L1 into L2 intrusions and L2 into L1 intrusions. This language competition profile may be characteristic of bilinguals who frequently switch between their languages and/or of bilinguals for whom L1 is a dominant language that interrupts their L2 performance causing L1 into L2 intrusions.

In summary, this study examined aspects of the bilingual language experience, with two bilingual samples. The results have provided a set of language status factors for our German-English group that slightly differ from the Arabic-English group using the same questionnaire. The language profile of the two groups did differ to some degree in terms of age of language acquisition, language exposure and proficiency. The Arabic-English bilinguals were first exposed to English in school after the age of 12 and became fluent on average at the age of 21 and have a context-dependent pattern of language use. In addition, their rated proficiency, while high for both languages, is unbalanced. The German-English bilinguals were first exposed to English in school somewhat earlier, at the age of 9 and became fluent on average at the age of 19. They are also more balanced in terms of proficiency, and were exposed daily to both languages, but primarily exposed to their L2 in their daily life. Together, the analysis of the linguistic backgrounds of these two groups of bilinguals is critical for the up-coming studies to understand how the ability to access and control languages is shaped by bilinguals' linguistic experience. Importantly, this detailed analysis of bilingual profile has illuminated subtle differences in language profile between two groups of bilinguals who could both be classed as highly proficient according to any more general criterion.

CHAPTER 4

HIGH LEXICAL SELECTION DEMANDS WHEN SWITCHING INTO L1 VERSUS SWITCHING INTO L2

Introduction

As mentioned in the literature reviewed in Chapter 1, most bilingual lexical access models agree that the semantic system is shared between bilinguals' two languages (Costa, Miozzo, & Caramazza, 1999; Poulisse & Bongaerts, 1994; Kroll & Stewart, 1994; De Bot, 1992). This means that during speaking, lexical representations of both languages receive activation from the shared semantic system and lexical representations of both target and non-target language are constantly active, even when the context or the task require the use of only one language (e.g., BijeljacBabic, Biardeau, & Grainger, 1997; Costa et al., 2000; Schwartz, Kroll, & Diaz, 2007). The parallel activation of the bilinguals' two languages makes speech production a demanding task since bilinguals need to select a target lexical representation among other co-activated non-target distractors (e.g., De Bot, 1992; Costa et al 2000; Costa & Santesteban 2004). Therefore, a language control mechanism must be involved to deal with this cross-language activation.

As explained in the "Competition versus non-competitive lexical selection in bilinguals" section in Chapter 1, the Inhibitory Control Model (ICM) suggests that bilingual speakers resort to language control to avoid conflict between their two languages by inhibiting the activation level of lexical representations from the non-intended language (see Green, 1998; Meuter & Allport, 1999). This control of lexical access is highly demanding especially during switching from one language to another where the requirement for language control is maximized by the need to resolve cross-language competition.

The requirement to engage an extra control mechanism during language switching has been found to be dependent on whether the language to be produced is L1 or L2. Intuitively, switching into the dominant language should be easier and less demanding. However, ample evidence suggests that switching into a first dominant language (L1) is more demanding than switching into a second, weaker language (L2) than vice versa. This is evident in longer naming latencies during switching from L2 into L1 than during switching from L1 into L2 (e.g., Meuter & Allport, 1999; Schwieter & Sunderman, 2008; Linck, Schwieter & Sunderman, 2012). This increased switching cost into L1 was initially taken as support for the ICM (Green, 1998), which suggests that naming in L2 requires strong inhibition of the more dominant L1 by engaging a general executive control system to prevent intrusions into the weaker L2. When switching back into the L1, additional cognitive effort and therefore time is required to overcome the residual inhibition of the L1, therefore leading to an asymmetrical switch cost between the two languages (Meuter & Allport, 1999; Schwieter & Sunderman, 2008).

According to the ICM, the amount of inhibition should be proportional to the relative strength of the two languages (i.e., the less dominant L2 in relation to L1, the more L1 must be inhibited in order to produce the weaker L2). Given the relative dominance of L1 and L2, bilinguals less proficient in L2/strongly dominant in L1 should experience a larger switch cost asymmetry than balanced bilinguals (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004; Kroll, Bobb, Misra & Guo, 2008). In accordance with this prediction, Costa and Santesteban (2004) found that low proficient bilinguals showed a larger switch cost asymmetry, whereas balanced bilinguals who were highly proficient in their L2, produced a symmetrical pattern of switch costs across their two languages. The symmetrical switch cost found in their study suggested that highly skilled bilinguals no longer need to actively inhibit their L1 since increased proficiency is positively related with the increased skill in language selection (Costa & Santesteban, 2004). This indicates that the switch cost patterns can be affected by the level of proficiency and that language proficiency plays a key role in modulating the language switching performance (Meuter & Allport, 1999; Costa & Santesteban, 2004; Green & Abutalebi, 2013).

However, an interesting finding was observed in Costa and Santesteban's (2004) fourth experiment. The asymmetrical switching cost previously observed for low-proficient bilinguals could not be replicated for trilinguals. They found that Spanish-Catalan-English trilingual speakers showed symmetrical switch costs when asked to switch between their L1 and their much weaker third later learned language. This result cannot be accounted for by the ICM. The inconsistency in these findings suggests that the proficiency levels of bilinguals' L1 and L2 cannot be the only factor that modulates performance in language switching.

Liu, Liang, Zhang, Lu and Chen (2015) suggested that individual differences in domain-general cognitive control ability could also account for performance in language-switching tasks. More specifically, Liu et al. (2015) examined the role of inhibitory control ability during language switching. They recruited Chinese-English bilingual speakers whose dominant language was Chinese. Participants were tested on the Simon task, a non-linguistic response selection task that requires inhibitory control/conflict resolution control (Simon & Rudell, 1967), and were divided into two groups according to their inhibitory control (IC) ability: those with high-IC ability and those with low-IC ability. Results revealed that the group with high-IC ability displayed symmetrical switching cost for L1 and L2, while the group with low-IC ability showed larger switching cost for L1. These findings suggest that variances in inhibitory control/conflict resolution ability during response selection play an important role in modulating L1 switch costs for non-proficient bilinguals who have different levels of proficiency in L1 and L2 (Liu et al., 2015).

In line with the idea that domain-general inhibition ability during response selection is related to switching efficiency when switching into L1, an fMRI study by Branzi, Della Rosa, Canini, Costa and Abutalebi (2016) found that the brain's response selection system is particularly heavily engaged when switching into L1 in comparison with switching into L2. Branzi et al. (2016) examined switch costs during picture naming task and their neurological correlates. They compared changes of brain activity of a group of unbalanced German/Italian bilinguals when naming the same picture before and after a language change (e.g., naming in L2 after having named in L1 or the reverse).

Results showed asymmetric switch cost regarding the pattern of the brain activity. More specifically, naming a set of pictures in L1 after having named them in L2 led to an increased engagement of brain regions related to a response selection system, namely inferior parietal and prefrontal areas. These brain areas have been shown to play a general key role in tasks involving selection of the target stimulus in contexts with interfering responses (Ridderinkhof, Ullsperger & Nieuwenhuis, 2004; Collette et al., 2005; Rodriguez-Fornells et al., 2005). Importantly, this extra brain activity was not observed (i.e., significant deactivation) when naming pictures in L2 after having named them in L1. Instead, the dorsal anterior cingulate cortex/presupplementary motor area (dACC/pre-SMA) brain areas were recruited, which have been associated with monitoring and detection processes (Abutalebi et al., 2012).

Based on these findings, Branzi et al. (2016) suggest that this asymmetry in the switch cost arises since switching into L1 is more demanding than switching into L2 as shown by the engagement of the domain-general response selection system. Therefore, more time and cognitive effort are required during response selection to overcome previous inhibition of prepotent L1 during L2 naming. In other words, the involvement of the response selection system is dependent on contexts where the greatest amount of interference is present: namely, when switching into the L1.

The current study

Branzi et al.'s (2016) finding predicts that only switching into L1, not into L2, should be demanding in terms of lexical selection in the sense that switching into a dominant L1 places a strong demand on response selection brain areas responsible for selecting target responses while suppressing interfering non-target responses. If this is the case, then switching into L1 should interact with lexical selection difficulties. That is, switching into L1 should interact with the level of lexical competition during the switch. In other words, a high momentary level of lexical selection demand (i.e., a high level of lexical competition) should strongly increase the demand on the lexical selection system when switching into L1. In contrast, a high momentary lexical selection demand should affect a switch into L2 less strongly, if at all. In line with this prediction, we tested whether switching costs are modulated by the degree of lexical competition. More precisely, we investigated whether bilinguals more strongly slow down when switching into L1 as compared to switching into L2 during heightened demand of lexical-semantic competition.

If the degree of lexical competition modulates switch costs, we would expect to see an interaction of the direction of the switch and the degree of lexical competition. We hypothesized that switching into L1 should be affected by the degree of lexical competition more strongly than switching into L2. Thus, while we expected participants to slow down during high lexical competition compared to low lexical competition, this should be more strongly the case when switching into L1 than when switching into L2. We tested this hypothesis by manipulating lexical selection difficulties (i.e., low versus high lexical competition) and the direction of the switch (i.e., switching into L1 versus into L2).

We manipulated the degree of lexical competition by using the blocked cyclic naming paradigm, which has been previously used for measuring competition during lexical retrieval (Belke et al., 2005; Belke, 2013). In this paradigm, participants are required to repeatedly name sets of pictures, which either stem from one semantic category (i.e., homogenous condition; e.g., all pictures are of animals) or from different semantic categories (i.e., heterogeneous condition; pictures of animals, fruit, furniture etc.) (e.g., Kroll & Stewart, 1994; Damian et al., 2001; Belke et al., 2005). As mentioned in Chapter 1, it is known that naming pictures in a homogeneous condition leads to slower responses than naming pictures in a heterogeneous condition, and the difference between the two conditions is known as the “semantic blocking effect” (Belke et al., 2005).

The exact processes the underlie the semantic blocking effect are still debated. It has been proposed that the effect originates at the conceptual level but has its effect at the lexical level. However, it is still debated whether lexical representations do or do not compete with each other during lexical selection (e.g., Levelt et al., 1999; Damian et al., 2001; Belke et al., 2005; Howard et al., 2006; Oppenheim et al., 2010; Belke, 2013). Some authors have assumed that the interference effect is caused by increased lexical-semantic competition between semantically related items (i.e., homogeneous condition) than unrelated ones (i.e., heterogeneous condition) (e.g., Damian et al., 2001; Belke et al., 2005; Kroll & Stewart, 1994). However, not all speech production models assume that competition is involved during lexical selection (see Oppenheim, Dell, & Schwartz, 2010, for a different view). The nature of the processes that underlie the semantic blocking effect is not important for the present study.

Important is only that the lexical selection demand in the homogeneous condition is increased compared to the heterogeneous condition.

The blocked cyclic picture naming seems to be the appropriate paradigm to study competition during lexical retrieval as the lexical competition in this paradigm is implicit and more natural than other picture naming tasks, such as picture word interference paradigm (Belke et al., 2005; Belke, 2013). To the best of our knowledge, there are no bilingual studies measuring lexical-semantic retrieval during increased lexical competition using the cyclic blocked naming paradigm. In addition to the blocked cyclic naming task, we asked participants to perform the Flanker task (Eriksen & Eriksen, 1974), which is, similarly to the Simon task, a non-verbal task that requires the selection and suppression of strong competitors. In a typical version of the Flanker task, five arrows are presented, and participants are required to respond to the direction of the arrow in the middle. The surrounding arrows (i.e., flankers) are either congruent with the direction of the central arrow or incongruent (see Method section below).

Responses are found to be slower and less accurate in the incongruent condition as compared to the congruent condition. The difference between the two conditions is referred to as the "flanker interference effect" (Eriksen & Eriksen, 1974) and it is assumed to measure how fast participants are in resolving the competition between irrelevant responses. The Flanker task is often associated with inhibition abilities. However, it is generally used to test the ability to resolve conflict between prepotent responses and the target response at a response selection stage (Ridderinkhof, 2002). Thus, the Flanker task does not only require the ability to inhibit/suppress irrelevant responses but also requires the ability to resolve the competition in order to select the target response.

Given Branzi et al.'s (2016) suggestion that the cost of switching into L1 is related to the domain general ability to resolve response competitions, we investigated whether participants' ability to resolve lexical selection competition is related to their domain-general response selection ability (i.e., general response competition resolution ability) measured by the Flanker task. In other words, we looked for additional evidence that the cost of switching into L1 under increased lexical competition is negatively related to bilinguals' response selection abilities.

Finally, we tested participants on a non-verbal switching task (i.e., The Colour-shape task) to investigate if enhanced general shifting ability could modulate language switching in a highly competitive context. Given the claim that enhanced language-switching ability should benefit general task-switching ability (e.g., Prior & Gollan, 2011), we expected to see a similar pattern of association of performance in both switching tasks but in an opposite direction. We predicted to see a positive correlation between the general ability to shift between non-verbal tasks (i.e., in the Colour-shape task) and the ability to switch between languages during increased lexical competition (i.e., in the semantic blocking task).

Method

Participants

The same group of Arabic/English participants who were analysed in the LEAP-Q study reported in Chapter 3 took part in the experiment. These were a total of 44 bilinguals participated (1 male and 43 females) with an average age of 26 years (SD = 5.9). The participants were native speakers of Arabic, having acquired Arabic from birth (i.e., dominant Arabic speakers). They spoke English as their second language, with a mean age of English onset of 11.3 years (SD = 1.7). The participants self-estimated their speaking, listening, reading and writing skills on a scale from one to seven, seven being representative of a native-like skill. They rated their overall English proficiency as 4.7 out of a maximum of 7 (SD = 1.1) and their Arabic as 7 out of 7 (SD = 0).

Procedure

Before the experiments began, participants were asked to sign an informed consent form (Appendix 2). Then they read the experiment instructions in English and the experimenter answered any questions. After participants completed the language history questionnaire (the LEAP-Q) described in Chapter 3, they performed three experiments, a linguistic task (i.e., cyclic semantic blocking) and two non-linguistic tasks (i.e., Flanker and Colour-shape) which were all performed in one session with short breaks offered between them.

The semantic blocking task consisted of four versions (a no-switch L1 version, a no-switch L2 version, a switch-into-L2 version and a switch-into-L1 version (described in detail below). In order to break up the monotony of the task, we asked participants to first complete a non-linguistic task (Flanker or Colour-shape task), followed by two versions of the semantic blocking task, followed by the other non-linguistic task, followed by the final two versions of the semantic blocking task. The order of the versions of the semantic blocking task as well as the order of the non-linguistic tasks was counterbalanced between participants. The total duration of the testing session was approximately 1.5 hours, and each participant was tested individually. All the participants were tested using the same Samsung laptop and all tasks were programmed using E-prime (Version 2.0.8.22).

The linguistic task (the cyclic semantic blocking paradigm)

Materials

We used the version of the cyclic semantic blocking paradigm developed by Damian, et al., 2001; see also Belke et al., 2005). The experimental materials consisted of 64 colour drawings of common objects drawn from 8 different semantic categories (tools, furniture, vehicles, animals, food, body parts, clothing and utensils), with 8 objects each. Four of the semantic categories (tools, furniture, vehicles and animals) were the same as the ones used by

Belke et al. (2005). The other four semantic sets were food, body parts, clothing and utensils (see Table 4-1 for all stimuli).

The objects were chosen as far as possible to depict common concepts and to have good name agreement in both languages. We also attempted to keep word length similar across the two language sets, that is all object names were one to three syllables in length (i.e., English average, Arabic average). Although there are hardly any Arabic-English cognates, care was taken to ensure that object names were non-cognates across the two language sets.

Table 4-1 The complete list of the semantic categories and objects used in the semantic blocking task for the Arabic-English participants. Note, Arabic picture names are transcribed using the International Phonetic Alphabet (IPA) conventions.

Set A							
Category set 1				**Category set 2**			
body parts	***clothes***	***furniture***	***utensils***	***food***	***tools***	***vehicles***	***animals***
thumb /ʔbaːm/	coat /mɛʕtˤf/	chair /kursɪ/	spoon /məlʕgh/	grapes /ʕinb/	pliers /kamaːʃh/	plane /tˤjaːrh/	horse /ħisˤaːn/
heel /kaʕb/	trousers /bantˤluːn/	rug /sud͡ʒaːd/	knife /skiːn/	pumpkin /jqtiːn/	bucket /dælu/	submarine /ɣwɑːsˤah/	monkey /qird/
leg /saːq/	glove /quːfaːz/	cradle /mahd/	whisk /χfaːqh/	cucumber /χjaːr/	drill /meθqaːb/	bicycle /draːdʒah	pig /χnziːr/
eye /ʕajn/	skirt /tɑnoːra/	shelf /rʌf/	glass /kaːsh/	mushroom /fitˤr/	screw /burɣaː/	car /sjaːrh/	dog /kælb/
Set B							
neck /ræqabh/	boot /ħðaːʔ/	wardrobe /duːlab/	plate /sˤaħn/	cherry /karaz/	ladder /sulam/	train /qtˤaːr/	duck /batˤah/
toe /ʔsˤbaːʕ/	dress /fʊstaːn/	curtain /staːrah/	bowl /zbdiːah/	lettuce /χas/	brush /furʃaːh/	ship /safiːnah/	pigeon /ħamaːmh/
back /ðˤahr/	glasses /nðaːrh/	table /tˤawlah/	fork /ʃuːkah/	onion /basˤal/	scissors /meqasˤ/	rocket /sˤaruːχ/	hedgehog /qunfuð/
cheek /χad/	suit /bdlah/	chest /sˤanduːq/	grater /baʃaːrh/	pineapple /ananas/	axe /fʔs/	carriage /ʕarabah/	chick /katkuːt/

Design

Each participant completed four versions of the semantic blocking task (i.e., a no switch L1 version, a no switch L2 version, a switch into L2 version and a switch into L1 version). We created the four different versions in order to make sure that each participant was equally exposed to all of the task conditions.

In the no-switch versions of the experiment, participants were asked to name all pictures in one of their languages, either Arabic or English for 12 cycles. In the switch versions however, participants were asked to switch languages half-way through a block. For instance, during the first six cycles of each block, they named the pictures in their L1 and during the second six cycles (from cycle 7 onwards) they named the same set of pictures in their L2. In the other language switch version, they did the opposite, that is they named the pictures in L2 first and then in L1. The language to be used was indicated by a flag that appeared at the beginning of a block or before the 7th cycle in the case of a switch version.

To reduce picture repetition and to avoid the same participant naming the same picture in the four versions of the naming task, we randomly divided the 8 semantic categories into two category sets containing four categories each. Category set 1 contained the categories body parts, clothes, furniture and utensils, while Category set 2 contained the categories food, tools, vehicles, and animals. These two category sets (Category set 1 and Category set 2) were then divided into two subsets (Set A and Set B) with four items per category in the two sets (See Table 4-1). Items within a category set were randomly ordered. However, for each category set, care was taken to ensure that the object names of the 4 semantic items were dissimilar in their initial phonemes in both languages (Arabic and English, See Table 4-1).

For example, in one version, participants named each set of objects (e.g., category set 1, subset A) always in their L1 (i.e., non-switching L1 version). In the second version, participants named each set of objects (e.g., category set 1, subset B) always in their L2 (i.e., non-switching L2 version). In the third version, participants named each set of objects (e.g., category set 2, subset A) for the first 6 cycles in L1 and they had to switch to L2 during the 6 remaining cycles (i.e., switching into L2 version). In the fourth one, participants named each set of objects (e.g., category set 2, subset B) in their L2 for the first 6 cycles and then switched to their L1 for the remaining 6 cycles (i.e., switching into L1 version). Half of the participants started with naming in L1, with either category set 1 or 2 subset A or B, and the other half started with naming in L2, with either category set 1 or 2 subset A or B, in order to counterbalance the exposure to the target pictures.

In addition, objects within the two subsets (Set A and Set B) were used to constitute 16 homogeneous blocks and 16 heterogeneous blocks. In the homogeneous blocks, a set of 4 objects from one of the semantic categories were presented (e.g., thumb, heel, leg, eye), while in the heterogeneous blocks one item from each of the 4 semantic categories within a subset were presented (e.g., thumb, coat, chair, knife). Eight such blocks were created out of four semantic categories within a subset (i.e., 4 homogeneous x 4 heterogeneous). For example, in one version of the task, participants saw 8 blocks of pictures, 4 homogeneous and 4 heterogeneous blocks, in an alternating fashion. Each block consisted of 12 presentation cycles, such that no picture occurred in the same position as in the previous cycle (with a total of 48 trials) (see Figure 4-1).

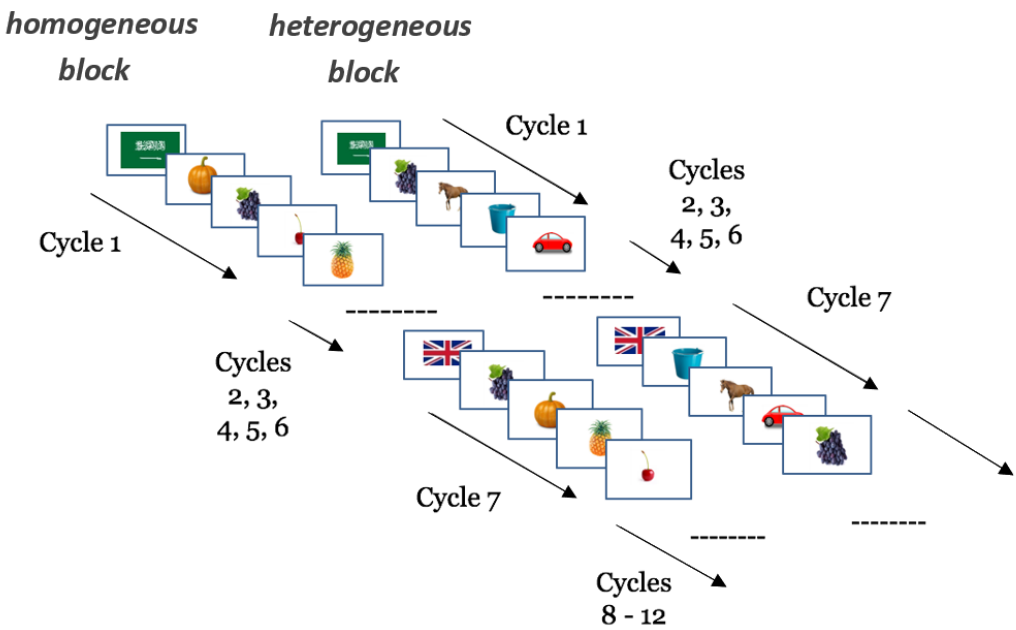


Figure 4-1 *Illustration of the experimental design (form a homogeneous and heterogeneous blocks) during the switch into L2 version, where pictures were named in Arabic first and the same set of pictures were named in English from the 7th cycle onwards as cued by the English flag. In the switch into L1 version (not shown here), pictures were named in English first and then in Arabic from the 7th cycle onwards as cued by the Arabic flag. In the two no-switch versions of the experiment (not shown here), there were no switching and the language remains the same across the cycles; all pictures were named only in one language, either in English in one version or in Arabic in the other.*

Half of the participants started with a homogenous block, the other half with a heterogeneous block. This was done to ensure that the homogenous and heterogeneous conditions occurred in the same position in an equal number of times. Objects were presented in the middle of the screen and were scaled to fit into frames approximately 3 by 3 cm in size.

Procedure

Before the beginning of the experiment, participants were given a booklet with the pictures with their names written underneath in both participants' languages in order to familiarize themselves with the stimuli and their names. The pictures were presented in a random order, not in semantic groups. The participants were asked to use the names listed in the booklet to name each object during the experiment.

Participants were instructed to press a key when they were ready to begin. At the beginning of a block and half-way through a block in case of a language switch version, a picture of a flag was displayed on the computer screen for 500 ms, indicating which language should be used to name the following pictures. Pictures were presented at the centre of a white screen. On each trial, a fixation cross was presented at the centre of the screen for 800 ms. Then the screen went blank for 100 ms, and subsequently the target picture was shown. Responses were audio-recorded, and response times were measures with an SV-1 voice key (Cedrus: http://www.cedrus.com/sv1/). Once the voice key was triggered, the picture disappeared, and the next trial started.

Flanker Task

Material and Procedure

For the Flanker paradigm (Eriksen & Eriksen, 1974) we adapted the procedure for the Flanker task used by Costa et al. (2009). Stimuli consisted of five arrows in a row, with the central arrow being the target and two arrows on each side being the flankers. This task had two types of trials: congruent trials where the central stimulus and the flankers pointed in the same direction (e.g., >>>>>), and an incongruent trial where both the stimulus and flankers pointed in opposite directions (e.g., >><>>). There were 75% congruent trials and 25% incongruent trials. Participants were required to only focus on the target stimulus that always appeared in the middle and to ignore any flanking stimuli on each side of the central stimulus. They were asked to either press a left or a right button in response to the direction of the central stimulus by using a Cedrus RB-834 response pad, which also measured their response time.

Each trial started with a fixation cross for 400 ms which was followed by the stimulus. The stimulus disappeared after the response or disappeared after 1700 ms in case of no response. The appearance of the stimuli was random, either below or above the fixation cross with a 50/50 chance of occurrence. 24 practice trials were followed by two blocks of 48 experimental trials. The sequence of stimuli was randomized, with a different randomization for each participant. The flanker interference effect was calculated by subtracting the average reaction times (RTs) on the incongruent trials from the average RTs on the congruent trials.

Colour-Shape Task

Material and Procedure

The Colour-shape Task (adopted from Miyake, Emerson, Padilla, & Ahn, 2004) was used as a measure of shifting ability. In this task, single triangles and circles (either red or green) appeared in the centre of the computer screen. Participants had to decide whether a stimulus was a circle or a triangle or whether it was red or green, depending on a cue. When they saw the cue word "Colour" appearing above the stimuli, they had to decide whether the colour of the stimulus was red or green. When the cue word was "Shape", they had to decide whether the object was a circle or a triangle. A Cedrus RB-834 response pad was used to record responses. Participants were asked to use their index fingers to make a response by pressing the designated keys on the response pad. Responses were mapped onto two buttons.

The procedure of the shifting task was taken from Friedman, Miyake, Young, DeFries, Corley and Hewitt (2008). In the task, there were 4 blocks, with 48 trials in each block. The cue was presented either for 150 ms before the beginning the stimulus (in the 1st and 3rd block) or presented for 1500 ms before the beginning of the stimulus (the 2nd and the 4th block). Both the cue and the stimulus remained on the screen for 5000 ms, unless a response was made before that.

Before the actual task took place, all participants completed two blocks for practice, with 24 trials each that were not included in the analysis. The sequence of trials was pseudorandomized, with in each block 24 switching trials and 24 non-switching trials and no more than 4 switching/non-switching trials occurring in a row. The switching effect was calculated by subtracting the average RTs on the switching trials from the average RTs on the non-switching trials.

Results

The Cyclic semantic blocking results

For response time analyses, only accurate responses were included. In addition, all responses above 2 SDs of each participant's mean reaction times or responses too fast to be responses evoked by the stimulus (i.e., faster than 250 milliseconds (ms)) were considered outliers and were removed from the analysis. Due to these outliers, 14% of data points were lost. That is, about 8% of all responses were RTs for error trials that were excluded and approximately 6% of responses were RTs that were 2 SDs from each participant's mean.

Because our main interest in this task was examining the effects of lexical competition on participants' language switching behaviour (i.e. switching from one language to another, either to a high or low competitive semantic environment), all analyses were based on responses from cycles 7. That is, participants' responses during the language switching condition and their responses during the no-switching condition. Therefore, the number of data points included in the analysis was 5,076. Errors and outliers were also excluded from the analysis of cycles 7, which accounted for about 4.1% of the total responses.

As can be seen in Figure 4-2, participants slowed down on cycle 7 when they switched languages compared to when they did not switch languages. While this effect seems to potentially last into cycle 8, the effect is largest on the 7th cycle which is the actual switch trial.

Figure 2 also shows participants' responses were slower during high lexical competition (i.e., homogeneous condition) as compared to low lexical competition (i.e., heterogeneous condition) when they switched from one language to another in cycle 7.

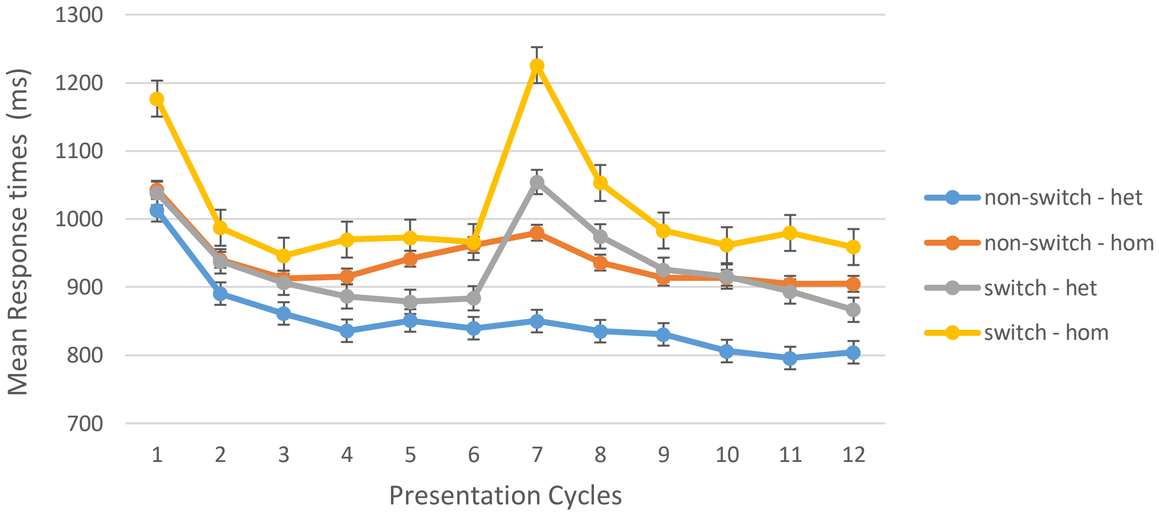


Figure 4-2 *Mean response times within the switching condition by semantics (homogeneous, hom versus heterogeneous, het) and presentation cycles: response times for the 12 presentation cycles in the switch versus non-switch version of the paradigm under increased lexical competition for the homogenous and heterogeneous conditions. In the switch version, participants alternated between their two languages and switched either into their L1 or their L2 on cycle 7. While in the non-switch version, the language remained the same across the cycles and participants named only in one language.*

Accuracy and Response times

Accuracy. In the semantic blocking experiment, speech accuracy was checked using the audio recordings. Any hesitations (i.e., "aa" or "uhh"), self-corrections (i.e., incorrect but semantically related/correct responses), incorrect object names (e.g., using 'shoe' instead of 'boot'), timeouts (i.e., failures to produce a response in the time limit) and language intrusion (i.e., wrong language; e.g., naming 'cradle' in English when the target language is Arabic '/mahd/= cradle') were counted as errors. Participants made mostly language intrusion errors (3.2%), timeouts errors (2.3%) and 2.1% of these errors were due to self-correction errors. The rest of the errors were either incorrect object names (1.1%) or hesitation errors (1.3%).

The resulting means are shown in Figure 4-3. As can be seen error rates are higher on switch compared to non-switch trials, and in homogenous compared to heterogeneous blocks. Switching into L1 is also associated with more errors than switching into L2.

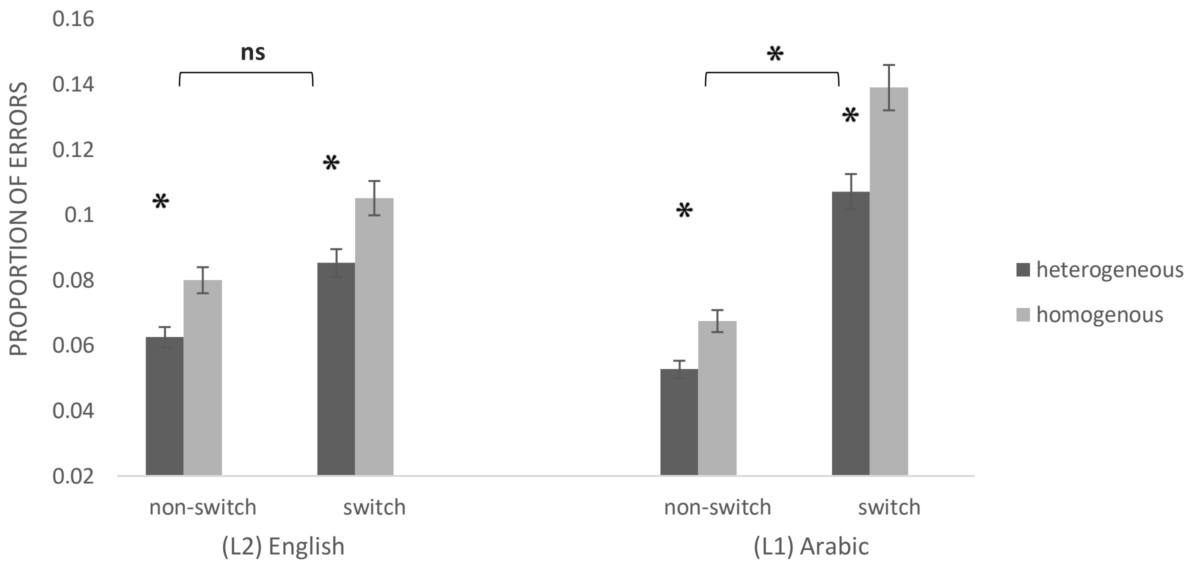


Figure 4-3 *Proportion of errors of the no-switch versus switch into L1 (Arabic) and no-switch versus switch into L2 (English) in the homogeneous and heterogeneous conditions in cycle 7 of the blocked cyclic picture naming task. Error bars represent standard errors. Significant differences between conditions are indicated with an asterisk.*

We used an analysis of variance (*ANOVA*) with the within-participant three independent variables: *homogeneity* (homogeneous, heterogeneous), *language* (L1, L2), and *switching* (language switch versus no switch). Bonferroni correction was applied when following up any interaction.

As expected from previous findings in the cyclic naming task, the results revealed a significant main effect of homogeneity, $F\ (1, 43) = 14.82$, $p < .001$, with participants responding less accurately in the homogeneous condition than in the heterogeneous condition. Also, a significant main effect of language switching was obtained, $F\ (1, 43) = 27.9$, $p < .001$, where responses in the switching condition were less accurate than no-switching condition. There was no main effect of language, F (1, 43) = 5.84, p =.202. However, the *ANOVA* yielded a significant three-way interaction of homogeneity, language and switching, F (1, 43) =7.73, p < .008. This can be seen in Figure 4-3.

We followed up the three-way interaction by investigating L1 and L2 separately to examine if the effects of homogeneity and switching were different for the two languages. Results showed that there was a significant interaction between homogeneity and switching for L1, F (1, 43) = 5.28, p < .026, but not for L2, F (1, 43) =1.264, p = .209 (see Figure 4-3).

The interaction for L1 was followed up with *t*-tests to examine if the homogeneity effect was significant for both switching conditions (i.e., switching and no-switching). Paired sample *t*-tests revealed that naming was more error prone in the homogenous than the heterogeneous condition for both the switching, t (43) = 4.93, p < .005, and the no-switching conditions, t (43) = 4.93, p < .006. Paired sample *t*-tests, comparing the size of the homogeneity effect (mean of homogeneous minus heterogeneous response times) in the switching and no-switching conditions indicated a significant difference (no-switching condition: M=.0035, SD=.0369; switching condition: M=-.0153, SD=.03722), t (43) = 2.298, p < .026). This suggests that the proportion of errors in the homogeneous condition was larger when switching into L1 as compared to continuing to name in L1 (see Figure 4-3).

Response times. We submitted the latencies for correct responses to *ANOVA* with the within-participant factors *homogeneity*, *language*, and *switching*. The means are shown in Figure 4 and the pattern of results is very similar to the error data.

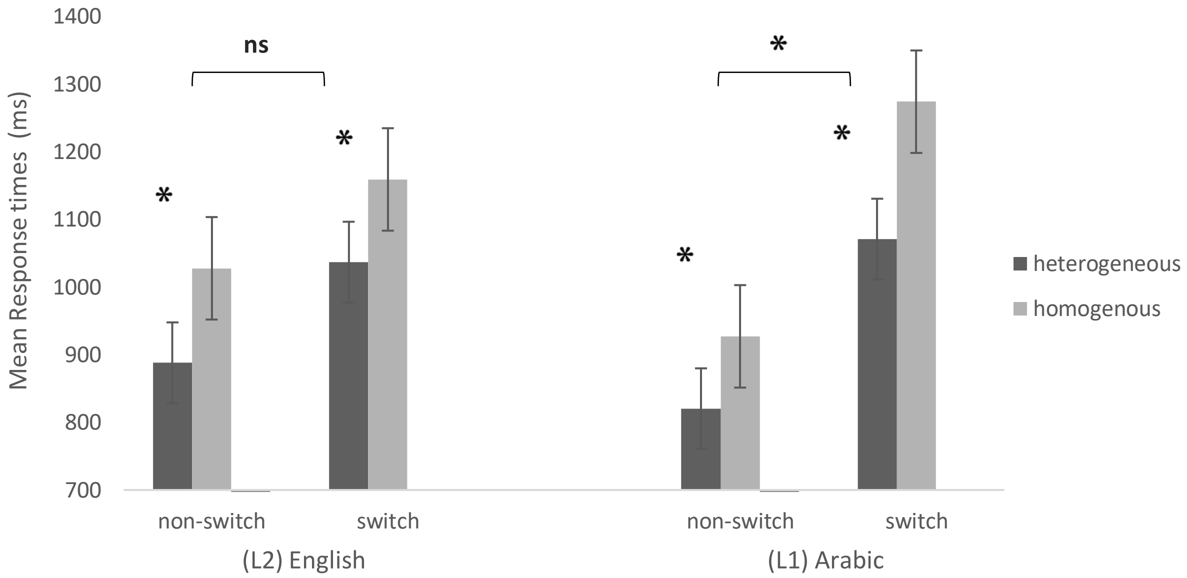


Figure 4-4 *The effects of homogeneity (homogeneous condition, heterogeneous condition) and language switching (switch versus no switch) on response times when naming in L1 (Arabic) and L2 (English) in cycle 7. An interaction of the two factors was only present for L1. Error bars represent standard errors. Significant differences between conditions are indicated with an asterisk.*

In line with previous studies in the cyclic naming task (e.g., Belke et al., 2005), *ANOVA* showed a significant main effect of homogeneity, F (1, 43) = 46.2, $p < .001$, with slower responses in the homogeneous than heterogeneous condition. Similarly, we found a significant main effect of language switching, F (1, 43) =34.561, $p < .001$, with slower responses in the switching than no-switching condition. There was no main effect of language, F (1, 43) =.18, $p = .671$, showing no RT difference between naming in L1 and L2. Nevertheless, the *ANOVA* revealed a significant three-way interaction of homogeneity, language and switching, F (1, 43) =10.8, $p < .002$.

We again followed up the three-way interaction by examining each language separately to see if the effects of homogeneity and switching were different for the two languages. There was a significant interaction between homogeneity and switching for L1, F (1, 43) = 4.103, p <.049, but this was not significant in the L2, F (1, 43) =1.603, p = .212 (see Figure 4-4).

The interaction for L1 was followed up with t-tests to examine if the homogeneity effect was significant for both switching conditions (i.e., switching and no-switching). Paired sample t-tests revealed that naming was slower in the homogenous than the heterogeneous condition for both the switching, t (43) = 4.93, p < .001, and the no-switching conditions, t (43) = 4.93, p < .001. Paired sample t-tests, comparing the size of the homogeneity effect (i.e., the difference between homogeneous and heterogeneous response times) in the switching and no-switching conditions indicated a significant difference (no-switching condition: M=111, SD=168; switching condition: M=216, SD=277), t (43) = -2.165, p < .036.

This suggests that the effect of homogeneity was significantly larger when switching into L1 as compared to continuing to name in L1 (see Figure 4-4). Thus, for both L1 and L2, lexical competition in the homogeneous condition and switching led to slower responses, but high lexical competition in the homogeneous condition made switching into L1 particularly slow.

The Flanker Task results

Accuracy and Response times

For the response time analysis of the Flanker task, only accurate responses were included. Additionally, all fast responses (below 250 ms) and responses deviating from the mean for each participant by more than 2 SDs were considered outliers and were removed from the analyses. The percentage of RT outliers accounted for 4 % of the total responses. RT Results are displayed in Figure 4-5. In line with previous findings, there was a significant main effect of congruency on response accuracy, F (1, 43) = 33.12, p < .001, with incongruent trials leading to more erroneous responses than congruent ones (see Figure 5).

Similarly, we found a significant main effect of congruency, F (1, 43) = 115.52, $p < .001$, indicating faster responses in congruent than incongruent trials. The Flanker task results replicated key findings and showed main flanker interference effect, with participants' responses being slower and more inaccurate during incongruent condition as compared to congruent condition.

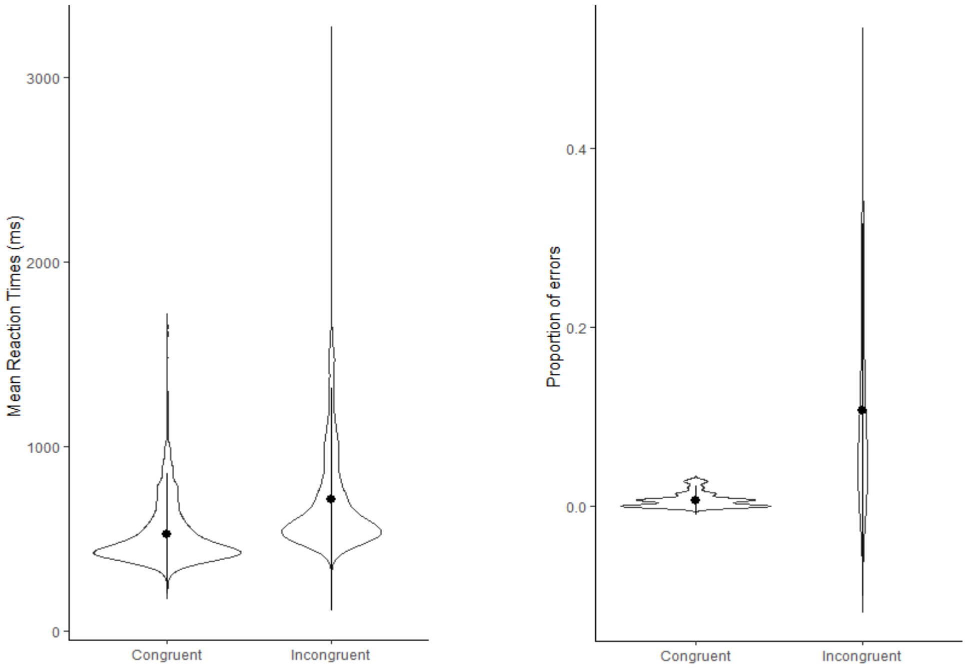


Figure 4-5 *(Left) Mean response times for congruent and incongruent conditions for the participants in the Flanker task. The shape of the violin represents the estimated distribution of mean data in the corresponding condition. The thickest part of the violin shows higher frequency, while the thinner part displays lower frequency in the dataset. The dot in the middle represents the median and the bars normalized within-participant 95% confidence intervals. (Right) Proportion of errors for congruent and incongruent conditions for the participants in the Flanker task.*

The Colour-Shape Task results

Accuracy and Response times

Only correct responses were included in the analyses. In addition, any outlier responses deviating by more than 2 SDs from each participant's mean reaction times or responses faster than 250ms were excluded. Response time outliers in the Colour-shape task accounted for 2% of the total responses. Mean accuracy and RTs for correct responses are shown in Figure 4-6.

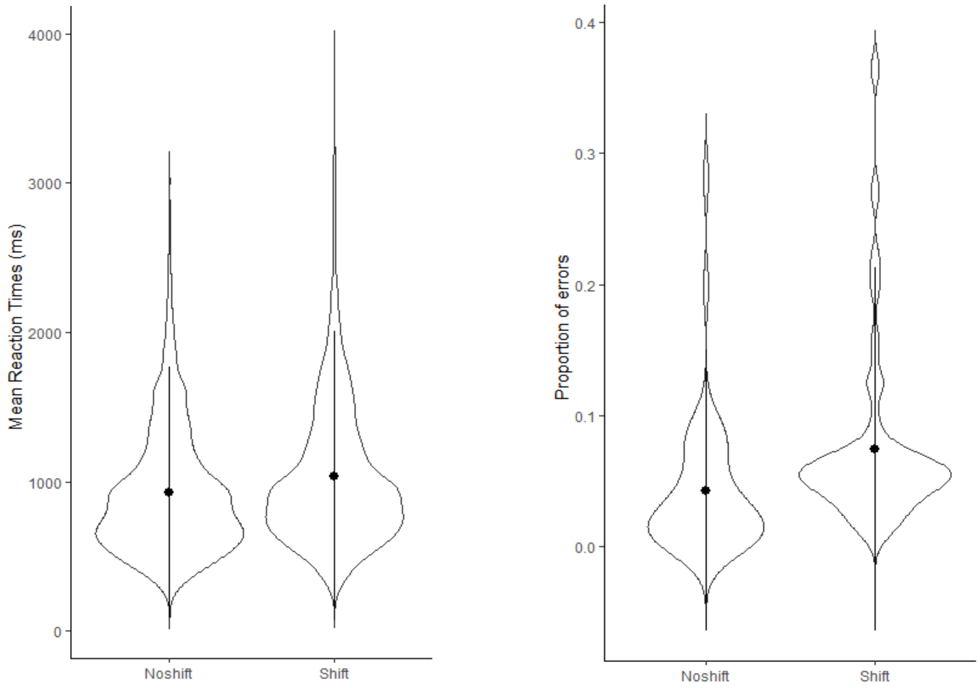


Figure 4-6 *(Left) Mean response times for shift and non-shift conditions. The shape of the violin represents the estimated distribution of mean data in the corresponding condition. The thickest part of the violin shows higher frequency, while the thinner part displays lower frequency in the dataset. The dot in the middle represents the median and the bars normalized within-participant 95% confidence intervals. (Right) Proportion of errors for shift and non-shift conditions for the participants in the Colour-shape task.*

Consistent with earlier research, we found a significant main effect of shifting, with more errors in the non-shift condition than in shift condition. The Colour-shape task analysis is in line with previous findings of shifting tasks and showed a significant main effect of shifting condition, with participants' responses being slower and more inaccurate in the shift than non-shift trials. F (1, 43) = 34.64, p < .001.

Pattern of associations between tasks

As reported above, we found that L1 switching trials were more affected by the increased lexical competition demands than L2 switching trials in the blocked cyclic naming task. Next, we wanted to see if participants' domain general response selection/inhibition ability measured by the Flanker task was related to their ability to resolve lexical competition during increased lexical competition demands when switching into L1 as compared to switching into L2.

To assess this, we performed Pearson correlation analyses with participants' performances in the blocked cyclic naming task at cycle 7 and the Flanker task. We correlated the homogeneity effect (RTs in the homogeneous condition minus RTs in the heterogeneous condition) in the semantic blocking task with the inhibition effect (RTs in the incongruent condition minus RTs in the congruent condition) in the Flanker task, when participants switched into L1 or L2. In line with the idea that switching into L1 is demanding for domain-general response competition resolution, we found a significant positive correlation for L1 (r = .472, p = .001; see Figure 4-7(b), but no significant correlation for L2 (r = .172, p = .264; see Figure 4-7(a).

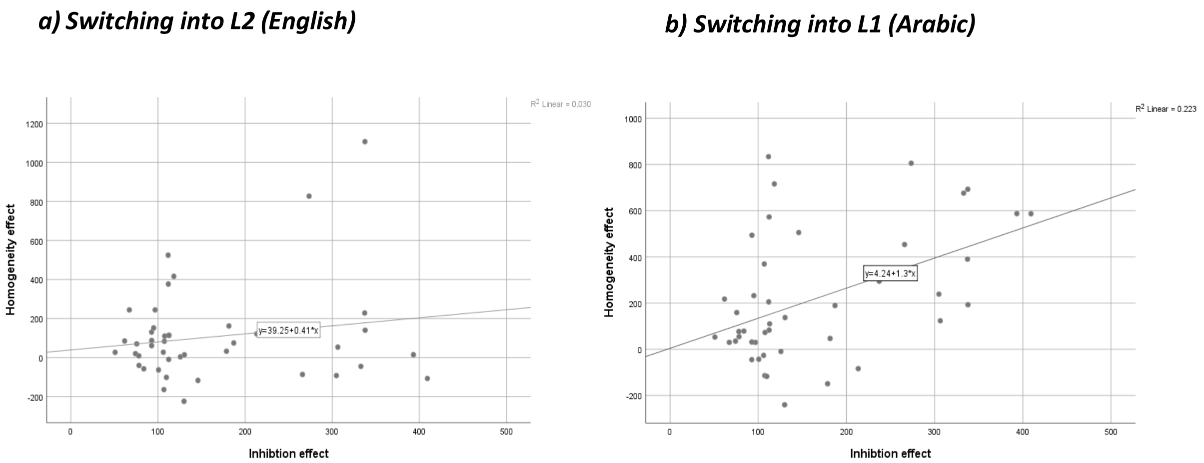


Figure 4-7 *Relationship between the inhibition effect in the Flanker task (incongruent minus congruent condition) and the homogeneity effect in the blocked cyclic naming task (homogeneous minus heterogeneous condition). Panel a) shows the relationship between the two variables when naming in L2 (English) after naming in L1 (Arabic) in cycle 7. Panel b) shows the relationship between the two variables when naming in L1 (Arabic) after naming in L2 (English) in cycle 7.*

We found significant positive correlations between the inhibition effect and the homogeneity effect, but only for the switch into L1, not the switch into L2. Thus, participants who are better at response selection abilities, also exhibit enhanced lexical selection abilities in competitive semantic contexts when switching into L1. Yet, this effect was absent when they switched into L2. Implications of these findings are further discussed in the Discussion section below.

In addition, to investigate whether task-switching ability is related to language switching ability, we correlated (Pearson’s coefficient) participants’ performances in these two switching tasks. We correlated the switching ability when resolving lexical competition (i.e., the homogeneity effect = RTs in the homogeneous condition minus RTs in the heterogeneous condition) in the semantic blocking task at cycle 7 with the shifting effect (RTs in the shift condition minus RTs in the non-shift condition) in the Colour-shape task.

As mentioned in the Colour-shape task procedure section, there were two different types of blocks, one where the cue was presented for 150 ms before the beginning of the stimulus and one where the cue was presented for 1500 ms before the beginning of the stimulus. We ran an analysis on the two different types of cues (i.e., short cues =150 ms and long cues =1500 ms); however, we focused our analysis on the long-cue condition because it is the relevant measure to our language switching task. That is, in the language switching task, participants were given an advance flag cue and a sufficient preparation time before the actual switch to the other language. Similar procedure was used for the shifting task where participants were provided with a 1500 ms before shifting to the upcoming sets of new rules. Although short-cue condition was not directly addressed by our study, we thought that its findings may have interesting implications.

For cues presented for 150 ms before the beginning of the stimulus, we found a significant negative correlation for switching into L1 (r = -.332, p = .028; see Figure 4-8(b) upper panel), but a trend towards significance for switching into L2 (r = -.296, p = .099; see Figure 4-8(a) upper panel). Thus, participants who are worse at general shifting abilities are better at switching languages in competitive semantic contexts, but only when they switched into L1.

In line with the proposal that the better the general shifting ability was, the better the language switching efficiency would be (e.g., Prior & Gollan, 2011), we ran the same set of correlations we did on the short-cue condition on the long-cue condition to see if enhanced general shifting ability could modulate language switching performance in a highly competitive context. We found no significant correlation for switching into L1 (r = -.154, p = .319; see Figure 4-8 (b) lower panel), and no significant correlation for switching into L2 (r = -.135, p =

.381; see Figure 4-8 (a) lower panel). These results suggest that the shifting ability did not affect the language switching costs in the language-switching paradigm.

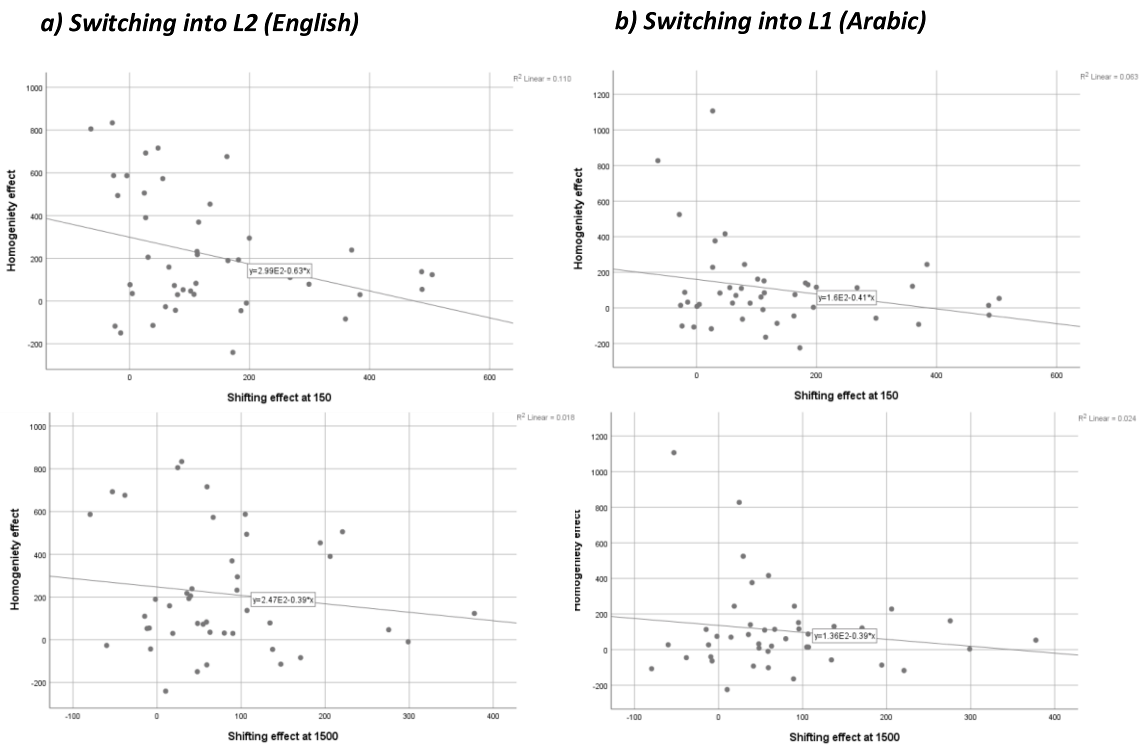


Figure 4-8 *Relationship between the shifting effect in the Colour-shape task (shifting minus non- shifting condition) and the homogeneity effect in the blocked cyclic naming task (homogeneous minus heterogeneous condition) in the switching cycle 7. Upper panel shows the relationship between the two variables when cues were presented for 150 ms before the beginning of the stimulus when (a) switching into L2 and when (b) switching into L1. Lower Panel shows the relationship between the two variables when cues were presented for 1500 ms before the beginning of the stimulus when (a) switching into L2 and when (b) switching into L1.*

Effects of the LEAP-Q factors

We next investigated correlations between the homogeneity effect when switching languages in the naming task and the language experience and proficiency factors (extracted from the LEAP-questionnaire using a principal component analysis; see Chapter 3). We found significant negative correlations between the homogeneity effect and the L2 proficiency and L2 exposure factors, but only for the switch into L1 (r = -.343, p = .023; r = -.319, p = .035; see

Figure 4-9 right panels), not the switch into L2 (r = -.220, p = .264; r = -.216, p = .159; see Figure 4-9 left panels). Thus, participants with low L2 proficiency and low exposure, suffered more from the semantic interference effect compared with high L2 proficiency and high exposure only when switching into L1. We found no correlation for the language competition and the L1 learning factors (see Figure 4-9). Thus, the amount of L2 exposure and L2 proficiency has an effect on one's ability to resolve increased lexical competition demands when switching into L1.

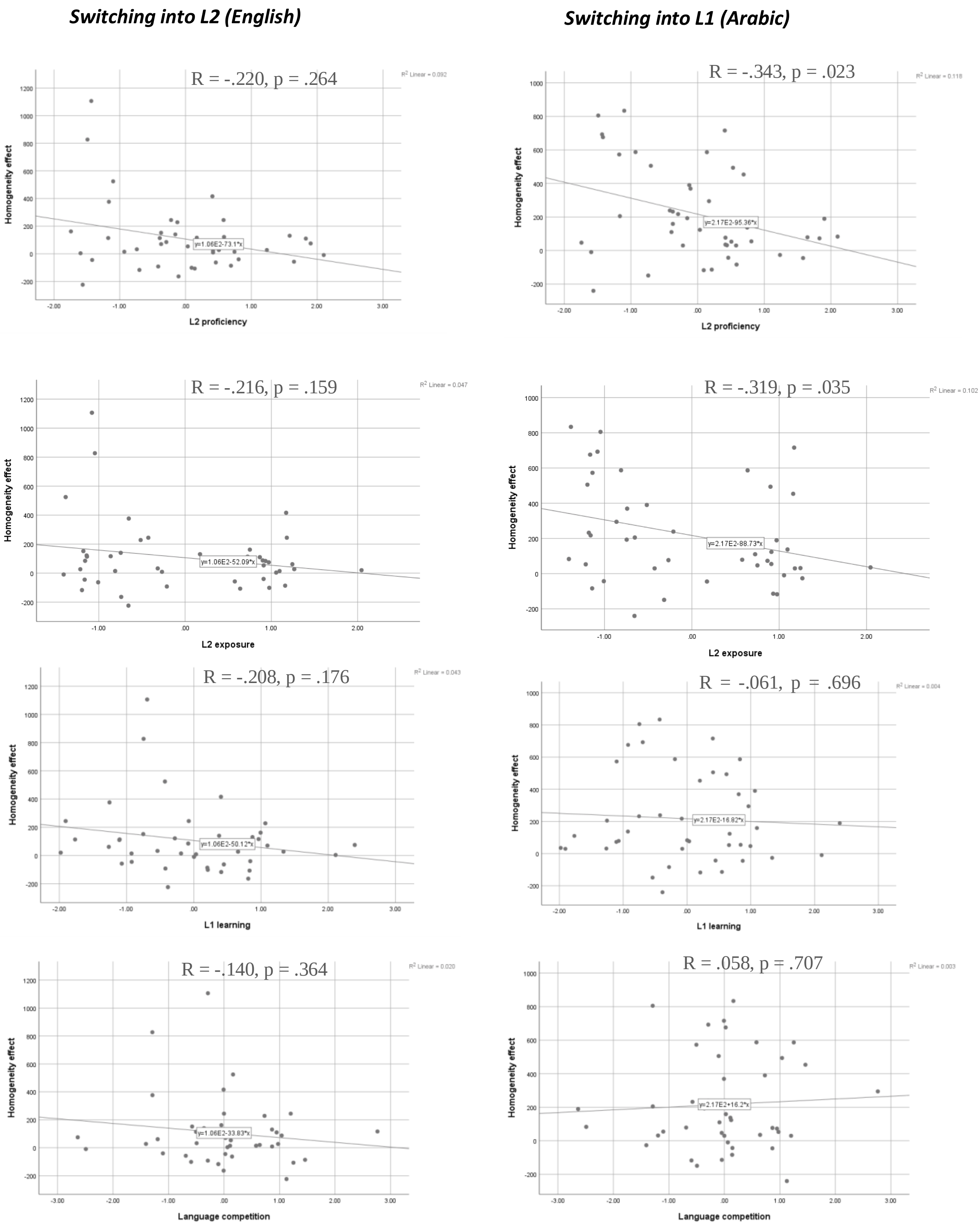


Figure 4-9 *Correlation plot for the relationships between the homogeneity effects in the blocked cyclic task when switching into L1 (right panels) and into L2 (left panels), and the LEAP-Q factors: L2 Proficiency, L2 exposure, Language competition and L1 learning.*

Discussion

The aim of the current study was to investigate bilingual language switching performance under increased lexical competition. More specifically, we were interested to explore whether the same processes are involved when bilinguals switch into their L1 compared to switch into their L2. We used the blocked cyclic paradigm to investigate the relationship between the direction of the language switch (i.e., whether the language to switch to is L1 or L2) and the degree of lexical competition (i.e., whether objects are named in the homogeneous or in the heterogeneous contexts). Our results showed that switching into L1 interacts with lexical competition whereas switching into L2 does not. Importantly, the effect of lexical competition (i.e., the homogeneity effect) correlated with participants' response competition resolution ability as indexed by the Flanker task. This correlation was only observed when participants switched into L1, but not when they switched into L2. These findings provide support for the proposal that switching into L1 is demanding on the domain-general response selection system in the brain (Branzi et al., 2016).

In addition, participants' general shifting ability, measured with the Colour-shape task did not correlate with their ability to switch between their languages during increased lexical competition. That is, general shifting ability did not seem to modulate language switching efficiency during lexical retrieval in competitive semantic contexts. Finally, the present study examined the effects of bilingual language status on the observed language switch cost patterns. Results showed that L2 proficiency and L2 language exposure factors affected participants' ability to resolve increased lexical competition demands for the switch into L1, but not for the switch into L2. These findings are discussed in more detail in the following sections.

Does the degree of lexical competition modulate language switch costs?

Our results showed main effects of the two variables of interest, namely homogeneity and switching. Firstly, our results in the blocked cyclic naming experiment were in line with previous studies where semantically related pictures in their L1 took longer to name than semantically unrelated pictures in their L1 (e.g., Belke et al., 2005). We replicated the same semantic blocking effect obtained in Belke et al., (2005) and found that participants' responses in condition where lexical-semantic competition was high (i.e., homogeneous condition) were slower than their responses in condition where lexical-semantic competition was low (i.e., heterogeneous condition).

The longer naming latencies observed when naming pictures in the homogenous condition are most likely due to increased difficulties in lexical retrieval difficulties. This results from the semantic overlap within semantically related homogeneous context compared to semantically unrelated heterogeneous context (Levelt et al., 1999; Oppenheim et al., 2010; Roelofs, 1992; Roelofs, 2003). More specifically, target lexical selection becomes more effortful in the homogeneous than in the heterogeneous conditions, as an activation of a target concept within semantically related context increases the activation levels of the lexical representation of the targets and its semantically related alternatives. This induces lexical-semantic competition between the targets and its shared semantic features (Abdel Rahman & Melinger, 2009; Bloem & La Heij, 2003; Levelt et al., 1999).

Secondly, our results revealed a main effect of the switching condition, such that participants were slower and more erroneous in the switching compared to the non-switching conditions. We obtained a similar pattern of switching cost reported in previous studies (e.g., Meiran, Chorev & Sapir, 2000; Meuter, 2005; Monsell, 2003; Prior & Gollan, 2011) for both languages: L1 and the L2. For instance, the cost of the language switching increased by 106 ms when participants switched relative to when they did not switch into their L1. The cost of language switching was thought to reflect participants' efforts to resolve cross-language competition when switching compared to no-switching between their languages (Hermans et al., 1998).

Additionally, the costs associated with the language switching was larger when participants switched from L2 to L1 than from L1 to L2. This finding is in line with previous language switching studies reporting an asymmetric reaction times cost, with naming in L1 being slower after naming in L2 (Costa & Santesteban 2004; Gollan & Ferreira, 2009; Meuter & Allport 1999; Verhoef, Roelofs, & Chwilla, 2009; Yeung & Monsell, 2003). The asymmetrical switch cost observed in our study could be explained by the Inhibitory Control model (ICM; Green, 1998). ICM suggests that naming in the L2 requires strong inhibition of the more dominant L1 by engaging a general executive system to prevent its intrusion into the weaker L2. When switching back into the L1, additional time and cognitive effort is required to overcome the residual inhibition of the L1 (Green, 1998).

We could therefore argue that the longer naming latencies observed when participants switched into L1 are most likely due to the extra cognitive effort needed to disengage from the L2 lexicon to access the L1 lexicon. That is, on the L2 naming trials (i.e., before the switch, when participants were only speaking in their L2), it is possible that participants have strongly inhibited the non-target L1 lexicon to prevent its intrusion into their the L2 (i.e., both the semantically related competitors and their translation equivalents). According to the ICM (Green, 1998), successful production in the target language could be achieved by suppressing the activation of the non-target language through language task schemas which "can... reactively inhibit competitors in the non-target language, [and] if there is a change of language, then any lemmas in the previously active language will become inhibited". (p.75). On the L1 switch trials, participants must have engaged more cognitive control mechanisms to overcome L1 inhibition and reactivate L1 semantic competitors and their translation equivalents that were strongly suppressed.

In line with Branzi et al.'s (2016) proposal that switching into L1 is more demanding than switching into L2, we predicted that only switching into L1 should interact (become exacerbated) with contexts where the level of lexical competition is high. We found in our study that switching into L1 is strongly affected by the homogenous context, in which there was increased competition in the lexicon. Particularly, additional analyses demonstrated that the degree of lexical competition and switching between languages led to slower responses for both L1 and L2. However, in the semantic blocking task, participants slowed down more strongly during increased lexical competition demand but only when they switched to L1 compared to when they switched to L2. This finding is consistent with Branzi et al.'s (2016) findings that switching into L1 is more cognitively demanding than switching into L2 in terms of lexical selection as indicated by the engagement of response selection system responsible for selecting a target response from other interfering responses (Green & Abutalebi, 2013).

Our results further extend Branzi et al.'s (2016) findings by showing that switching into L1 is strongly affected by the degree of lexical competition than switching into L2, since switching into L1 interacted with increased lexical-semantic competition (i.e., the homogeneous condition), as shown by the larger switching costs for L1. Thus, our participants were faced with an increased level of lexical selection demand. In addition, the response selection system must have been involved to resolve not only between-language competition but also to select the correct response when within-language competition was high. This was the case for the semantic blocking task, especially in the homogenous context. This extra cognitive demand on the response selection system did not seem necessary for participants when they switched into L2 (Branzi et al., 2016). It therefore appears that the involvement of the response selection system is related to the degree of cognitive effort imposed by the increased lexical selection demands. Our result suggests that only switching into L1, not L2, was affected by the increased cognitive load on the response selection system. Therefore, it can be concluded that the degree of lexical-semantic competition could modulate the switch costs within bilinguals' lexical retrievals.

Do domain-general inhibition and shifting abilities modulate language switch costs and language switching efficiency?

The present study examined the performance of bilinguals during increased lexical competition when they switched into their L1 as compared to when they switched into their L2. The lexical selection difficulties were manipulated during a language switching task by using the semantic blocking paradigm (Belke et al., 2005). In addition, we used two non-linguistic tasks - a Colour-shape shifting task (Miyake, Emerson, Padilla, & Ahn, 2004) and a Flanker task (Eriksen & Eriksen, 1974) - to assess individual differences in cognitive control in bilingual speakers and understand whether the individual differences in inhibitory control could influence bilinguals' language selection and switching.

In line with the previous finding that that cost of switching into L1 is related to inhibition ability or ability to resolve response competition (Branzi et al., 2016), we predicted that the lexical semantic interference effects (i.e., homogeneity effect) should correlate with participants' performance in the Flanker task which was used to provide a measure of participants' domain-general inhibition ability (i.e., response selection ability/response competition resolution ability). Our results demonstrated that naming latencies were slower in the homogenous condition where pictures appeared in a high lexical competition context compared to when they appeared in a low lexical competition context (i.e., heterogenous condition), showing the expected semantic blocking effect or the homogeneity effect (Belke et al., 2005; Damian et al., 2001). Importantly, our results showed that participants' performance when switching into L1 under high lexical selection demands positively correlated with their response selection ability, measured by the Flanker task. This effect was absent when they switched into L2. This means that bilinguals who are better at response selection ability, also exhibit enhanced lexical selection ability in competitive semantic contexts when switching into L1.

Our findings are consistent with previous studies showing that domain-general inhibition ability could modulate language switch costs (e.g., Linck et al., 2012; Liu, Rossi, Zhou & Chen, 2014; Liu, et al., 2015). In particular, Linck et al. (2012) showed that lower inhibitory control was correlated with larger L1 switching costs, as indexed by the Simon task. Similarly, Liu, et al., (2014) observed larger L1 switching costs for unbalanced bilinguals with a low inhibitory control (large Simon effect) compared to those with a high inhibitory control (small Simon effect), showing smaller L1 switching costs. Importantly, the predominant view in these studies suggests that individual differences within inhibitory control abilities play an important role during language switching.

However, what about our manipulation of lexical selection difficulties (i.e., low versus high lexical competition) during language switching task? Although our findings support these studies, the role of inhibitory control in language switching do not explain the observed correlations between competition resolution and lexical-semantic competition effects. In our study, we found evidence for a relationship between lexical-semantic competition effects in the semantic blocking task and participants' response competition resolution ability in the Flanker task. This finding indicates that these two tasks tap into similar control processes involved in resolving competition during increased selection demands. Importantly, the relationship between lexical selection and response selection was only present when they switched into L1 but was absent when they switched into L2. This suggests that response selection ability could modulate the cost of language switching, but only in demanding contexts where the degree of lexical competition is high. It is important to finally note that the participants in the above-mentioned studies (Linck et al., 2012; Liu, et al., 2015; Branzi et al.'s, 2016) were low proficient bilinguals who rated themselves as unbalanced bilinguals. It might therefore be the case that a particular demand on the response selection system is only present in bilinguals with two languages that are not balanced in terms of dominance.

In the Colour-shape shifting task, we obtained a different pattern of performance. We found no relationship between the homogeneity effect in the semantic blocking task and the shifting ability in the Colour-shape task, for both switching into L1 and switching into L2. This finding indicates that different cognitive control abilities, other than shifting ability, are involved in resolving competition when switching between languages. Together with the correlation we found between the homogeneity effect and participants' performance in the Flanker task, our findings indicate that switching into L1 involves different cognitive processing related to response selection/inhibition ability, rather than task-switching ability.

In addition, and in line with previous task-switching studies, our participants only showed a robust shifting cost, with slower performance on switch trails compared to repeat trials (e.g., Rogers & Monsell, 1995). However, the lack of a correlation between the homogeneity effect and the shifting effect suggests that bilinguals do not seem to benefit from domain-general shifting control abilities to enhance their performance in language switching tasks.

Does bilingual language profile modulate language switch costs and language switching efficiency?

According to the ICM, the amount of inhibition is found to be proportional to the relative proficiency of the two languages (Green, 1998). Thus, less proficient L2/strongly dominant in L1 bilinguals recruit more inhibition of the L1 when naming in the L2 to prevent its intrusions into the weaker L2. Accordingly, when switching back into the L1, additional time is required to overcome the residual inhibition of the L1. Our study examined the effect of L2 proficiency on language switching. Our study extends the impact of L2 proficiency and examined bilingual's language experience factors: namely L2 exposure, language competition and L1 learning. We found that participants' lexical competition resolution ability during language switching was negatively related to their L2 proficiency and L2 exposure factors, but only during the switch into L1, not the switch into L2. Thus, participants with low L2 proficiency and low L2 exposure, suffered more from the semantic interference effect compared with high L2 proficiency and high exposure but only when switching into L1.

However, the language competition and the L1 learning factors showed no effect on participants' ability to resolve increased lexical competition demands when switching into L1. Therefore, the amount of L2 exposure and L2 proficiency should have an effect on participants' ability to resolve increased lexical competition demands when switching into L1, with more time was needed for inhibition and suppression of cross-language interference; accordingly, more time was needed for releasing inhibition, resulting in asymmetrical switch costs. Our results thus show evidence that language switch cost patterns could be changed as a function of L2 exposure and L2 proficiency.

Furthermore, although previous language switching studies observed that low proficient bilinguals exhibited asymmetrical switch costs, while highly proficient bilinguals show symmetrical switch costs (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Calabria, Hernández, Branzi & Costa, 2011), L2 proficiency, hence L2 exposure, do not seem to be the only factors that determine the switch costs pattern. Our study found that low proficient bilinguals' population showed pattern of switch costs was regulated by the degree of lexical competition and inhibition control abilities. These findings highlighted that both the proficiency levels of bilinguals' L1/L2 and daily L2 exposure, together with individual differences in domain-general cognitive control abilities could modulate bilinguals' performance in language switch costs.

Conclusion

The present study examined the effect of lexical competition during bilingual language switch. Results suggest that only switching into L1 interacts with lexical competition by making response selection slower, but not switching into L2. The current results provide strong support that switching into L1 is demanding for domain-general response selection processes. In addition, more evidence was reported for the role of general response competition resolution in modulating language switching performance. This aligns with the notion that the cost of switching into L1 is related to the ability to resolve response competition (Branzi et al., 2016).

Additionally, both the degree of lexical competition and inhibitory control modulates switch cost patterns. Thus, participants' general shifting ability did not seem to modulate language switching efficiency during lexical retrieval in competitive semantic contexts. Taken together, these findings suggest that competition resolution in bilinguals is not related to the bilingual's general ability to shift between mental sets and representations, but their response selection ability.

CHAPTER 5

IS LEXICAL ACCESS DURING HIGH LEXICAL COMPETITION DEMANDS DIFFERENT FOR BILINGUALS SPEAKING RELATIVELY SIMILAR LANGUAGES?

Introduction

In Chapter 4, we investigated whether switching into L1 is demanding in terms of lexical selection as compared to switching into L2. In order to do this, we tested the language switching behaviour of a group of unbalanced Arabic-English bilinguals by using the cyclic semantic blocking paradigm (Belke et al., 2005). It has previously been found that switching into the dominant L1 creates increased demand on different brain areas, compared to switching from L2 into L1. More specifically, switching into L1 had been associated with the involvement of the domain-general response selection areas, while switching into L2 had been associated with the engagement of the attentional and monitoring brain areas (Branzi et al., 2016).

Our study demonstrated that the direction of the language switch affected bilinguals' responses differently. Switching into L1 was more strongly affected by lexical competition than switching into L2. In other words, only the cost of switching into L1, not of switching into L2, interacted with the level of lexical competition. Furthermore, we found that the effect of lexical competition during the language switch (i.e., the homogeneity effect) was correlated with the Flanker task, but only when participants switched into L1, not when they switched into L2. In contrast, the homogeneity effect did not correlate with the switching effect of the Colour-shape task. These results suggest that bilinguals' ability to resolve lexical competition is related to their domain-general response selection ability, but not their general ability to shift between representations. These findings confirm the conclusion by Branzi and colleagues (2016) that switching into L1 is particularly demanding on the domain-general response selection system in the brain.

Importantly, Branzi and colleagues had found evidence for increased response selection demand when switching into L1 in a group of bilinguals with very similar languages: Indo-European languages (German and Italian). Our results in Chapter 4 showed the same evidence but within a group of bilinguals with dissimilar languages: a non-Indo-European language (Arabic) and an Indo-European language (English). This suggests that the typological similarity of bilinguals' languages does not necessarily matter. In order to test this, we conducted the same experiment as in Chapter 4, but with a group of bilinguals with relatively similar languages: German and English, both belonging to the Germanic languages within the Indo-European language family.

The Role of Language Similarity

Previous empirical evidence has shown that the two languages of bilinguals are always active even if only one is in use, suggesting that bilinguals have a shared mental lexicon for both of their languages (Kroll et al., 2012). Consequently, lexical representations that are orthographically, phonologically and/or semantically similar to the target lexical item are automatically activated (Dijkstra & van Heuven, 2002), and potentially compete for selection (e.g., Gollan & Silverberg, 2001). Studies investigating the influence of language similarity on lexical selection have demonstrated that bilinguals' two languages are active to the level of phonology and/or orthography (i.e., to the point of selection), for both bilinguals whose two languages share the same-script (e.g., Spanish – English; Costa et al., 2000) and those whose two languages have different scripts (e.g., Japanese-English; Hoshino & Kroll, 2008). Moreover, findings that support the parallel activation of the bilinguals' languages have also showed that the simultaneous activation of bilinguals' two languages leads to cross-language interactions in both directions, such that the L2 adapts to the structure and lexicon of L1, and vice versa (Kroll et al., 2014). This parallel activation of bilinguals' two languages assumes that general control mechanisms are demanded to resolve cross-language interactions (Coderre & van Heuven, 2014).

Importantly, given the well-established non-selective activation of bilinguals' two languages, the amount of competition between the activated lexical representations has been found to differ according to the degree of overlap between the two languages (Dijkstra et al., 1999; Schwartz et al., 2007). For example, although cognate words are generally recognized faster by bilinguals than non-cognate words, Dijkstra et al., (1999) found that the degree of phonological similarity between lexical items produces interference effects, while Schwartz et al., (2007) showed that the he degree of phonological similarity did not show interference effects when cognates were dissimilar in orthography. Findings from these two studies indicated that the amount of competition between activated lexical representations can be modulated by variables such as the degree of phonological or orthographic similarity between bilinguals' lexical items.

Therefore, if cross-language interactions differ in regard to the similarity between the two languages, language similarity could influence the amount of cognitive control needed to produce L1 and L2 efficiently, thereby arguably affecting cognitive control demands in two different ways. First, speaking two similar languages may result in more cross-language interference, leading to difficult lexical selection and large language switching costs, which would demand more cognitive control to inhibit interference from the unintended language

(Coderre & van Heuven, 2014). Alternatively, speaking two similar languages could provide more adaptation between the two languages, thus facilitating lexical selection due to their shared phonology and grammar. In this case, similar L1 and L2 should reduce the need for cognitive control (Barac & Bialystok, 2012). In line with the second hypothesis, dissimilar languages should demand stronger inhibitory control, leading to an increased language switching costs. The fact that we found more inhibition with dissimilar languages (in Chapter 4) is in line with the latter proposal. However, in order to test this proposition properly, we need to determine whether a high degree of language similarity leads to increased inhibition or facilitation.

Current literature on the impact of language similarity on bilinguals' cognitive performance is inconclusive. Generally, studies have shown that language combinations, whether they are typologically similar or not, could affect bilinguals' performance on cognitive controls tasks requiring switching and ignoring irrelevant information. For instance, Barac and Bialystok (2012) have found that bilingual children with more similar languages (e.g., Spanish-English) performed better than bilingual children with less similar languages (e.g., Chinese-English) on a Colour-shape switching task. However, a current meta-analysis study reported null effects of language similarity on bilinguals' performance in different components of cognitive control such as in inhibition and shifting (Lehtonen, Soveri, Laine, Järvenpää, de Bruin & Antfolk, 2018). Thus, whether and how the similarity of the two languages spoken might influence the cognitive performance of bilinguals remains unclear.

The current study

The aim of the present study was therefore to gather evidence for the role of bilinguals' cognitive control (e.g., inhibitory control and shifting ability) when resolving lexical competition during language switching between more closely related languages. More specifically, we examined whether bilinguals with similar languages would show a different lexical access profile and different relationships to cognitive processes than bilinguals with dissimilar languages. We therefore tested a group of bilinguals with similar languages (German-English; see Method section) in order to compare their results to the results of a group of bilinguals with dissimilar languages (Arabic-English, Chapter 4). In addition, the present study tested whether the asymmetries of cognitive control observed in the Arabic-English study and the increased demand on the response selection system during lexical selection would be observed for bilinguals with similar languages. No study has directly addressed the specific role of language similarity on lexical selection during language switching. To do so, we recruited German-English speakers and the criterion was that, just like the Arabic-English speakers, participants should be proficient in their L2. The participants in this study were those who took part in the LEAP-Q previously reported in Chapter 3.

In Chapter 3, we reported a factor analysis of the LEAP-Q (Marian et al., 2007) that extracted information related to the language history, AoA, L2 exposure, and self-rated proficiency of the bilinguals' languages. The result of this study elicited a set of factors that described in detail the language profile of each participant within the two groups of bilinguals: the Arabic bilinguals and the German bilinguals. Both groups are highly proficient L2 English speakers who acquired their second language English sequentially. The language profile of the two groups does differ to some degree in terms of age of language acquisition, language exposure, proficiency. The Arabic-English bilinguals were first exposed to English in school after the age of 12 and became fluent on average at the age of 21 and have a context-dependent pattern of language use (i.e., a clear separation of contexts for English, used at work and school, and Arabic is spoken with family and friends). In addition, their rated proficiency, while high for both languages, is unbalanced. The German-English bilinguals were first exposed to English in school somewhat earlier, at the age of 9 and became fluent on average at the age of 19. They are also more balanced in terms of proficiency, and were exposed daily to both languages, but primarily exposed to their L2 in their daily life. It is therefore important to note that these German-English bilinguals did not only differ from our participants in Chapter 4 and from Branzi et al.'s participants in terms of language similarity, but also in terms of language balance and use. We return to this issue in the General Discussion.

In Chapter 4, we demonstrated that bilinguals with dissimilar languages required inhibitory control to reduce the costs of switching into their L1. Individuals who speak similar languages should engage inhibitory control differently depending on whether switching between similar languages requires more or less inhibitory control. As we argued earlier, similar languages may interfere less with each other, yielding more facilitation, and therefore require no additional cognitive control processes (i.e., no inhibition). If so, we should observe faster lexical access and reduced switching cost, with no interaction between switching direction and lexical selection.

Alternatively, similar languages may produce more interference. If so, we should observe slower lexical access, increased switching costs and a stronger interaction between switching direction and lexical selection. We tested these hypotheses by assessing bilinguals' performance under increased lexical competition demands during a language switching task. We used the same cyclic semantic blocking paradigm as Chapter 4 to investigate whether the same cognitive processes are involved when bilinguals speaking two similar languages switch into L1 as compared to switch into L2. In addition, we tested participants on Flanker task and Colour-shape task to test for different involvement of cognitive control processes related to inhibitory and shifting control during increased lexical competition demands when switching into L1 versus switching into L2. Although we did not observe an effect of shifting control in the Arabic data, we tested this in the German data as their bilingual language profile shows that they are more regular switchers. Thus, one might expect that language switching proficiency may be more related to the German bilinguals' performance in the shifting task.

Method

Participants

The same group of German/English participants who were tested and analysed in the LEAP-Q (Marian et al., 2007) study reported in Chapter 3 took part in the experiment. A total of 44 bilinguals participated (10 male and 34 females) with an average age of 24 years (SD = 5.1). All participants spoke German as their L1 from birth. However, six of the participants also acquired another language at birth (Turkish: n = 3, Dutch: n = 1, Vietnamese: n = 1 and English: n = 1). These six participants are therefore early bilinguals.[1]

All participants spoke English as their second language which was acquired at the average age of 9.5 years (SD = 3.0). Participants self-estimated their speaking, listening, reading and writing skills in both languages on a scale from one to seven, seven being representative of a native-like skill. They rated their overall English proficiency as 6.7 out of a maximum of 7 (SD = 0.2) and their German as 7 out of 7 (SD = 0). Of the 44 participants, 30 reported that they had some experience in at least one other language, such as French, Dutch, Italian, Swedish,

[1] We re-analysed the data without the early bilinguals and found the same pattern of findings.

Spanish, Greek and Latin. Importantly, when those participants were asked to rate their proficiency level in these languages, no one rated themselves more than a 2 on a scale from one to seven. This suggests that these participants are bilinguals, not multilinguals.

Materials

The experimental materials were identical to those reported in Chapter 4, with some minor modifications detailed below. As in Chapter 4, the objects showed common concepts and had generally good name agreement in both languages. In addition, for each category set, care was taken to ensure that the object names were dissimilar in their initial phonemes in both German and English (see Table 5-1).

Table 5-1 The complete list of the semantic categories and objects used in the semantic blocking task for the German-English participants. German translation between brackets.

Set A							
Category set 1				**Category set 2**			
body parts	***clothes***	***furniture***	***utensils***	***food***	***tools***	***vehicles***	***animals***
thumb [Daumen]	coat [Mantel]	chair [Stuhl]	spoon [Löffel]	grapes [trauben]	pliers [Zange]	plane [Flugzeug]	horse [Pferd]
heel [Ferse]	dress [Kleid]	rug [Teppich]	knife [Messer]	pumpkin [Kürbis]	bucket [Eimer]	*scooter* *[Roller]*	monkey [Affe]
leg [Bein]	glove [Handschuh]	cradle [Wiege]	whisk [Schnee-besen]	cucumber [Gurke]	drill [Bohrer]	*ambulance* *[Kranken-wagen]*	pigeon [Taube]
eye [Auge]	skirt [Rock]	shelf [Regal]	*cup* *[Tasse]*	mushroom [Pilz]	screw [Schraube]	car [Auto]	dog [Hund]
Set B							
neck [Hals]	boot [Stiefel]	*stool* *[Hocker]*	plate [Teller]	cherry [Kirsche]	*ruler* [Lineal]	*train* *[Zug]*	duck [Ente]
toe [Zehe]	trousers [Hose]	curtain [Vorhang]	bowl [Schüssel]	lettuce [Salat]	*compass* *[Zirkel]*	bicycle [Fahrrad]	pig [Schwein]
back [Rücken]	glasses [Brille]	*mirror* *[Spiegel]*	fork [Gabel]	onion [Zwiebel]	scissors [Schere]	submarine [U-Boot]	hedgehog [Igel]
cheek [Wange]	suit [Anzug]	chest [Brust]	grater [Reibe]	pineapple [Ananas]	*Pencil* *[Bleistift]*	carriage [Waggon]	chick [Küken]

We also kept the average word length similar across the three language sets (i.e., English, German, Arabic; see also Chapter 4), with all object names being one to three syllables in length. Importantly, while there are a large number of cognates between the German and English languages, care was taken to ensure that object names were non-cognates across these two languages. We had to replace 9 items from the Arabic-English materials reported in Chapter 4, as these items were either cognates or much longer words in German. This was to ensure the effects shown were solely due to language typology (see items printed in italics in Table 5-1).

Design and Procedure

After participants filled in the language use questionnaire (LEAP-Q) in each of their languages, they completed the Cyclic semantic blocking, the Flanker and the Colour-shape task, in the same order as the experiment in Chapter 4. The experimental design and procedure were also the same as in Chapter 4. The only difference was that in the semantic blocking task, participants named pictures in L1 (German), instead of L1 (Arabic), as cued by the German flag.

Results

The Cyclic semantic blocking results

As for the Arabic-English experiment in Chapter 4, we were interested to see participants' switching behaviour in the blocked cyclic naming task. We thus based our analysis on response times on cycles 7 (with a total of 5,076 data points). That is, we obtain the size of the switching cost by comparing participants' mean response times at the 7th cycles during the language switching condition and their responses to the no-switching condition in which they continued naming in the same language (for details of which responses were included into the response time analysis, see below). As in in Chapter 4, outliers were defined as responses too fast to be responses evoked by the stimulus (i.e., faster than 250 ms) or response times at least 2 SDs above the mean RT of each participants. Errors and outliers excluded from the analysis of cycles 7 accounted for about 2.2% of the total responses.

As in the Arabic-English experiment, and as can be seen in Figure 5-1, participants slowed down on cycle 7 when they switched languages compared to when they did not switch languages. While, again, this effect seemed to potentially last into cycle 8, we focussed our analysis on cycle 7, the actual switch trial. In addition, and as expected, participants' responses were affected by the increased lexical competition demands. Figure 5-1 shows participants' responses were slower during high lexical competition (i.e., homogeneous condition) as compared to low lexical competition (i.e., heterogeneous condition) when they switched from one language to another in cycle 7. We will report statistical analyses for these effects on cycle 7 below.

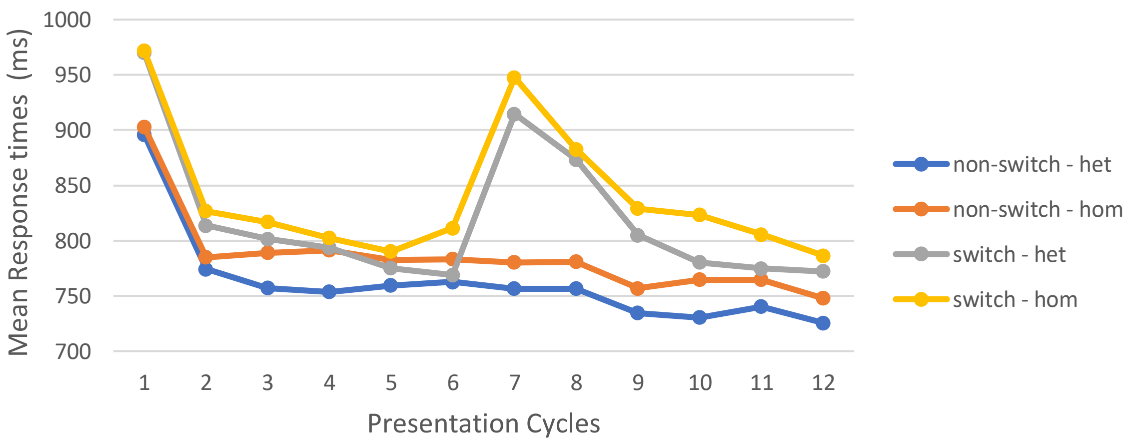


Figure 5-1 *Response times for the 12 presentation cycles in the switch versus non-switch version of the paradigm. In the switch version, participants produced picture names in one language (e.g., L1) during the first 6 cycles and in the other language (e.g., L2) during the last six cycles, meaning cycle 7 was a language switch cycle. While in the non-switch version, the language remained the same across the cycles and participants named only in one language. Participants named all pictures in homogenous (hom) or heterogeneous (het) conditions.*

Accuracy and Response times

Accuracy. Speech accuracy was checked using the audio recordings. Any hesitations, self-corrections (i.e., incorrect but semantically related/correct responses), incorrect object names (e.g., using ‘shoe’ instead of ‘boot’), timeouts (i.e., failures to produce a response in the time limit) and language intrusion (i.e., wrong language; e.g., saying ‘cradle’ (English) for ‘Wiege’ (German)) were counted as errors. Error rate was calculated as the percentage of incorrect responses at cycle 7 and was submitted to an *ANOVA* with the within-participant factors homogeneity (homogeneous, heterogeneous), language (L1, L2), and switching (language switch versus no switch). Proportion of errors in heterogeneous and homogeneous conditions for both switch and no-switch conditions are shown in Figure 5-2.

In accordance with previous research, the *ANOVA* showed a marginally significant main effect of homogeneity F (1, 43) = 3.886, p = .055, with the homogeneous condition leading to more speech errors than the heterogeneous condition. In addition, there was a significant main effect of switch, F (1, 43) = 5.035, p = .030, with the switch condition being more error prone than the no-switch condition. However, there was no main effect of language, F (1, 43) = .462, p =.500, with no difference in naming in L1 and L2. Importantly, the two-way interaction between homogeneity and switch was not significant, F (1, 43) = .133, p =.717, neither was the three-way interaction, F (1, 43) = 1.047, p = .312.

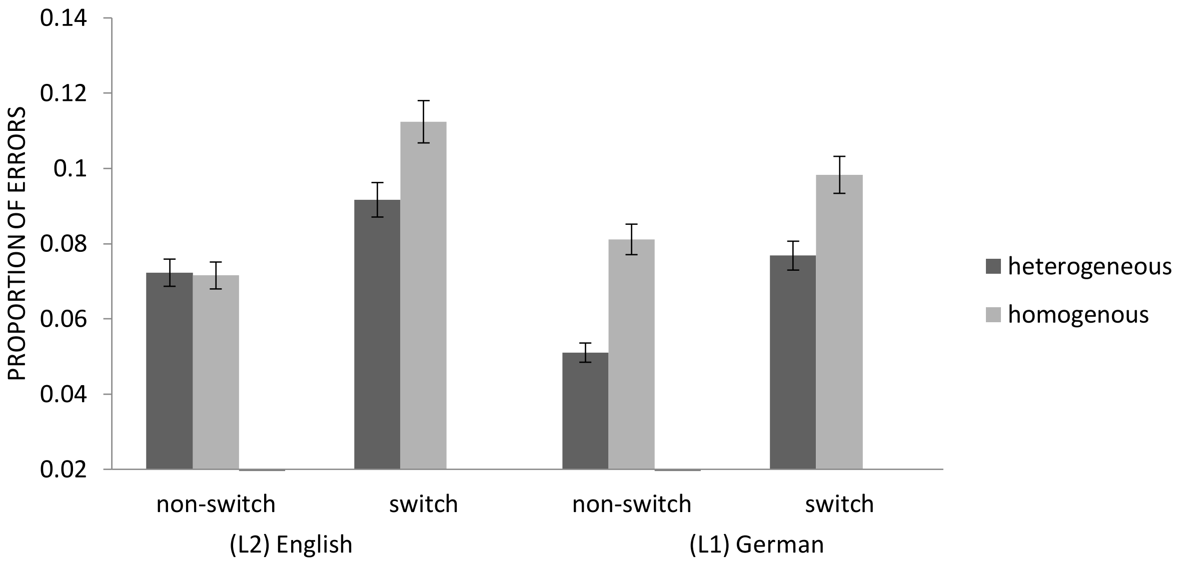


Figure 5-2 *The effects of homogeneity (homogeneous condition, heterogeneous condition) and language switching (switch versus no switch) on error rates when naming in L1 (German) and L2 (English) in cycle 7. There was a main effect of homogeneity and a main effect of switching. Yet, there was no effect of homogeneity for the English non-switch condition. No interaction was found between factors. Error bars represent standard errors.*

Response times. For response time analyses, only accurate responses were included. In addition, all responses above 2 SDs of each participant's mean reaction times or responses too fast to be responses evoked by the stimulus (i.e., faster than 250 milliseconds) were considered outliers and were removed from the analyses. Due to these outliers, 8% of data points were lost from the analysis. Only correct responses in cycle 7 were submitted for analysis.

The resulting means are shown in Figure 5-3 which displayed a very similar pattern of results to the error data. As expected, and in line with previous studies in the cyclic naming task (e.g., Belke et al., 2005), the *ANOVA* showed a significant main effect of homogeneity, F (1, 43) = 9.842, p < .003, with slower responses in the homogeneous than heterogeneous condition. Moreover, there was a significant main effect of language switch, F (1, 43) =177.7, p < .001, with slower responses in the switching than no-switching condition. However, there was no main effect of language, F (1, 43) = 1.69, p = .200, showing no difference between the speed of naming in L1 as compared to L2. Contrary to the significant three-way interaction of homogeneity, language and switching, F (1, 43) =10.8, $p < .002$ reported in the Arabic-English experiment (Chapter 4), the analysis yielded no significant three-way interaction, F (1, 43) =.006, p = .940, no significant homogeneity by switching interaction F (1, 43) =.349, p = .558, and no significant homogeneity by language interaction F (1, 43) =.097, p = .757.

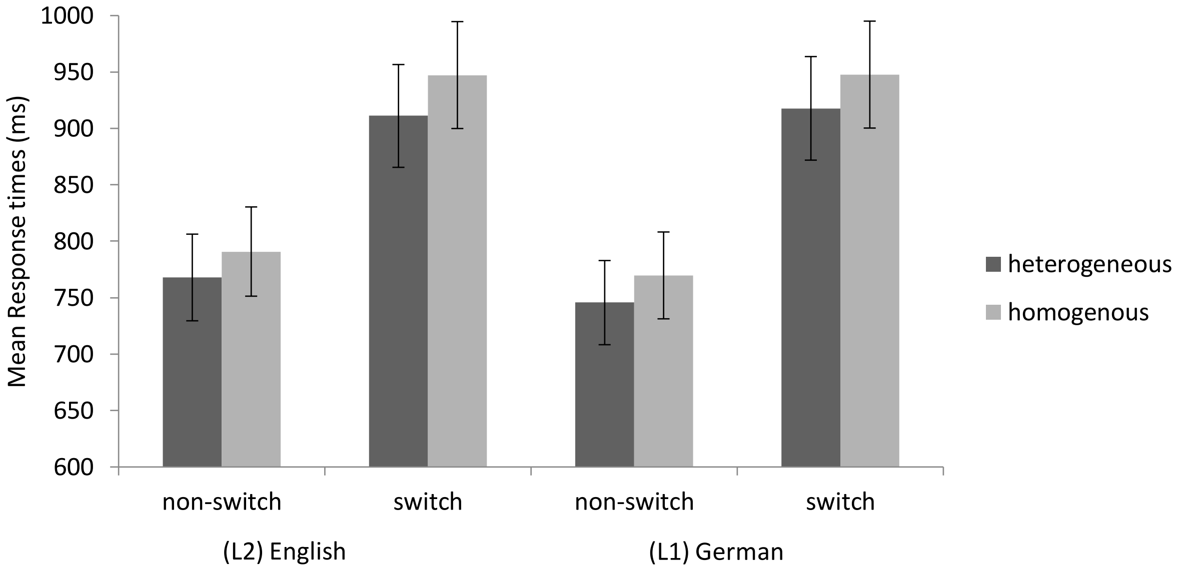


Figure 5-3 *The effects of homogeneity (homogeneous condition, heterogeneous condition) and language switching (switch versus no switch) on response times when naming in L1 (German) and L2 (English) in cycle 7. There was a main effect of homogeneity and a main effect of switching. No interaction was found between factors. Error bars represent standard errors.*

Flanker Task results

Accuracy and Response times

We first aimed to establish that the Flanker experiment showed the expected results. We thus analysed the Flanker task by comparing proportion of errors and response times in congruent and incongruent conditions with each other.

Mean accuracy are displayed in Figure 5-4. As expected, we found a significant main effect of congruency on error rates, *F* (1, 43) = 62.134, p < .001, with incongruent trials leading to more erroneous responses than incongruent ones (see Figure 5-4).

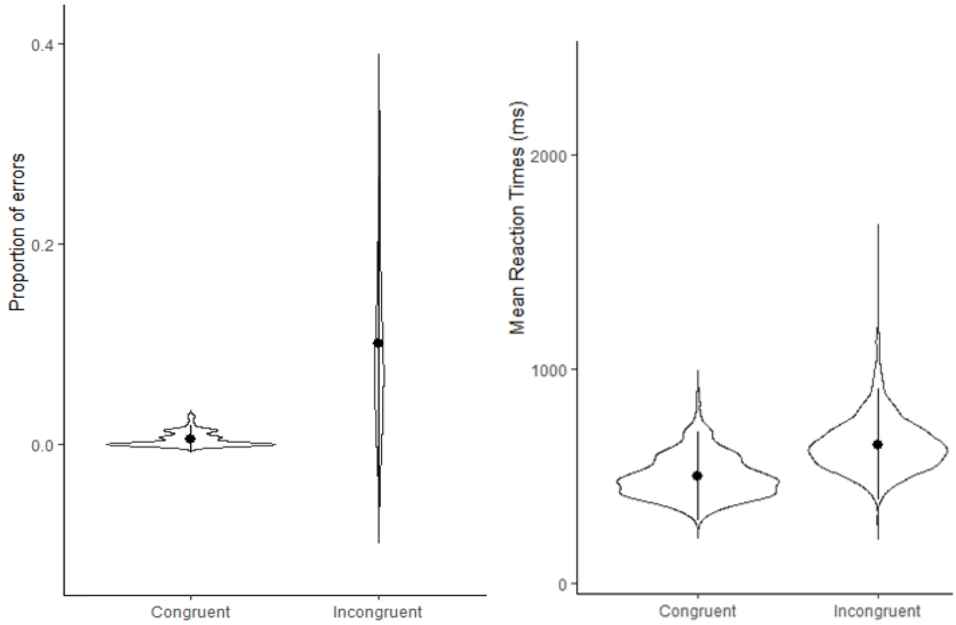


Figure 5-4 *Proportion of errors (Left) and Response Times (Right) for congruent and incongruent conditions for the participants in the Flanker task. The shape of the violin represents the estimated distribution of mean data in the corresponding condition. The thickest part of the violin shows higher frequency, while the thinner part displays lower frequency in the dataset. The dot in the middle represents the median and the bars normalized within-participant 95% confidence intervals*

For response time analyses, only accurate responses were included. Additionally, all responses deviating from the mean for each participant by more than 2SDs were considered outliers and were removed from the analyses. The percentage of RT outliers accounted for 1.9 % of the total responses. All responses were above 250 ms, thus there was no need to remove any slow responses (below 250 ms).

In accordance with previous research, we found a significant main effect of congruency on response times, *F* (1, 43) = 333.54, p < .001, with the incongruent condition leading to slower response than the congruent condition. The Flanker task results replicated key findings of this task, showing a flanker interference effect, with participants' responses being slower and more inaccurate during the incongruent condition as compared to the congruent condition.

The Colour-Shape Task results

Accuracy and Response times

Similar to the Flanker task, we first established that the Colour-shape task led to the expected effects. We thus compared error rates and response times to shifting with no-shifting trials. Results are shown in Figure 5-5.

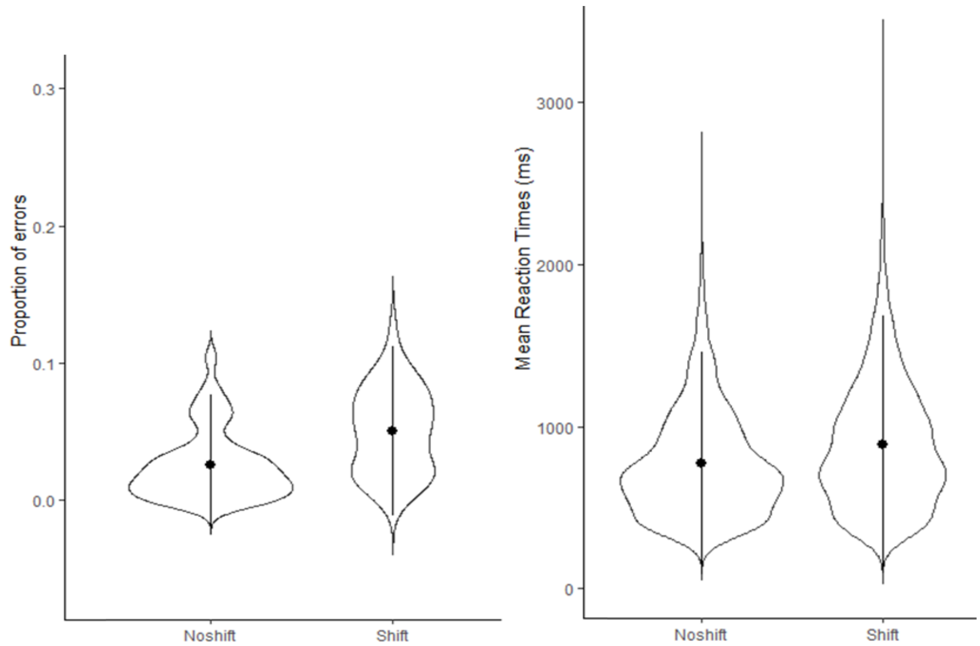


Figure 5-5 *(Left) Proportion of errors for shift and non-shift conditions for the participants in the Colour-shape task. (Right) Mean response times for shift and non-shift conditions. The shape of the violin represents the estimated distribution of mean data in the corresponding condition. The thickest part of the violin shows higher frequency, while the thinner part displays lower frequency in the dataset. The dot in the middle represents the median and the bars normalized within-participant 95% confidence intervals.*

For the response time analysis, we only included correct responses. In addition, any outlier responses deviating by more than 2 SDs from each participant's mean reaction times or response faster than 250ms were excluded. RT outliers in this task accounted for 1% of the total responses.

As expected, we found a main effect of shifting on proportion of errors, F (1, 43) = 41.50, $p < .05$, with no-shifting trials leading to less errors than shifting trials (see Figure 5-5-left). Consistent with earlier shifting tasks, we found a significant main effect of shifting, F (1, 43) = 122.83, $p < .001$, with responses being slower in the shifting than no-shifting condition (see Figure 5-5-right).

Pattern of associations between tasks

Above we reported a significant main effect of homogeneity in our cyclic semantic blocking task, with slower responses in the homogeneous than heterogeneous condition. We also found a main effect of congruency, with participants' responses being slower during incongruent condition as compared to congruent condition. We wanted to see if participants' domain general inhibition ability measured by the Flanker task was related to their ability to resolve lexical competition during increased lexical competition demands when they switched between their languages. To assess this, we performed Pearson correlation analyses with participants' performances in the cyclic semantic blocking task at cycle 7 and the Flanker task.

We correlated the homogeneity effect in the semantic blocking task effect (RTs in the homogeneous condition minus the RTs in the heterogeneous condition) with the inhibition effect in the Flanker task (RTs in the congruent condition minus RTs in the incongruent condition) and did so for when participants switched into L1 or L2. In contrast to Arabic-English bilinguals, we found no correlations between the inhibition effect and the homogeneity effect, when German-English participants switched into their L1 or their L2. That is, we found no correlation for the switch into L1 (*r* =. -.008, p = .572; see Figure 5-6 (a)), and no significant correlation for the switch into L2 either (*r* = .023, p = .881; see Figure 5-6 (b)).

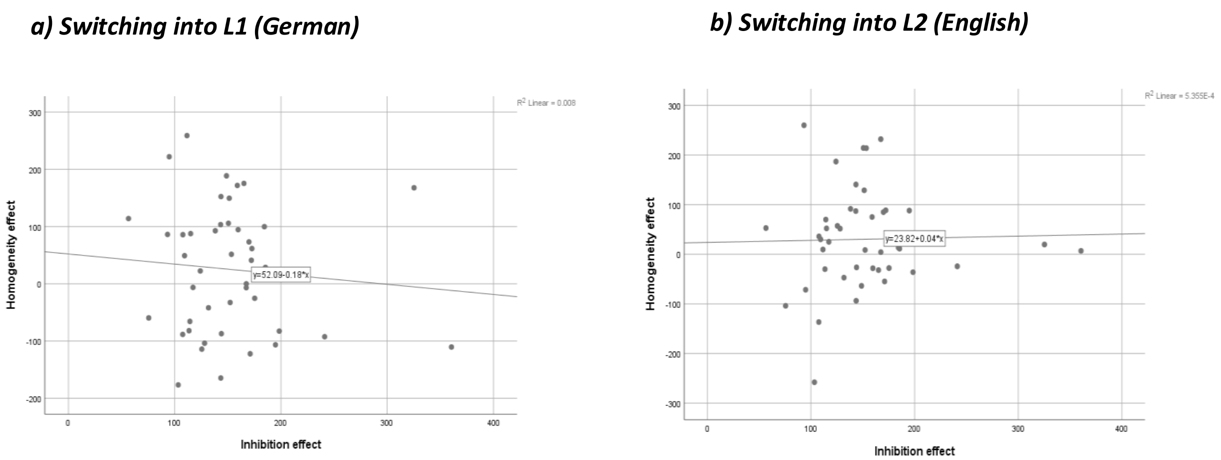


Figure 5-6 *Lack of a relationship between the inhibition effect in the Flanker task (incongruent minus congruent condition) and the homogeneity RT effect in the blocked cyclic naming task (homogeneous minus heterogeneous condition) for the German-English experiment. Panel a) shows the relationship between the two variables when naming in L1 (German) in cycle 7 after naming in L2 (English). Panel b) shows the relationship between the two variables when naming in L2 (English) in cycle 7 after naming in L1 (German).*

Additionally, we investigated if participants' general shifting ability is related to their switching ability under increased lexical competition. To assess this, we correlated (Pearson's coefficient) participants' performances in these two switching tasks. That is, we correlated participants' switching ability in the cyclic semantic blocking task at cycle 7 and their shifting ability in the Colour-shape task. In other words, we correlated the switching ability when resolving lexical competition (i.e., the homogeneity effect=RTs in the homogeneous condition minus RTs in the heterogeneous condition) in the semantic blocking task at cycle 7 with the shifting effect (RTs in the shift condition minus RTs in the non-shift condition) in the Colour-shape task.

The correlations are shown in Figure 7 and the pattern of results is very similar to the one found between the inhibition and the homogeneity effects. More specifically, we found no significant correlation for switching into L1 (r = .007, p = .966; see Figure (5-7(a)), and no significant correlation for switching into L2 (r = .018, p = .908; see Figure (5-7(b)). These results suggest that the shifting ability did not affect the language switching costs in the language-switching paradigm.

a) Switching into L1 (German) ***b) Switching into L2 (English)***

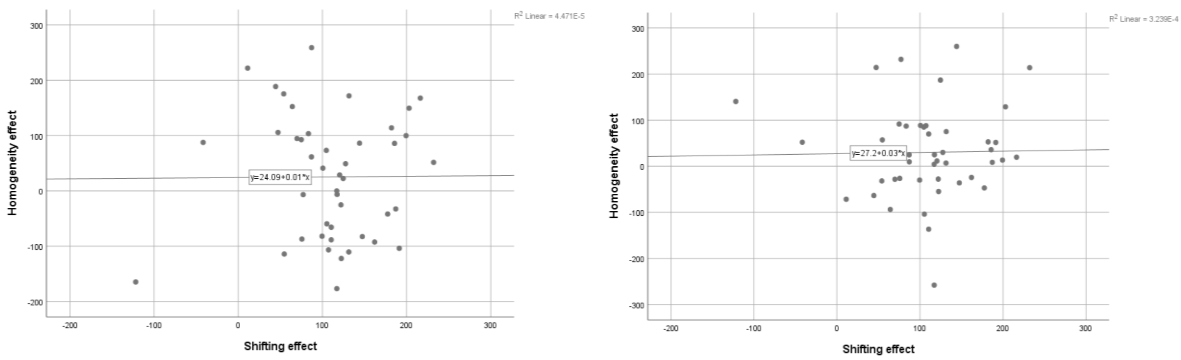


Figure 5-7 *Lack of a relationship between relationship between the shifting effect in the Colour-shape task (shifting minus non-shifting condition) and the homogeneity effect in the blocked cyclic naming task (homogeneous minus heterogeneous condition) in the switching cycle 7. Panel a) shows the relationship between the two variables when naming in L1 (German) in cycle 7 after naming in L2 (English). Panel b) shows the relationship between the two variables when naming in L2 (English) in cycle 7 after naming in L1 (German).*

Effects of the LEAP-Q factors

We next investigated correlations between the homogeneity effect when switching between languages in the blocked cyclic naming task and the language experience and proficiency factors (extracted from the LEAP-questionnaire using a principal component analysis; see Chapter 3).

We found a marginally significant negative correlation between the L2 exposure factor and the homogeneity effect, but only for the switch into L2 (r = -.290, p = .056; see Figure 5-8 left panels), not for the switch into L1(r = -.009, p = .953; see Figure 5-8 right panels). Thus, participants with low L2 exposure suffered more from the semantic interference effect compared with high L2 exposure but only when switching into L2. We found no correlations between the homogeneity effect with any of the other LEAP_Q factors: L2 Proficiency, L2 age of acquisition (AoA), L2 informal learning, Language competition and L1 learning (see Figure 5-8).

a) Switching into L2 (English) ***b) Switching into L1 (German)***

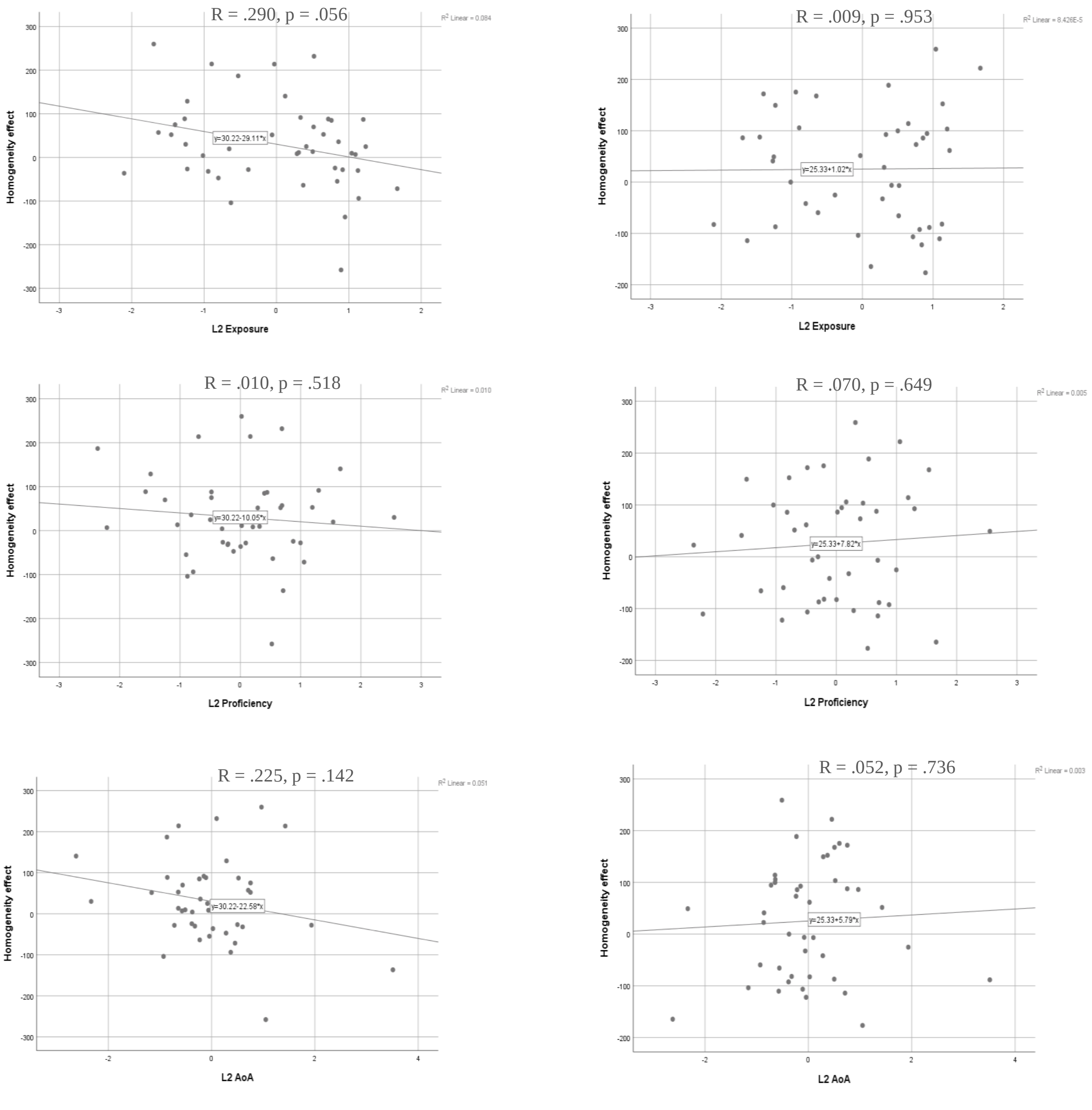


Figure 5-8 *Correlation plot for the relationships between the homogeneity effects in the blocked cyclic task when switching into L1 (right panels) and into L2 (left panels), and the LEAP-Q factors: L2 exposure, L2 Proficiency and L2 AoA. There was only a negative relation between the L2 exposure factor and the homogeneity effect when switching into L2.*

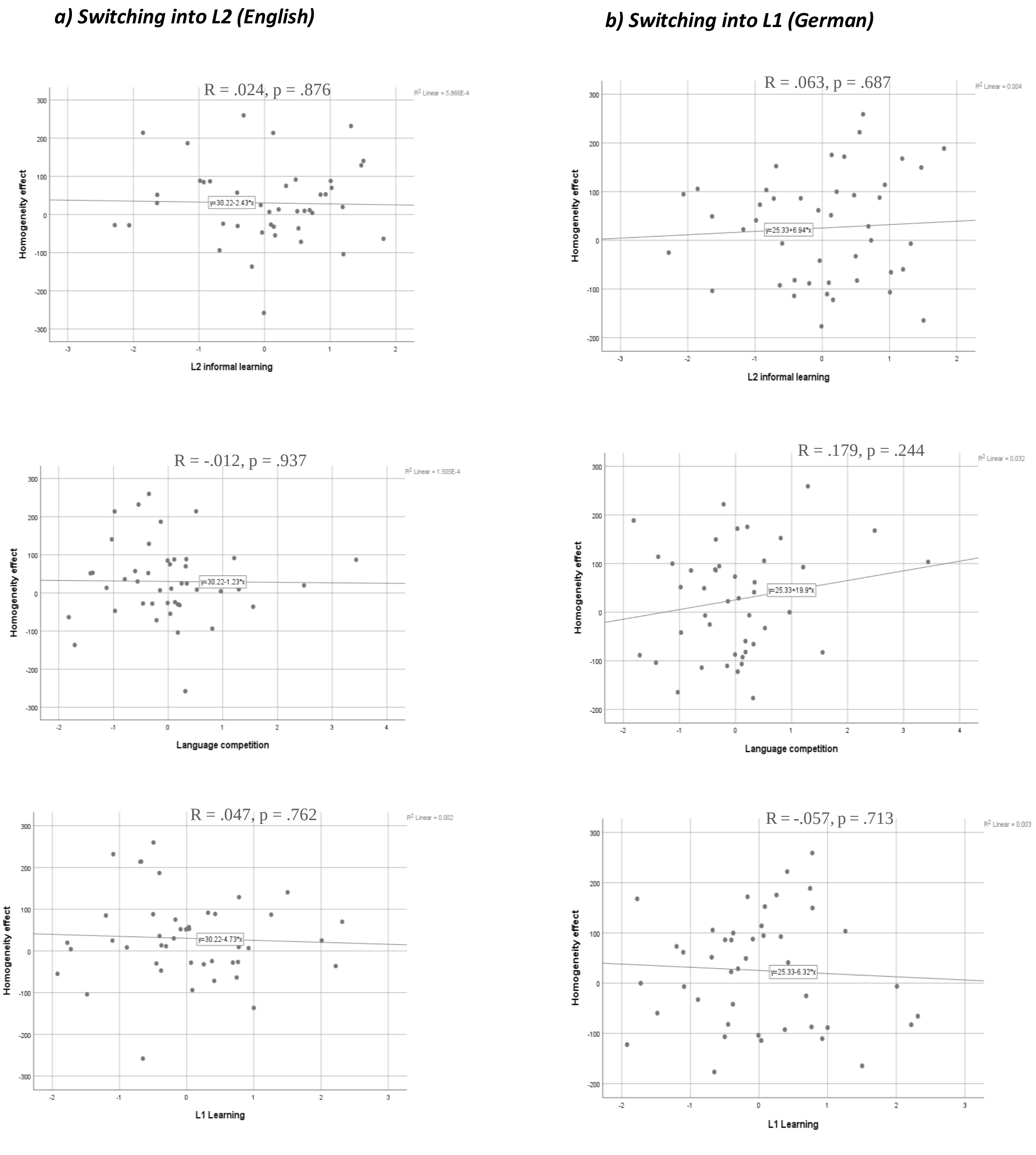


Figure 5-9 *Correlation plot for the relationships between the homogeneity effects in the blocked cyclic task when switching into L1 (right panels) and into L2 (left panels), and the LEAP-Q factors: L2 informal learning, Language competition and L1 learning. There was no relation between the aforementioned LEAP-Q factors and the homogeneity effect when switching into L2.*

Discussion

The aim of this chapter is to examine the role of language similarity and bilingual language profile in lexical selection mechanisms during high lexical selection demands when performing a language switching task. More specifically, we investigated whether the same control processes are involved when bilinguals switch into L1 as compared to switch into L2. We tested a group of bilinguals with relatively similar languages (German and English) using an adapted version of the cyclic semantic blocking paradigm (Belke et al., 2005) with additional language switching component. Furthermore, we correlated the homogeneity effect when switching into L1 or L2 with the interference effect in a Flanker task and the Shifting effect in a Colour-shape task.

Our results in the blocked cyclic naming experiment were in line with previous studies for monolingual participants in a blocked pictures' naming task (Belke et al., 2005; Kroll & Stewart, 1994), and with our results for Arabic-English speakers in Chapter 4: Participants slowed down when they were naming in the homogeneous condition as compared to the heterogeneous condition. The results for accuracy were also in accordance with previous research, with participants performing less accurately in the homogeneous than the heterogeneous condition. This is likely due to larger lexical competition in the homogeneous condition compared to the heterogeneous condition, potentially due to co-activation of semantically related representations (Abdel Rahman & Melinger, 2009; Belke & Stielow, 2013). Thus, together with Chapter 4, our results suggest that the semantic blocking effect can affect the responses of monolinguals and bilinguals, independently of the typological similarity of bilinguals' languages.

Moreover, consistent with language switching studies (e.g., Declerck & Philipp, 2015; Philipp, Gade & Koch, 2007), our participants showed a main effect of switching (i.e., switching cost), with slower responses in the switching than no-switching conditions. They also displayed more errors in the switching condition as compared to the no-switching condition. This again is the same pattern of results as the Arabic-English bilingual group in Chapter 4. In addition, we found a symmetrical switch cost for switching into German (L1) and English (L2). In contrast, the results of our Arabic-English experiment in Chapter 4 showed asymmetric switch costs between languages, with switching into the Arabic (L1) being longer than switching into the English (L2) (Meuter & Allport, 1999).

Since the bilingual language profile showed differences between the two bilingual groups in term of proficiency, the symmetric switch cost found for the German-English bilingual group could be interpreted in line with the previously mentioned studies on balanced/high proficient bilinguals (e.g., Costa & Santesteban, 2004; Calabria et al., 2011), which demonstrated that highly proficient bilinguals showed no switching asymmetry. As argued, highly proficient bilinguals may recruit different language control strategies than less proficient bilinguals when switching between their languages (Costa et al., 2006). Evidence in support of this comes from neuroimaging studies showing that highly proficient bilinguals recruit the same cortical regions during lexical retrieval tasks in both of their languages, while low proficient bilinguals further employ frontal lobe areas, which have been linked to domain-general inhibitory control and conflict resolution (Abutalebi & Green, 2008).

In addition, this pattern of symmetric switch cost may mirror the effects of other aspects related to the German bilingual language profile, such as L2 exposure and language switching frequency. For example, high L2 exposure was found to reduce switch cost in L1, thus reduce the need of actively inhibiting L1 (Wu & Thierry, 2017). This suggestion is in line with our German-English participants' switching behaviour who showed reduced switch cost in L1 that could be due to their high English exposure. In relation to daily frequency of language switching, Prior & Gollan (2011) found that daily frequency of language switching modulates switching costs. Thus, we could predict that the fast naming latencies during the switching trials may be related to the German bilingual profile as being frequent language switchers.

Importantly, these findings only explain how aspects of the participant's bilingual profile could contribute to the pattern of the symmetric switching cost. Given that they do not directly point to the effects of aspects of bilingual profile in modulating switching cost during increased lexical competition (i.e., homogeneity effect), as none of the LEAP-Q factors interacted with the homogeneity effect during the switch into L1 or L2. We only found a marginal correlation between L2 exposure factor and the homogeneity effect when German bilinguals switched into their L2. This could mean that the increased amount of exposure to English, reduces the effect of semantic competition when switching into L2 (not L1). In other words, the amount of L2 exposure had an effect on German-English participants' ability to resolve increased lexical competition demands when switching into L2. These data showed that higher L2 exposure may seem to reduce the demand of inhibition, thereby arguably reduced the lexical competition effect (Ma, Li, & Guo, 2016).

Maybe the most important difference between the Arabic-English and the German-English experiment was the finding that neither switching into L1 nor switching into L2 interacted with the level of lexical competition for the German-English bilinguals. Thus, unlike Arabic-English speakers who slowed down strongly during increased lexical competition demand when they switched between their languages, for German-English speakers, switching under increased lexical competition demands was not particularly difficult. This suggests that greater inhibitory control/conflict resolution ability was not needed to resolve lexical competition during language switches, thereby no large switching cost was observed (as indexed by the lack of correlation with the Flanker task).

These findings are in line with other models of bilinguals' lexical selection that do not focus on inhibition, but instead employ activation to successfully produce a target lexical item. For instance, Philipp and Koch (2009) proposed a "persistent activation" account, which supports the role of activation, rather than inhibition in lexical selection. The persistent activation account suggests that the strong activation of the target language is needed to resolve lexical competition.

Alternatively, the absence of the interaction between the effect of lexical competition and the direction of the switch could mean that the German bilinguals have a very strong inhibitory control that modulated their L1 switching costs. This finding is consistent with the previous work of Liu and colleague (2015) showing that variances in inhibitory control/conflict resolution ability during response selection could play an important role in modulating language switching performance, with the group with high inhibitory control ability showing symmetrical switching cost for L1 and L2, irrespective of L2 proficiency.

To conclude, in this chapter we aimed to test the effect of language similarity and inhibitory control during language switching. We found that, in contexts of language competition, the absence of an interaction with the level of lexical competition and language switching, together with the lack of a correlation with inhibition and shifting abilities, is in line with the previous assumption that bilinguals with relatively similar languages demand no extra cognitive controls to resolve cross-language interaction (Barac & Bialystok, 2012). Language adaptations facilitate language processing when both languages are similar, thus reducing cognitive control demands. This is in line with the finding that bilinguals with more similar languages (e.g., Spanish-English) display language facilitating effects in linguistic tasks when compared with bilingual peers with less similar languages (e.g., Chinese-English). Taken together with our results, these findings support the notion that linguistic adaptation is more pronounced for more similar languages.

However, as we have discussed above, our pattern of results cannot be uniquely attributed to language similarity as some aspects of the bilingual language profile might have also contributed to the findings. Our selection criteria for our German-English and Arabic-English speakers were the same, as we sought highly proficient participants. However, the language profile was different between these two groups. German bilinguals were more proficient, perhaps unsurprisingly for European bilinguals, who have a different life experience with English. The groups also differed in the degree of switching frequency, with German bilinguals switching more than the Arabic bilinguals who had quite context-dependent language use. These key differences in language profile are difficult to control for in these two groups of bilinguals. It therefore remains unclear the extent to which the different patterns of results we have observed are due to the differences between the languages or differences between bilingual profiles. Future studies are required to determine the contribution of these factors to language switching behaviour.

CHAPTER 6

THE EFFECT OF BILINGUAL LANGUGE EXPERIENCE ON LANGUAGE SWITCHING: COMPARISON OF THE CHARACTERISTICS OF TWO TYPOLOGICALLY DIFFERENT BILINGUALS

Introduction

The performance of bilinguals during language switching is modulated by several variables such as language proficiency, age of language acquisition, language exposure and the degree of overlap between languages or language typology. In this thesis so far, we have investigated the role of cognitive control in competition resolution during a language switching task. We have particularly focused on shifting and inhibitory control abilities to examine the role of individual differences in modulating bilingual language performance. We have also addressed the specific role of language similarity on highly proficient bilinguals switching between two proficient but dissimilar languages (Arabic and English; Chapter 4) and similar languages (German and English; Chapter 5).

This chapter takes our understanding of the role of language similarity one step further by assessing whether differences in language proficiency, age of language acquisition and language exposure significantly vary between the two bilingual groups. Additionally, this chapter explores the role of specific aspects of bilingual language experience in modulating language switching performance and whether it is similar or different between the two groups. In order to do that, we extracted several factors concerning the bilingual language experience previously reported in Chapter 3, such as L2 proficiency, L2 exposure and age of L2 acquisition to explore their effects on naming latencies during language switching task reported in Chapters 4 and 5. We then compared and examined the pattern of switch costs, that is, the delay when changing from one language to another (Declerck & Philipp, 2015) between the two bilingual groups. We lastly shed light on the relationship between specific aspects of the bilingual language experience and cognitive control processes that is responsible for mediating language switch costs.

Several studies focusing on the mechanisms underlying language control have mainly used language switching tasks to examine switch costs in lexical production and explain how some characteristics of bilingual experience affect bilingual language control (e.g., Costa & Santesteban, 2004). For instance, the level of L2 proficiency has been consistently reported to play a crucial role in modulating language access and control (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Meuter & Allport, 1999). As according to Inhibitory Control Model of language control (Green, 1998), the amount of and the time course of inhibition needed to suppress the activation from the unintended language depends on the amount of activation of each language, which in turn depends on level of L2 proficiency (Meuter & Allport, 1999). That is, the higher the L2 proficiency, the less inhibition required (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Meuter & Allport, 1999) and, put simply, the smaller the switch costs between the two languages. Therefore, the relationship between language proficiency and inhibitory processes is essential to determine the switching costs in bilinguals. Other studies on language switching found that the frequency of L2 switching (Prior & Gollan, 2011), amount of L2 daily exposure and early or late age of acquisition (Chamorro, Sorace, & Sturt, 2016) are all further factors that contribute in modulating the performance of bilinguals during language switching.

The effect of language similarity has also been found to play a role on the process of bilingual language selection during language-switching performance. Only few studies have investigated the role of language similarity directly, but a recent study of bilingual lexical access by Cui and Shen (2016) provides some relevant findings. Cui and Shen (2016) found that the similarity of the two languages can influence the switching process of bilinguals. Their experiments revealed asymmetrical switching costs of bilinguals switching between dissimilar more-proficient and less-proficient languages, a finding that is different from the switching behaviour (i.e., symmetrical switching costs) of other bilinguals with similar languages performing a language-switching task under the same experimental conditions (Costa et al., 2006). Cui and Shen (2016) proposed that language similarity may affect the language selection mechanism, as highly skilled bilinguals may resort to the Inhibitory Control Mechanism instead of the Language-Specific Selection Mechanism in some conditions.

In this study, we therefore examine what aspects of the bilingual experience modulates language control by examining the switching costs in a cued language switching task in two typologically different bilingual populations: Arabic-English bilinguals and German-English bilinguals. In addition, we are interested in finding whether different or similar mechanisms of language control are recruited by these two bilingual groups when performing lexical access in the context of language switching.

In Chapters 4 and 5, we used a cyclic semantic blocking task (Belke et al., 2005) with an integrated language switching task to investigate the underlying language control mechanisms of two dissimilar bilingual groups during increased lexical-semantic competition demands. In this Chapter, we investigate language switching performance of these two bilingual groups independently of lexical competition in order to only examine and compare the pattern of their switching costs. In this Chapter, the term switch costs will be used to refer to the cognitive effort that is required during language switching.

Additionally, we used two non-linguistic tasks, including a Flanker task (Eriksen & Eriksen, 1974) and a Colour-shape shifting task (Miyake, Emerson, Padilla, & Ahn, 2004) to understand whether the individual differences in inhibitory and shifting control could influence competition resolution in bilinguals. The Flanker task is tightly linked to the inhibitory control ability which is required to resolve conflicting mental representations between prepotent responses and a target response (Ridderinkhof, 2002). Enhanced inhibitory control would result in successful conflict/competition resolution. In this chapter, we will use the terms flanker effect and inhibition effect interchangeably to refer to the processes involved in resolving conflict. The Colour-shape shifting task, on the other hand, is generally related to the ability to change behavioural goals. In particular, the term "shifting" is used to refer to the ability to select the correct rule set and switch between these sets of rules (Allport, Styles, & Hsieh, 1994). This suggests that good shifters are better at performance on the rule shifting tasks than poor shifters.

In this Chapter, we will focus on the effect size of the flanker and shifting tasks that measure inhibition and shifting abilities, respectively. More specifically, we will compare the performance of our two groups of bilingual speakers on executive control tasks, tapping into inhibition and shifting abilities to better understand how domain-general control mechanisms contribute to language selection and how is that different between two groups of bilinguals who have orthographically dissimilar L1s.

Method

Participants

Data in this Chapter is taken from studies presented in the previous chapters. We combined the data from Chapters 3-5 for the analyses presented in this Chapter. A total of 88 bilinguals (divided into two groups of 44) were analysed. The selection criteria were to be proficient speakers of English and native speakers of Arabic (group 1) or German (group 2). All participants completed a language history questionnaire (previously reported in Chapter 3), which evaluates their proficiency and exposure to different languages (Marian et al., 2007). Since we want to investigate what aspects of bilingual language experience modulate language control during language switching, we directly examined the role of specific aspects of the bilingual language experience extracted from the language history questionnaire (Marian et al., 2007). That is, we specified some key variables of the bilingual language experience such as age of L2 acquisition, L2 proficiency and L2 exposure to examine the effects of these variables on bilinguals' language switching performance within and between the two groups of the bilinguals (group 1: Arabic bilinguals) and (group 2: German bilinguals). Table 6-1 shows the differences across the two groups.

Table 6-1 Participants' mean responses to the key aspects of the bilingual language experience and proficiency questionnaire (and SD in parentheses) in the two groups, and comparison (*t*-test) of the two groups.

Key aspects of bilingual language experience and proficiency questionnaire	Arabic-English	German-English	Comparison
Age (years)	26 (5.9)	24 (5.1)	*
L1 AoA (years)	0 (0.0)	0 (0.0)	
L1 age mastered	6.2 (0.68)	6.1 (1.27)	
L1 understanding	7.0 (0.0)	7.0 (0.0)	
L1 reading	7.0 (0.0)	6.9 (0.2)	*
L1 speaking	7.0 (0.0)	6.9 (0.2)	
L1 writing	7.0 (0.0)	6.9 (0.2)	**
L1 % of daily exposure	61.7 (24.8)	44.4 (35.5)	***
L2 AoA (years)	11.3 (1.7)	9.5 (3.0)	***
L2 age mastered	21.7 (5.2)	17.7 (5.1)	***
L2 understanding	5.6 (0.9)	6.1 (0.8)	**
L2 reading	5.1 (1.1)	6.1 (0.9)	***
L2 speaking	4.7 (1.1)	5.5 (1.1)	***
L2 writing	4.5 (1.1)	5.5 (1.0)	***
L2 % of daily exposure	38.3 (24.8)	54.8 (34.4)	**
Switching frequency	3.7 (1.9)	5.4 (1.2)	**

* $p < .05$.
** $p < .01$.
*** $p < .001$.

- Group 1. Arabic-English bilinguals (N=44, mean age 26 years, SD=5.9). These participants were Arabic native speakers who had been living in an Arabic-speaking country on average for 23 years (N=21) or in an English-speaking country on average for 2.7 years (N=23) at the time of testing.

- Group 2. German-English bilinguals (N=44, mean age 24 years, SD=5.1). These participants were German native speakers who had been living in a German-speaking country on average for 18 years (N=17) or in an English-speaking country on average for 1.5 years (N=27) at the time of testing (see Chapter 3 for more details).

As shown in Table 6-1, responses to the language history questionnaire showed that the key differences between the two bilingual groups were age of L2 acquisition/mastered and the degree of language exposure. The Arabic-English bilinguals were significantly different than the German-English bilinguals in their age of L2 acquisition and age of acquired fluency (t (86) = 3.02, p =.001; t (86) = 3.21, p =.001 respectively). That is, the Arabic-English group were late bilinguals who were exposed to English on average at the age of 12 and became fluent on average at the age of 21. On the other hand, the German-English group were relatively early bilinguals who acquired their L2 on average at the age of 9 and became fluent on average at the age of 17.

The Arabic-English bilinguals' daily exposure to English was on average lower than the exposure to English in the German-English group (t (78) = -2.57, p =.01). Exposure to L1 was also incongruent in the two groups, as the average rating for daily exposure to L1 in the Arabic-English group was higher than the average rating for daily L1 exposure in the German-English group (t (76) = 2.64, p =.009). Moreover, the comparison of L1 and L2 daily exposure within groups showed that the Arabic-English bilinguals were strongly L1 dominant in relation to L2 (p < .003), whereas the German-English bilinguals showed no significant differences between their L1 and L2 exposure (p =.330), reflecting the fact that they were more balanced bilinguals.

In terms of L2 proficiency, responses in the two groups were significantly different in both modalities: the active modalities (speaking and writing) and the passive modalities (understanding and reading). The average rating for L2 in the German-English group was higher than the average rating for L2 in the Arabic-English group in their L2 understanding (t (86) = -2.32, p =.02), L2 reading (t (83) = -3.99, p =.001), L2 oral production (t (86) = -3.03, p =.003) and L2 written production (t (85) = -3.92, p =.001). This indicates that the German-English group were highly proficient in their L2 as compared to the Arabic-English group.

Finally, daily frequency of language switching differed significantly across the two groups (t (86) = 2.03, p=. 017), with the German-English participants switching more frequently between their languages than the Arabic-English bilinguals. Therefore, the Arabic-English bilinguals were less balanced bilinguals with strongly dominant L1, as compared to the German-English bilinguals who were more balanced bilinguals.

Materials, design and procedure

The experimental materials were the same to those reported in Chapters 4 and 5.

Results

Results will be presented in three steps. First, we will present a between-group analysis of each cognitive task (i.e. Flanker task and Colour-shape task) and the linguistic task (i.e. semantic blocking paradigm). Then, we will directly examine the role of key aspects of bilingual language experience (e.g., age of acquisition, proficiency, language exposure) on the bilinguals' ability to control their two languages during language switching. Finally, we will investigate the relationship between cognitive control abilities, including inhibition and shifting, and bilingual lexical production in a language switching task. The RTs from the linguistic and non-linguistic tasks will be used for the group comparison analysis. Only accurate responses were included for the three tasks. In addition, all responses deviating from the means by more than 2SDs or responses below 250ms were considered outliers and were not included in the analyses.

Non-linguistic Tasks Analyses

Flanker task

In Chapters 4 and 5, we found that the performance of our two bilingual samples replicated key findings and showed main flanker interference effect, with participants' responses being slower and more erroneous during incongruent condition as compared to congruent condition.

With regard to the effect size of the flanker task between groups, the German bilingual group were faster and showed less of a RT inhibition effect in the flanker task than the Arabic bilingual group. The inhibition effect RT was obtained by subtracting average RT in the incongruent condition from average RT in the congruent condition. Results of the flanker task (see Figure 6-1) displayed a smaller flanker effect in RTs in our sample of the German bilinguals compared to the Arabic bilinguals' sample.

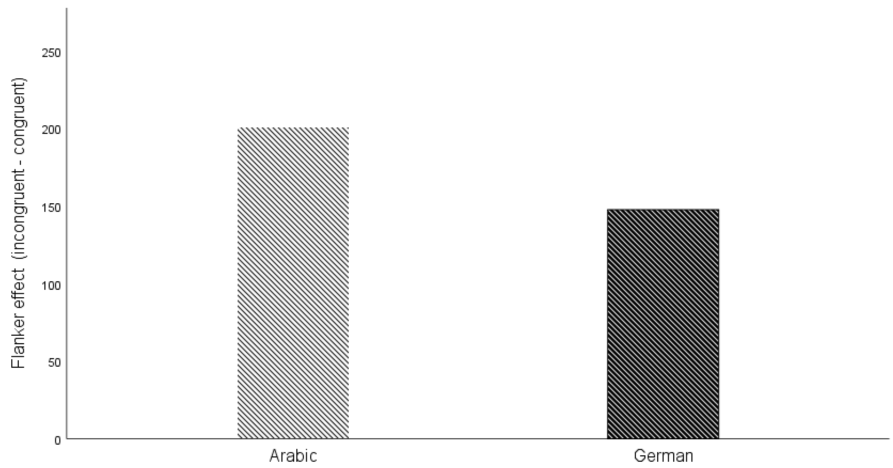


Figure 6-1 *Average flanker effect for the Arabic and German groups in the flanker task in which Arabic speakers are showing larger flanker effect than German speakers.*

This means that Arabic speakers showed larger flanker effect (M = 200.53) than German speakers (M = 147.63) (t (52.97[2]) = 2.32, $p < .02$). This suggests that Arabic speakers were more affected by the competitive nature of the flanker task, in which there was increased demand to resolve conflict interference during the response selection stage.

Shifting task

Eighty-eight participants took part in the Colour-shape task: 44 bilingual Arabic-English speakers and 44 German-English bilingual speakers (see Chapters 4 and 5). Results from the Colour-shape task were consistent with previous studies of shifting tasks that showed a significant main effect of shifting condition, with participants' responses being slower and more inaccurate in the shift than non-shift trials. With regard to the shifting performance, both groups showed similar RT shifting costs in the Colour-shape task (RTs on non-shift trials minus RTs on shift trials) (see Figure 6-2).

Independent sample t-tests revealed that the two groups of participants did not differ in terms of their shifting ability. That is, no difference for shifting effect was found in Arabic speakers (M = 118.71) and German speakers (M = 108.92) t (69.4[3]) = .49, p = .619, suggesting that the two groups had similar shifting costs.

[2] A Fligner-Killeen test of homogeneity of variances was calculated to assess homogeneity of variance. We found that this was significant. X (1) = 7.76, p = .005, indicating that homogeneity of variance was violated.

[3] A Fligner-Killeen test of homogeneity of variances was calculated to assess homogeneity of variance. We found that this was significant. X (1) = 4.09, p = .04, indicating that homogeneity of variance was violated.

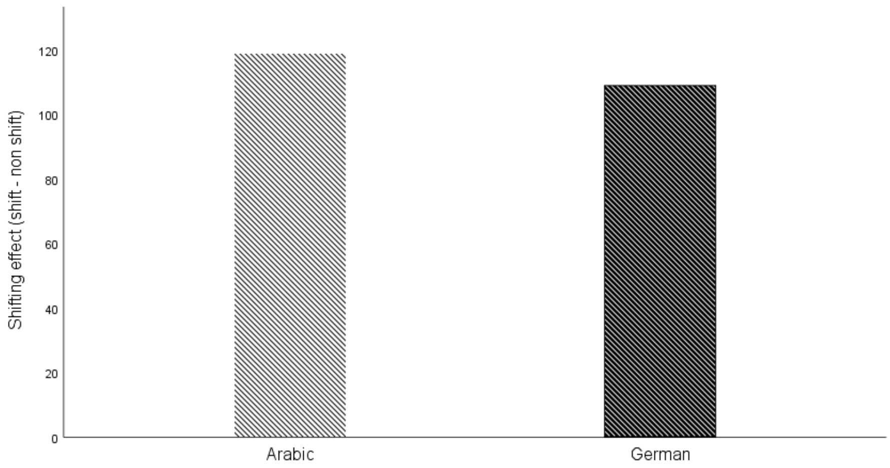


Figure 6-2 *Average shifting effect for the Arabic and German groups in the colour-shape task in which there is no difference between the two participant groups.*

Linguistic Task Analyses

Language-switching task (Semantic blocking paradigm)

In Chapter 4, the analysis of RT in the semantic blocking task showed a main effect of homogeneity, as homogeneous condition was slower than heterogeneous condition, as well as a main effect of language switching, reflecting the fact that switch trials were slower than no-switch trials when naming in L1 (Arabic) and L2 (English). We also found an interaction between these two factors, but it was only present when Arabic-English bilinguals switched into L1 not L2. As for the German-English bilinguals (Chapter 5), only simple effect of factors (homogeneity and language switching) was present, but no interaction was found between them.

In this Chapter, only an analysis of L1 and L2 switch costs (differences in naming latencies between switch and non-switch trials in L1and L2) was conducted, irrespective of homogeneity factor as we want to examine the impacts of bilingual language experience on the modulation of switch costs. Additionally, we want to explore how different dimensions of the bilingual experience relate to domain-general cognitive control.

Response times were analysed using a 2 (Language switch cost) x 2 (Group) mixed design *ANOVA*, with Group being a between-group factor. Bonferroni correction was applied when following up any interaction. We focused on the main effects of Language switch cost and Group, as well as on any interactions when reporting results. In the analysis of naming latencies, we found a significant main effect of Language switch cost, F (1,86) = 20.064, $p <$ .001, with L1 switch costs being larger than L2 switch costs (see Figure 6-3).

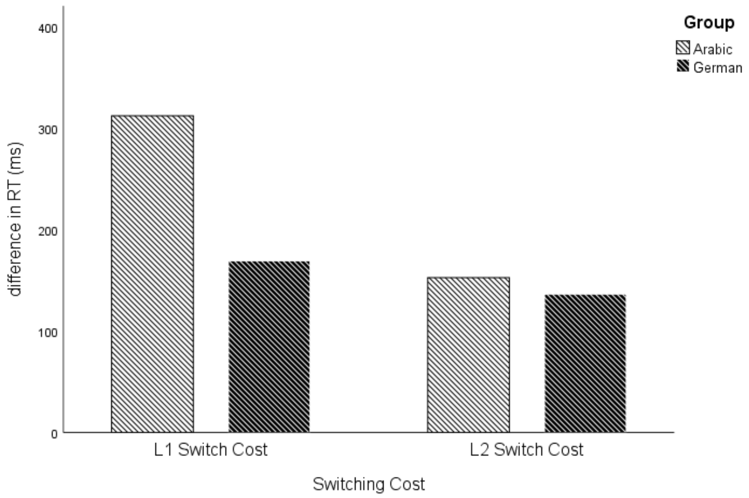


Figure 6-3 *Average of switch cost in L1 and L2 for the Arabic and German groups in the language switching task. There is an interaction only for L1 switch cost that is significant for both Arabic and German groups, but the switch effect is more prominent in the Arabic group.*

There was also a main effect of Group, F (1,86) = 14.07, $p < .01$, with the Arabic speakers showing larger switching cost than the German speakers. The interaction between Language switch cost and Group was also significant, F (1,86) = 8.707, $p < .04$. Follow up independent sample t-tests revealed that Arabic speakers showed more prominent L1 switch costs than German speakers, t (86) = 4.24, $p < .001$. However, there was no significant difference in L2 switch costs between the two participant groups, t (86) = .617, $p = .539$ (see Figure 6-3).

Follow up paired sample *t*-tests showed that only the Arabic group showed a significant difference between L1 switch costs, (M=313, SD=200) and L2 switch costs (M=137, SD=132), t (43) = 5.05, $p < .001$, but not the German group, t (43) = .83, $p = .406$. This suggests that the significant interaction was driven by the Arabic speakers suffering more from cross-language competition when switching into L1 (see Figure 6-3).

Pattern of associations between variables

In the previous section, we found that the Arabic-English bilingual group took longer to suppress irrelevant responses in the flanker task than the German-English bilingual group. Similarly, the Arabic-English bilingual group displayed larger switch costs in the cued language-switching task than the German-English bilingual group, but only when switching into L1. However, the two groups showed similar shifting costs in the colour-shape task. Here, we investigated the relationship between individual differences, including inhibitory (flanker scores) and shifting (colour-shape scores) control abilities, and L1 versus L2 switching performance (switch cost scores) for our two groups of bilinguals to assess the role of cognitive control abilities in modulating bilingual language switching performance.

In addition, we further correlated key variables from the language history questionnaire (i.e., L2 age of acquisition, L2 proficiency, average daily exposure to L2 and daily frequency of language switching), with the inhibition effect (i.e. average RTs in the incongruent condition minus RTs in the congruent condition) and the shifting effect (RTs on non-shift trials minus RTs on shift trials) to explore the relation between bilingual language control and bilingual language experience. With regards to L2 proficiency, we only correlated the role of L2 proficiency in the active modalities (speaking and writing), as we administered a picture naming task, which depends on the activation of speech production, as opposed to speech perception areas (e.g., Price et al., 2006). This was computed by aggregating participants' score of speaking and writing proficiency. In addition, we analysed age of acquisition of participants' second language as both onset of exposure and age of acquired fluency. Correlations between the switch costs effect and the effects in the two executive control tasks and the bilingual language experience variables are displayed in Table 6-2.

Table 6-2 Correlation coefficients of German group (above the diagonal) and Arabic group (below the diagonal) for L1 and L2 switch costs, individual differences in inhibitory and shifting, and other bilingual language experience variables.

	Switch costs into L1	Switch costs into L2	Inhibition effect	Shifting effect	L2 AoA	Active proficiency	L2 daily exposure	Switching frequency
L1Switch costs		.23	.09	-.02	.12	-.14	-.05	-.28
L2 Switch costs	.08		-.14	-.06	-.01	-.09	.24	-.25
Inhibition effect	.46**	.07		.20	.22	-.21	-.12	-.18
Shifting effect	-.17	.15	.07		-13	-.21	-.17	-.22
L2 AoA	.18	.14	.16	-.05		.15	-.16	-.08
Active proficiency	-.34*	.06	-.25	.22	.61**		.32*	.45**
L2 daily exposure	-.26	.15	-.12	.08	.28	.18		.08
Switching frequency	-.15	-.22	-0.07	.07	.12	.19	.15	

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

We found a significant positive correlation between the inhibition effect and the size of the switch cost for L1, but only for the Arabic-English bilingual group (r =.468, p = .001), as compared to the German-English bilingual group (r = -.094, p = .543) (see Figure 6-4). This suggests that the Arabic participants showed more effortful lexical selection when switching into L1 than German participants, and that the significant relationship with flanker effect reflects the fact that Arabic participants rely on inhibitory control to help resolve cross-language competition between lexical representations in the two languages. Put simply, people with high inhibitory control showed enhanced lexical selection abilities during speech production when switching from the L2 to the L1. The relationship is displayed in Figure 6-4.

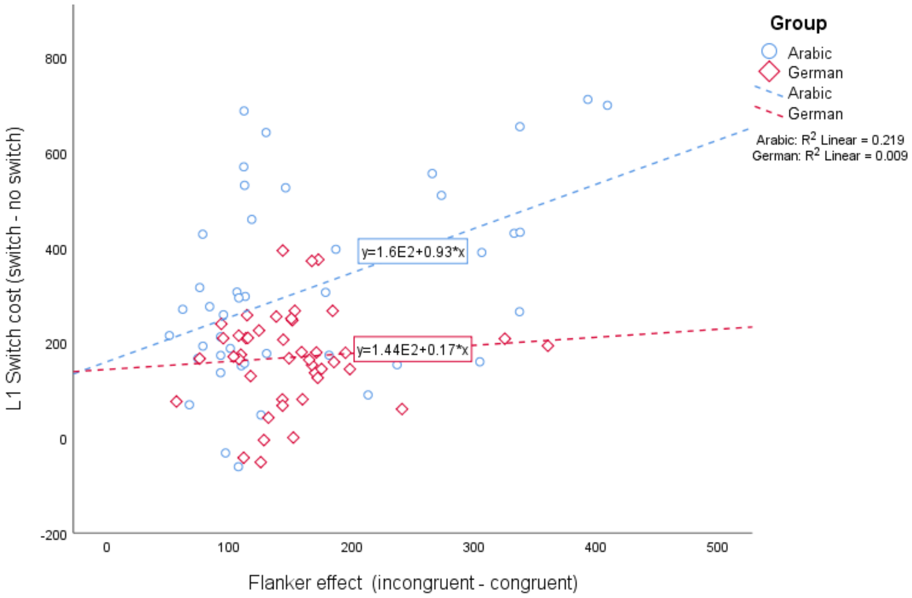


Figure 6-4 *Correlations between L1 switch costs and the inhibition effect in the Flanker task. There was no linear relation in the German group. The relationship exists only for the Arabic group where there was a positive relationship between flanker effect and L1 switch costs.*

However, no correlation was found between the inhibition effect and the magnitude of switching cost for L2 in the two groups when performing the language-switching task (the Arabic-English bilingual group (r =.073, p = .639); the German-English bilingual group (r = -.144, p = .352) (see Figure 6-5)).

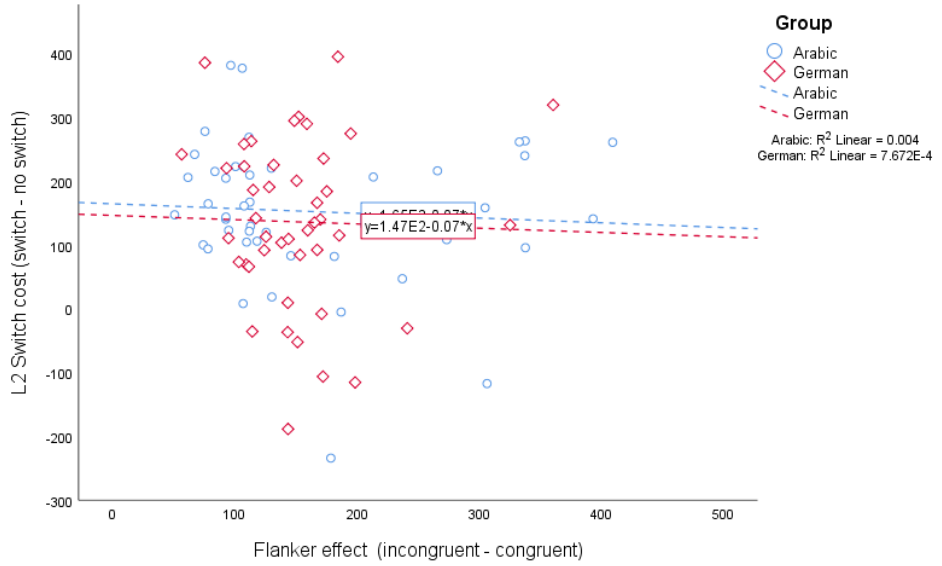


***Figure 6-5** Relationship between L2 switch costs and the inhibition effect in the Flanker task. There was no linear relation in both groups: the Arabic and German groups.*

The interaction of shifting abilities with L1 and L2 switch costs was also not significant for both groups (Arabic group L1 switch costs: r = -.172, p =. 365; L2 switch costs: r =.152, p = .213) (German group L1 switch costs: r = -.028, p = .857; L2 switch costs: r = -.064, p = .678), suggesting that the ability to shift between tasks did not have any effect on naming latencies and on the relative switch costs.

None of the bilingual language experience variables were related to L1 or L2 switch costs in the German group. In the Arabic group however, L2 active language proficiency was negatively related to L1 switch costs (r = -.341, p = .023) but not to L2 switch costs (r = .060, p = .697). The significant interaction of L2 active language proficiency with L1 switch costs reflects the fact that lower L2 proficiency was related to larger switch costs when switching into the dominant L1.

Regression analysis

In this section, we conducted regression analyses to understand the role of cognitive control abilities and language similarity in modulating bilingual language switching performance. In addition, the regression analyses were conducted to provide further information about the contribution of the language experience variables to the performance of bilinguals switching between similar/dissimilar languages. Only L2 proficiency was included from the language experience variables, since none of the other variables influence switch costs in either group.

Regression models were calculated for Arabic and German groups separately. The effect of inhibition, shifting and L2 proficiency were included as predictors, while participants' L1 switch cost was included as the outcome variable. For the Arabic group, L1 switch cost was only significantly predicted by the inhibition effect (b =.243, t (85) = 2.4, $p < .01$). This finding indicates that participants with a large inhibition effect exhibit larger L1 switch costs. This means that poorer inhibitory control ability (i.e. the ability to suppress inappropriate responses) relates to slower retrieval of lexical items when switching into L1. Therefore, bilingual speakers who have enhanced inhibitory control ability would show enhanced conflict resolution ability across their two languages. For the German group, we found no significant contribution of inhibition (b = -.21, p = .060), shifting (b = .13, p = .238) or L2 proficiency (b =.43, p =.215).

Since we are interested in the issue of whether the size of the inhibition effect is bigger for one group than for another, we compared the regression coefficients of the German group with the Arabic group and found a significant regression equation only for the inhibition effect F (7, 80) = 3.735, $p < .01$, R^2 = .577. Additionally, we found that the impact of inhibition persisted only for the Arabic speakers' L1 switching performance (b= .277, t (42) = 2.9, p <

.007). This suggests that inhibition is a stronger predictor of L1 switch costs for the Arabic group (*b*= .50) than for the German group (*b*= -.09).

Discussion

In the language switching task involving Arabic-English and German-English bilinguals, we found an asymmetric switch cost only in the Arabic-English group, where the switch costs into Arabic were larger than into English. This finding is in line with the previously mentioned studies on unbalanced bilinguals in which switch costs were found to be larger in L1 than in L2. (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Meuter & Allport, 1999). In contrast, we found a symmetric switch cost in the German-English group (i.e., smaller switch costs into L1), consistent with prior studies on highly proficient bilinguals showing no asymmetrical switching cost when switching between their languages (e.g. Costa et al., 2006; Costa & Santesteban, 2004).

These different patterns of switch costs in our two bilingual groups may reflect the impact of language similarity on the language selection mechanisms, as suggested by previous research postulating that bilinguals' lexical selection mechanism is sensitive to the different degree of language similarity rather than the level of proficiency between two languages (Cui & Shen, 2016). We tested two bilingual groups with a different degree of language similarity, a group of bilinguals with dissimilar languages: a non-Indo-European/Semitic language (Arabic) and an Indo-European language (English) and a group of bilinguals with relatively similar languages: German and English, both belonging to the Germanic languages. This means that the German language shares more similarity with the English language compared to the Arabic language.

Cui and Shen (2016) found that bilinguals of dissimilar languages (Mandarin-English) displayed asymmetrical switch costs when performing a language switching task compared to a group of bilinguals switching between similar languages (Catalan-English) (Costa et al., 2006). Cui and Shen (2016) attributed the differences in the results to the effect of language similarity as the similarity of Catalan and English is more than that of Mandarin and English.

In the analysis of the language-switching costs of our Arabic group (bilinguals with dissimilar languages), we found that the size of the switching costs was greater when participants switched from the less-proficient L2 to the proficient L1 than from L1 to L2. This result is similar to those observed in Cui and Shen (2016) where asymmetrical switch costs were observed within bilinguals switching between two dissimilar languages (Mandarin-English). In addition, our analysis of the German group (bilinguals with similar languages) showed a symmetrical switch cost for L1, a finding that aligns with the results of Costa et al. (2006) in which bilinguals with similar languages (Catalan-English) displayed a symmetrical switch cost. Based on the results, it seems reasonable to conclude that language similarity may play a role in bilingual lexical selection mechanisms. It has been suggested that the similarity of bilinguals' languages can impact their executive control abilities (Coderre & van Heuven, 2014). The authors suggested that similar languages activate each other to a greater degree, leading to a higher requirement for cognitive control. Compared to dissimilar languages, similar languages therefore promote executive control to a larger degree (Coderre & van Heuven, 2014).

Although typological distance may represent an important factor for the process of bilingual language selection as suggested by aforementioned studies, the difference between the patterns of switch costs within our two bilinguals' groups cannot be solely attributed to the language similarity. This is because our analysis of bilinguals' responses to the language history questionnaire revealed key differences between the two bilingual groups. Such that the German-English bilingual group was more proficient in their L2 and had an earlier onset of L2 than the

Arabic-English bilingual group. These differences mean that German-English bilinguals might have performed more like highly proficient bilinguals, showing symmetrical switch costs, while Arabic-English bilinguals might have performed more like L2 learners, showing asymmetrical switch costs. Thus, we cannot say for sure if our results are consistent with Costa et al. (2006) and Cui and Shen (2016) studies, as the level of L2 proficiency has been found to play an extensive role in modulating L1/ L2 switch costs. This finding is in line with previous research showing the important effect of proficiency on modulating bilinguals' switch costs, with higher L2 proficiency leading to smaller switch costs in both languages (Costa & Santesteban, 2004; Costa et al., 2006).

The two different patterns of switch costs may therefore reflect the effect of L2 proficiency on lexical selection mechanism during language switching. We found evidence for a relationship between lower L2 proficiency and larger switch costs into L1 for Arabic participants, but not for German participants. Previous studies of language switching that reported asymmetrical pattern of switch costs have attributed this result to the relative strength of the two languages, suggesting that the asymmetrical pattern of switch costs is only found for less proficient L2 or strongly L1 dominant bilinguals (e.g., Costa & Santesteban, 2004; Costa et al., 2006; Meuter & Allport, 1999).

Accounts of bilinguals' language control have linked proficiency to cognitive control mechanisms underlying cross-language interference resolution. According to the Inhibitory Control Model (Green,1998), the amount of inhibition applied to resolve competition between languages is found to be proportional to the level of activation of a given language. That is, the higher the level of activation of the non-target language, the more inhibition is needed to suppress it (Abutalebi & Green, 2007; Green,1998). The strength of inhibition should be therefore a function of L2 proficiency (i.e., the lower proficiency L2 is in relation to a dominant L1, the more L1 must be inhibited in order to produce the weaker L2).

We found evidence for a relationship between the inhibition effects in the Flanker task and the size of the switch costs for L1, but only for the Arabic group as compared to the German group. This suggests that, for the Arabic group, more inhibition was involved in order to resolve conflict interference between the two languages. In other words, switching into L1 was effortful in term of lexical selection for the Arabic participants as more time was required to overcome the strong inhibition of L1 representations that were highly activated and strongly competed for selection during L2 access (i.e., inhibition of the dominant L1 during the naming of the weaker L2). Therefore, the strong inhibition of irrelevant L1 representations during the access of task-relevant L2 representations should reflect the fact that larger switch costs in L1 were related to lower L2 proficiency.

In accordance with this finding, balanced bilinguals should experience symmetrical and reduced switch costs as compared to less proficient bilinguals (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004; Kroll, Bobb, Misra & Guo, 2008). Supporting evidence has shown that the higher the L2 proficiency, the smaller the asymmetry in switch costs across two languages (Calabria, Hernandez, Branzi, & Costa, 2012; Costa et al., 2006; Costa & Santesteban, 2004).

Costa and Santesteban (2004) reported evidence suggesting that balanced and highly proficient bilinguals produce a pattern of switch costs that is symmetrical between L1 and L2. The authors proposed that highly proficient bilinguals no longer need to actively inhibit their L1 since increased proficiency is positively related with the increased skill in language selection (Costa & Santesteban, 2004). In our experiment, we found no evidence for a relationship between inhibition effect and switching costs in L1 in the German-English group. This finding is in line with the idea that highly proficient bilinguals may recruit different language control mechanisms from low proficient bilinguals, such as a language selection mechanism that does not resort to inhibition to supress the activation of lexical representations of the non-target language. Instead, to ensure that the correct language is selected during the language switch, proficient bilinguals make use of a language-specific selection mechanism that is only sensitive to lexical representations belonging to the intended language. In line with these findings we can conclude that the switch cost patterns can be affected by the level of language proficiency and that language proficiency could play a key role in modulating L1 switching performance (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004; Green & Abutalebi, 2013).

Studies on bilingual language switching show that other aspects of bilingual language experience may interact with proficiency in the modulation of bilingual language control, such as age of language acquisition, language exposure (Bonfieni et al., 2019; Costa et al., 2006) and frequency of language switching (Prior & Gollan, 2011). In this current study, we tested this hypothesis by examining the role of bilingual language experience in modulating of language switching costs. We found no evidence for a relationship between bilingual language experience variables and L1 or L2 switch costs in the German and Arabic groups. However, as we mentioned earlier, only L2 proficiency seems to affect L1 switch costs, but only for the Arabic group.

Although our result does not point to a direct effect for age of acquisition, language exposure and frequency of language switching on the modulation of language switch costs (i.e., age of acquisition, language exposure and frequency of language switching did not correlate with L1 or L2 switch costs), these variables might have potentially affected bilingual's L1/L2 lexical access during language switching. In term of age of acquisition, Costa and Santesteban (2004) found that longer naming latencies in L1 are related to L1 dominance. In line with this finding, longer naming latencies in L2 should be related to early L2 acquisition, thereby arguably the earlier acquired the language, the more dominant the language. Age of acquisition, therefore, could have an important role in making the switch task between languages generally easy. Our German bilinguals, whose level of proficiency in English was significantly higher than the Arabic-English group, showed reduced L1 switch costs as compared to the Arabic bilinguals, suggesting that earlier acquisition to L2 can affect how the L1 is processed.

In addition, L2 daily exposure has also been found to affect pattern of switch costs. Bonfieni et al. (2019) show that exposure to the L2 predicted reduced switch costs in L1. Supporting neuroimaging evidence has demonstrated that the amount of exposure modulates cortical activity during lexical access (Perani et al., 2003). Our results did not show an effect of daily language exposure in modulating switching costs. Yet, higher L2 exposure appears to reduce the load of suppressing L1 for the German group in relation to the Arabic group. This finding is in line with research on language control which shows that exposure to the L2 affects how the L1 is processed as it seems to alleviate the dominance of the L1 (Wu & Thierry, 2017).

As for daily frequency of language, unlike previous studies (Prior & Gollan, 2011), our study did not show an effect of everyday language switching frequency on L1 or L2 switch costs. This could be explained in the light of participants' differences in interpreting some of the questions in the bilingual language experience questionnaire (Marian et al., 2007). It is expected therefore to find no effect of some variables as some aspects of the bilingual language experience may not be precisely captured. This may be the case of misinterpretation of some questions by participants. For example, the question about daily frequency of switching referred to different contexts of language use (i.e., one at home and one at school, one with friends and one with family, use both at home, etc), participants may have interpreted more or less strictly what 'contexts of use' means.

To conclude, this chapter examined the role of key factors of bilingual language experience in the modulation of language-switching performance and their relationship to bilingual language control. We found that language switching is modulated by L2 proficiency, which also mediates language access and control. We found evidence of the role of inhibitory control in modulating speech production in the performance of low proficient bilinguals switching between dissimilar languages, as compared to proficient bilinguals switching between similar languages. However, the role of other aspects of bilingual language experience (age of acquisition, language exposure, and frequency of language switching) still not very clear.

CHAPTER 7

GENERAL DISCUSSION

The aim of this thesis was to explore how lexical interference is resolved in bilingual speakers when switching between languages. Both lexical interference and language switching tasks were used to understand the effects of semantic interference and cross-linguistic competition on lexical access. This thesis also contributed to our understanding the effects of bilingual language similarity and bilingual language profile on cognitive control abilities in language selection and switching.

Summary of results

This thesis reports a series of studies designed to examine lexical retrieval in bilingual spoken word production. The first empirical Chapter, Chapter 3, assessed the language profile of two groups of bilingual speakers in their first (L1; i.e., Arabic or German) and second (L2; i.e., English) languages, in order to evaluate the language profiles of these two bilingual groups. We employed the LEAP-Q questionnaire, which yields reliable self-reported proficiency measures that have been found to correlate significantly with behavioural measures of language performance (Marian et al., 2007). Subsequently, we placed these responses into a Principal Component Analysis (PCA) to identify the factors that capture the differences in their language status.

Our results provided a set of language status factors for our German-English group that differed to some degree from the Arabic-English group. More specifically, the language profile of the two groups differed in terms of the age a language was acquired, language exposure and proficiency. For instance, the German bilinguals rated themselves as more proficient in their English than the Arabic bilinguals. The groups also differed in the frequency of language switching, with German bilinguals switching more than the Arabic bilinguals. Although the selection criteria for our German and Arabic bilinguals were the same, the comprehensive analysis of the bilingual profile showed important differences in language profile and language status of these two bilingual groups. The individual factors from the LEAP-Q data were used in the two empirical Chapters (4 and 5) to understand the nature of their effects on bilinguals' lexical selection.

In Chapter 4, we investigated lexical-semantic retrieval in bilinguals with dissimilar typologies (Arabic-English bilinguals) during a language switching task. More specifically, we examined the relationship between the language switching cost and the level of lexical semantic interference during lexical selection. In addition, we assessed the relationship between domain-general cognitive controls, including inhibitory and shifting control abilities, and bilingual lexical production. To answer this question, we combined a semantic blocking paradigm (Belke et al., 2005) and a language switching paradigm (Meuter & Allport, 1999). The effect of lexical-semantic interference was measured with semantic blocking paradigm, while cross language interference was assessed with the language switching paradigm. In addition, we assessed individual differences that underlie cognitive control during increased lexical competition within and across languages with two non-verbal tasks: a Colour-shape shifting task (Miyake et al., 2004) and a Flanker task (Eriksen & Eriksen, 1974). The Flanker task was shown to test the ability to resolve conflict between prepotent responses and the target response at a response selection stage (Ridderinkhof, 2002).

Branzi et al. (2016) found that, relative to switching into L2, switching into L1 relies heavily on brain areas associated with the response selection system, namely inferior parietal and prefrontal areas. These brain areas have been shown to play an important role in resolving competition between responses and producing the correct response (Collette et al., 2005).

Branzi et al.'s (2016) findings suggest that language switching into L1 should be demanding in terms of lexical selection and should interact with the degree of lexical selection difficulties. Our results showed an increased level of lexical-semantic competition and language switch led to slower responses when switching into L1 and L2. Critically, a highly competitive semantic context made switching into L1 particularly slow (see Figure 7-1 upper panels).

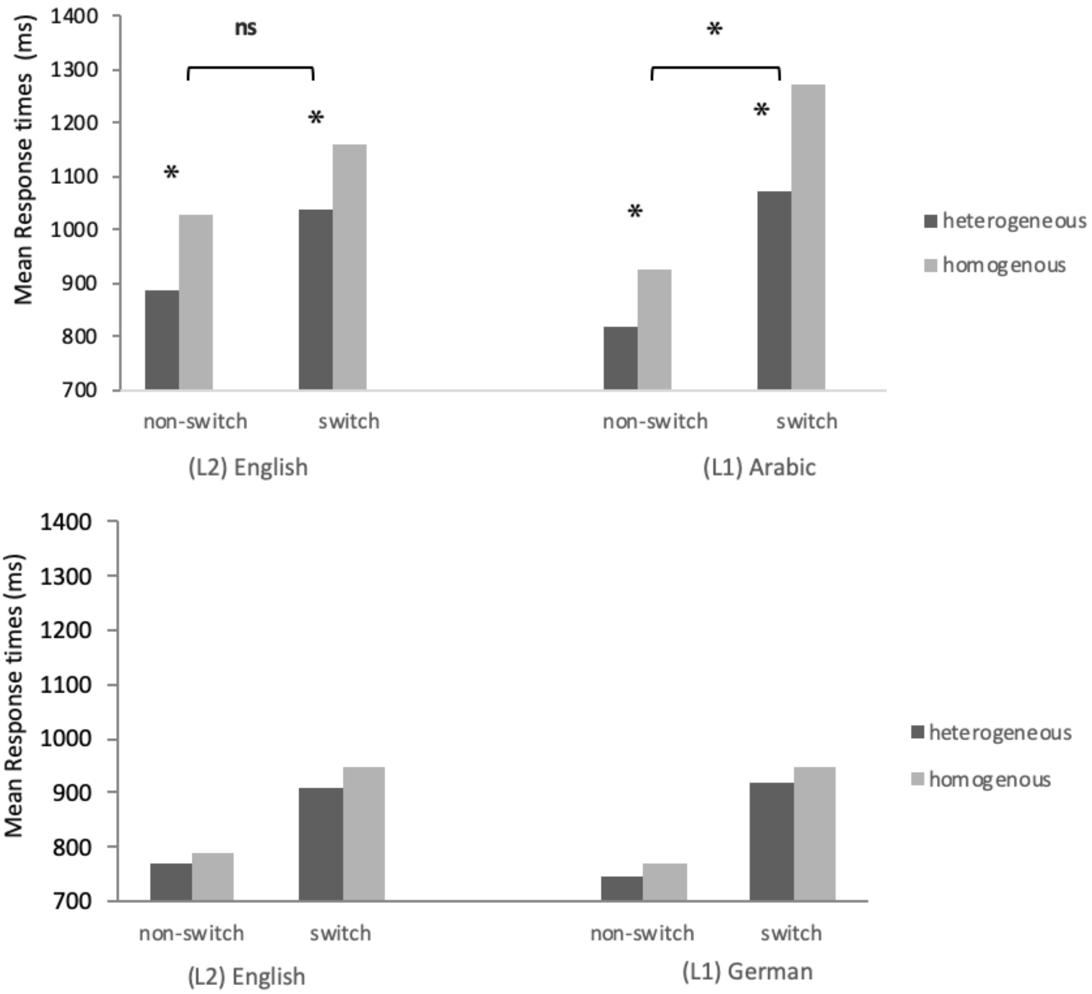


Figure 7-1 *The effects of homogeneity (homogeneous condition, heterogeneous condition) and language switching (switch versus no switch) on response times when naming in L1 and L2.* ***Upper panels.*** *An interaction of the two factors was only present for L1. Significant differences between conditions are indicated with an asterisk.* ***Lower panels.*** *There was a main effect of homogeneity and a main effect of switching. No interaction was found between factors.*

This means that switching into L1 is affected by increased cognitive load and that the slow naming of L1 in the switching condition was due to the heightened lexical selection demand. This finding suggests that the degree of lexical semantic interference during lexical selection modulates L1 switch costs for unbalanced bilinguals who have different levels of proficiency in L1 and L2. Furthermore, we found that the effects of lexical semantic interference (i.e., the homogeneity effect) were correlated with participants' performance in the Flanker task, but only when they switched into L1 (see Figure 7-2 upper panels).

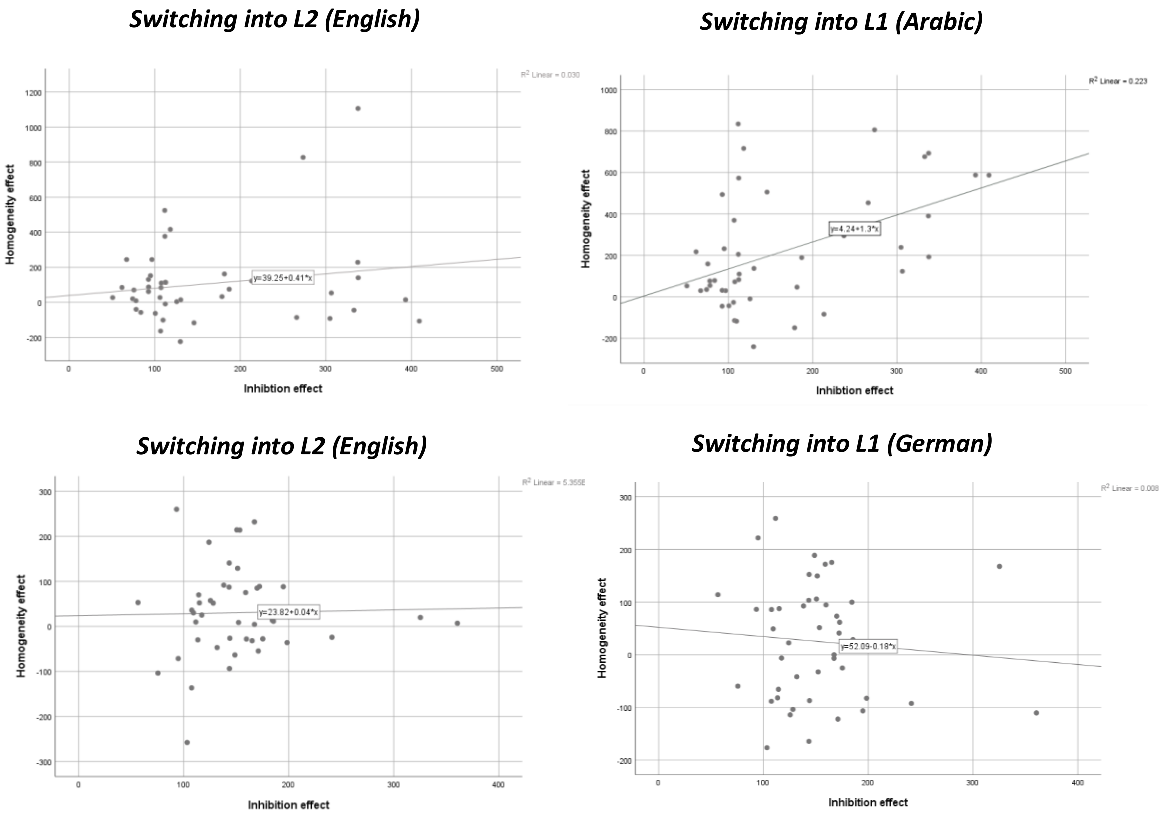


Figure 7-2 *The relationship between the inhibition effect in the Flanker task and the homogeneity RT effect in the blocked cyclic naming task when switching into L1 (right panels) and when switching into L2 (left panels).* ***Upper panels.*** *Presence of a relationship between the two variables for the Arabic-English bilinguals only when switching into L1, not L2.* ***Lower panels.*** *Lack of a relationship between the two variables for the German-English bilinguals when both switching into L1 and L2.*

This finding suggests that switching into the L1 reflects extra processing cost imposed on bilinguals to resolve the increased lexical selection demand, specifically in conditions where lexical-semantic competition was increased. In contrast, we found no evidence of a relationship between the homogeneity effect and participants' performance in the Colour-shape task, during switching into L1 or switching into L2 (see Figure 7-3 upper panels).

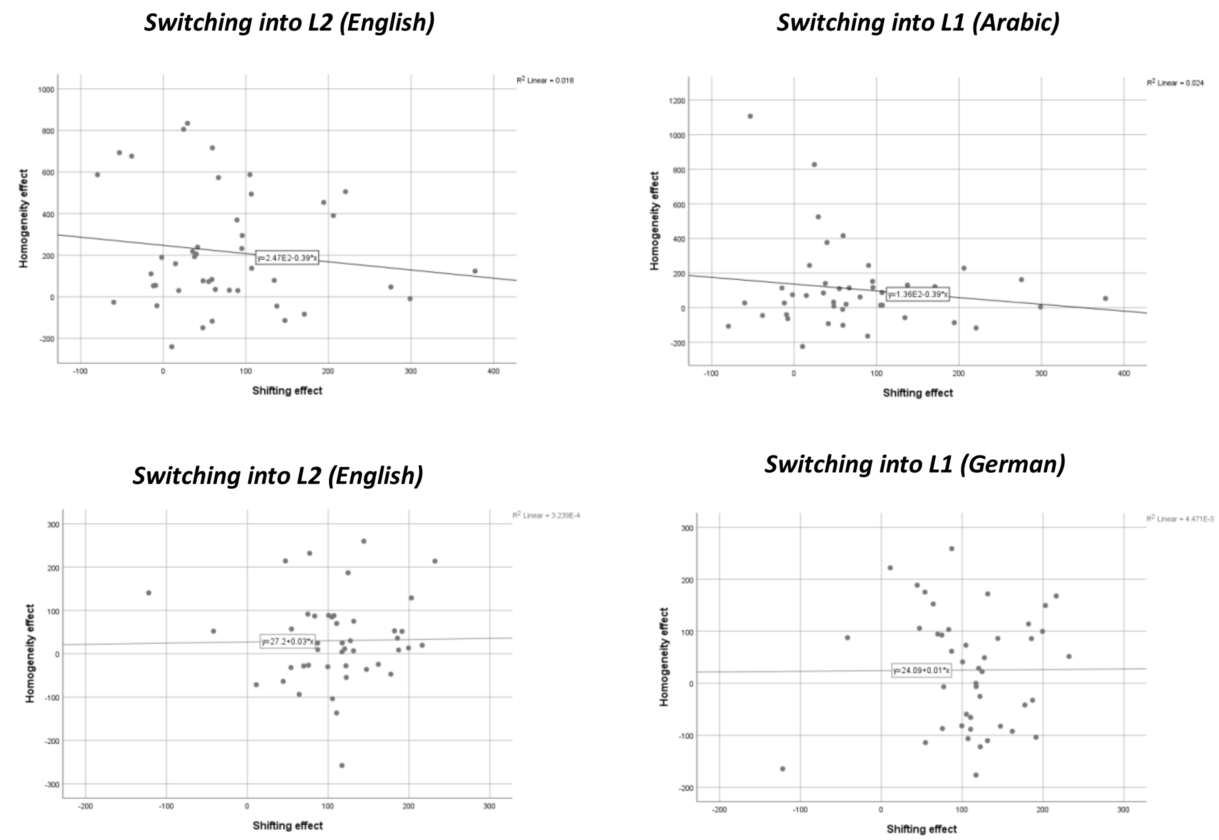


***Figure 7-3** Lack of a relationship between the shifting effect in the Colour-shape task and the homogeneity effect in the blocked cyclic naming task in the switching cycle. **Upper panels.** Lack of the relationship between the two variables for the Arabic-English bilinguals when both switching into L1 and L2. **Lower panels.** Lack of a relationship between the two variables for the German-English bilinguals when both switching into L1 and L2.*

Taken together, these findings suggest that competition resolution in bilinguals is not related to the bilingual's general ability to shift between mental sets and representations, but their response selection ability. This finding confirms the assumption that switching into L1 relies heavily on brain areas associated with response selection compared to switching into L2 (Branzi et al., 2016).

In addition, Chapter 4 examined the effect of the bilingual language profile in lexical selection. The results showed significant negative correlations between the homogeneity effect and the L2 proficiency and L2 exposure factors, but only for the switch into L1. Compared to bilinguals with high L2 proficiency and high L2 exposure, bilinguals with low L2 proficiency and low exposure suffered more from the semantic interference effect only when switching into L1. In contrast, we found no correlation between the language competition and the L1 learning factors. The study demonstrated that the amount of L2 exposure and proficiency affected competition resolution in bilinguals when switching into L1.

In Chapter 5, we explored whether bilinguals with typologically similar languages (i.e., German-English speakers) differ from bilinguals with typologically dissimilar languages (i.e., Arabic-English speakers) in lexical-semantic retrieval and competition resolution during language switching. More specifically, we examined whether bilinguals with similar languages, would show different cognitive profile to that of bilinguals with dissimilar languages. In order to test this aim, we conducted the same experiment as in Chapter 4, with German-English bilingual speakers.

The study demonstrated a symmetrical switch cost for switching into German (L1) and English (L2); yet, no interaction was found between the level of lexical-semantic competition and language switching (see Figure 7-1 lower panels). Participants only showed a main effect of homogeneity, with slower responses in the homogeneous than heterogeneous conditions. In addition, participants displayed a main effect of language switching, with slower responses in the switching than no-switching conditions. Importantly, our results showed no evidence of a relationship between the levels of lexical-semantic interference during language switching and participants' performance in the Flanker task or Colour-shape shifting task (see Figure 7-2 lower panels and Figure 7-3 lower panels). Taken together, these findings suggest that lexical competition resolution was not related to the general response selection or general switching ability in the German bilinguals. In addition, we found no correlations between the homogeneity effect with any of the other LEAP_Q factors. Relative to bilinguals with high L2 exposure, those with low L2 exposure therefore suffered more from the semantic interference effect but only when switching into L2. This suggests that the amount of L2 exposure may have an effect on German-English participants' ability to resolve increased lexical competition demands when switching into L2.

In Chapter 6, we directly compared the two bilingual groups with varying degrees of language similarity (i.e. bilinguals with dissimilar languages: Arabic-English and bilinguals with similar languages: German-English) reported in Chapters 4 and 5. We found that the bilingual group with similar languages exhibited smaller switch costs between L1 and L2 compared to the bilingual group with dissimilar languages, with more closely related languages showing less interference with each other, leading to a reduction in cognitive control demands (Barac & Bialystok, 2012). In line with the prediction, dissimilar languages should demand stronger cognitive control processes, leading to an increased language switch cost. The fact that we found more inhibition effects with dissimilar languages (in Chapters 4 and 6) is in line with this proposal.

Studies investigating the influence of language similarity on bilinguals' executive control abilities, on the contrary, argue that bilinguals with closely related languages need greater cognitive control to manage the larger degree of overlap between their two languages, leading to greater interference effects as compared to bilinguals with dissimilar languages (Coderre & van Heuven, 2014). We found that the absence of an interaction with the level of lexical competition and language switching (in Chapter 4), together with the lack of a correlation with inhibition ability when both languages are similar (in Chapter 6), are in line with the former assumption that bilinguals with relatively similar languages require less cognitive control to resolve cross-language interaction (Barac & Bialystok, 2012).

Theoretical implications

The key finding of this thesis relates to Branzi et al.'s (2016) suggestion that switching into L1 is particularly demanding in terms of lexical selection as shown by the engagement of the neural regions implicated in response selection, namely inferior parietal and prefrontal areas. Supporting evidence was shown in Chapter 4, such that latencies were slowest in homogeneous context when switching into L1 compared to switching into L2. This finding suggests that switching into L1 is affected by cognitive load as shown by its interaction with the degree of lexical selection difficulties. Additional evidence was obtained that switching into L1 under increased lexical competition is related to response inhibition in bilinguals, indicated by the positive correlation between the performance in the Flanker task and the size of the homogeneity effect. This finding suggests that bilinguals with dissimilar languages require inhibitory control ability to reduce the costs of switching into their L1 under increased lexical-semantic competition. This pattern of results is more consistent with the competition-based theory of lexical selection in bilinguals (e.g., Abdel-Rahman & Melinger, 2009; Belke et al., 2005; Damian et al., 2001) than non-competition theory of non-lexical selection (e.g., Howard et al., 2006; Oppenheim et al., 2010).

As discussed in Chapter 1, lexical selection was assumed to be either a competitive or a non-competitive process. A competition account of lexical selection assumes that a target lexical representation must be selected from co-activated candidates that compete for selection (e.g., Abdel-Rahman & Melinger, 2009; Belke et al., 2005; Damian et al., 2001). According to such a view, inhibition ability is expected to be involved to resolve this competition (e.g., Guo et al., 2011). Alternatively, it could be argued that lexical selection can occur without competition, thereby no inhibition ability is required. Instead, such an effect can be explained by an incremental learning model that modifies the semantic-to-lexical links at the end of each successful lexical selection (e.g., Howard et al., 2006; Mahon et al., 2007; Oppenheim et al., 2010).

Our finding, that is, switching into L1 under increased lexical competition is related to response inhibition ability, is consistent with the lexical competition account, since we found a positive correlation between the homogeneity effect and the non-linguistic inhibitory measure (right upper panel, Figure 7-2). In the semantic blocking paradigm, naming pictures in the same semantic category causes activation to accumulate in the semantic system leading to lexical-semantic competition (Belke et al., 2005). A correlation with a task that is related to the ability to resolve competition among interfering responses (i.e., Flanker task) indicates an involvement of a similar cognitive control mechanism that is crucial in resolving competition. More importantly, since competition resolution ability seems to be partly involved in both Flanker and Semantic blocking tasks, as indicated by the significant correlation between the homogeneity effect and the Flanker effect, lexical selection by competition offers a better fit for our Arabic bilinguals' group.

For the German bilinguals' group, an interaction between the inhibition effect in the Flanker task and the homogeneity effect while switching between languages was absent. A tentative explanation of this might be that, for balanced bilinguals, language switching could be achieved without inhibitory processing. That is, more balanced bilinguals make use of a language-specific selection mechanism that ensures the correct word is selected by attending to lexical representations that belong to the target language (e.g. Costa et al., 1999), not by suppressing the activation of the lexical representations of the non-target language (Green, 1998). Put simply, inhibition is irrelevant for balanced bilinguals who are equally proficient in both languages. It is therefore possible to conclude that balanced bilinguals develop a selection mechanism that does not require inhibition of the non-intended language to successfully select the lexicon in the intended language.

This thesis examines the effect of language similarity on lexical control. Indeed, a different pattern of results was observed for the Arabic-English and German-English bilinguals. Importantly, the Arabic-English bilinguals showed an increased demand on response selection during lexical selection and asymmetries concerning cognitive control that was otherwise not shown by the German-English bilinguals. In Chapter 5, we found faster lexical access and reduced switching cost for German bilinguals, with no interaction between switching direction and lexical selection. This finding suggests that similar languages may interfere less with each other, yielding more facilitation, and therefore require no additional cognitive control processes (i.e. no inhibition).

However, our pattern of results cannot be uniquely attributed to language similarity, as some aspects of the bilingual language profile might have also contributed to the findings. Our selection criteria for our German-English and Arabic-English speakers were the same, as we sought highly proficient participants. However, the language profile was different between these two groups. For example, the German bilinguals were more proficient in their L2 and had an earlier onset of L2 than the Arabic bilinguals as indicated by the comparison between the two groups in Chapter 6. Additionally, German bilinguals were more balanced in terms of proficiency and were exposed to both languages, but primarily exposed to L2 in their daily life compared to the Arabic bilinguals. The groups also differed in the degree of switching frequency, with German bilinguals switching more than the Arabic bilinguals who demonstrated context-dependent language use. Importantly, the two groups did significantly differ in terms of the age they acquired their L2, insofar as the Arabic bilinguals were first exposed to English in school after the age of 12, while the German bilinguals were first exposed to English in school earlier, at the age of nine. A different pattern of results may have occurred as a result of these differences in terms of the language profile between the bilingual groups.

There is evidence that the relative proficiency of L2 might reduce asymmetry and, therefore, reduce the need to actively inhibit L1 (e.g. Wu & Thierry, 2017). In Chapter 6, we found that German bilinguals showed no asymmetric switch costs when switching into L1. According to the IC model (Green, 1998), the amount of inhibition required to resolve competition between languages is found to be relative to the level of activation of a given language. That is, the higher the level of activation of the non-target language, the more the inhibition required to suppress it (Abutalebi & Green, 2007; Green, 1998). It thus follows that the strength of inhibition should be a function of L2 proficiency.

In Chapter 6, we found evidence that inhibition was only involved within low proficient bilinguals, as indicated by the significant correlation between the inhibition effects in the Flanker task and the size of the L1 switch costs in the cued language-switching task. That is, we only found increased naming latencies within the Arabic group when participants switched into L1, suggesting that L1 representations were strongly inhibited during access of L2 representations. Thus, the stronger the inhibition of L1 representation, the longer the time required to overcome and recover from inhibition. Therefore, the strong inhibition of unrelated L1 representations during the access of related L2 representations should reflect the fact that proficiency and inhibition might develop together, as reduced proficiency has shown to lead to more cross-linguistic interference, and thereby more inhibition.

Limitations

The first limitation of the study is the use of individual differences measures, namely the flanker and colour-shape tasks. Although these tasks are widely available and heavily relied on to measure individual differences in shifting and inhibitory control abilities, they have exhibited a lack of reliability in measuring individual differences (Hedge, Powell & Sumner, 2018). Recently, Rouder Kumar and Haff (2019) have argued that these measures may not reliably capture the components underlying inhibitory control. They found that the flanker task behaviour does not correlate with the task performance of the Stroop task, contradicting unified concepts of inhibition. This result demonstrates the poor reliability of these experimental measures in assessing individual differences in inhibitory control abilities (Rouder et al., 2019).

In the present thesis, we found there was no relationship between the homogeneity effect in the semantic blocking task and shifting effect in the Colour-shape task for both bilingual groups. Further, we did not find the same pattern of correlation between the two groups for the inhibition effect in the flanker task. The null finding may reflect the unreliable nature of these individual differences measures in studying individual differences in executive functioning. Our results do provide some evidence that despite robust experimental effects, such response inhibition tasks are often difficult to relate to reliable individual differences (Rouder et al., 2019). In turn, this may not enable us to assess the individual differences that underlie response inhibition and interference control. Thus, we emphasise that our correlations (i.e., the correlation between non-verbal measures and verbal measure) should be treated with caution.

The second limitation is the effect of the verbal task used in this present study and its relation to language processing. We employed the cyclic semantic blocking paradigm in which bilinguals had to select a target word in a highly competitive context. We manipulated the level of lexical competition by asking the participants to repeatedly name sets of pictures in twelve successive presentation cycles. Beside naming pictures in succession multiple times, we added an additional measure of switching where participants switched from one language to another in a high lexical competition context. Such a lexical selection in a highly competitive context and a switching under external constraints (i.e., according to external cues) could have affected the language control mechanisms underlying bilingual language production and thus would have elicited unreliable effects of language switching.

Studies that have examined the effects of language switching in different communicative contexts propose that interactional context is critical in determining the language control processes (e.g., Blanco-Elorrieta & Pylkkänen, 2017; Green & Abutalebi, 2013). For instance, recent neuroimaging research has investigated language switching in natural, compared to laboratory, contexts. Results showed that the prefrontal cortex and the anterior cingulate brain regions were heavily engaged when language switching was elicited by laboratory paradigms. However, natural and voluntary switching showed lower engagement of prefrontal control regions (Blanco-Elorrieta & Pylkkänen, 2017). This finding suggests that the switch effects observed in previous behavioural and neural studies may be limited to situations where switching was artificially cued (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004; Abutalebi et al., 2008). It is therefore unclear to what extent our findings can be generalised to naturally occurring language switching. In particular, in our task, the significant interaction of homogeneity effects and language switching that is derived from artificially cued switching paradigms, calls into question the extent to which the current finding is relevant within naturally occurring language switching.

Future directions

There were some questions left unanswered in the current thesis. Critically, we still do not know why the German bilinguals showed a different pattern of results to that of the Arabic bilinguals. What factors drove the asymmetries of cognitive control observed in the Arabic-English study and the increased demand on the response selection system during lexical selection that were not observed in the German-English study? Our two groups, according to any more general matching criterion, were perfectly matched in the sense that they both included only highly proficient bilinguals. However, the LEAP-Q study highlighted a number of subtle differences which are potentially critical. Therefore, it is not just enough to recruit bilinguals with certain level of proficiency and treat them as similar; our approach has shown that this is not adequate. In order to investigate the effect of language similarity we attempted to keep our two groups of bilinguals constant and manipulate their languages. However, this approach has proven to be difficult. We are therefore still some way from a full understanding of the effect of language similarity on cognitive control abilities in language selection and switching.

One way to investigate the issues that have arisen from our study would be to keep the languages constant but vary the bilinguals' profile. Future studies could therefore aim to replicate our experimental findings but using a different set of Arabic-English bilinguals. As discussed in Chapter 2, Arabic is a widely spoken language, which is used differently in various cultural settings. This means that there are different approaches to learning the Arabic language. It would therefore be possible to find a group of Arabic-English bilinguals with more anglocentric experience that may affect lexical retrieval and resolving lexical competition. For example, a group of Arabic-English bilinguals who lives in a culturally diverse city as in Dubai-UAE would be perfect candidates for potential future study. There are several nationalities in

Dubai that encourages interaction with the English language, since it is the language shared for communication between people from different countries that reside in Dubai. Although Arabic is the official Language in Dubai, English is the primary language for education, economics, medicine and business interactions. English has therefore been incorporated in the education system from early ages, around age five ("United Arab Emirates Cultural Division | K-12 Education", 2019). Accordingly, more insight would be gained about the effect of language similarity on general cognitive ability, if we tested two groups of homogeneous bilingual population.

Another interesting line for future research is to address the question of whether the effect of semantic blocking during bilingual language switching transfers to new set of pictures from the same semantic category. Our Arabic bilinguals' study showed that the semantic blocking effect interacted with switching into L1, such that switching into L1 was costly when accompanied with an increased lexical competition, but only when participants named the same pictures that were previously named in their L2. This finding predicts that the accumulation of inhibition applies to the L1 translation equivalents that were just named in the L2. Belke et al. (2005) showed that, the semantic blocking effect is not only restricted to the naming of a set of pictures from a certain semantic category, but it generalises to the naming of new members of the same semantic category. The pictures that were used in our study were the same in both languages and repeated before and after the switching cycle. It would be interesting to find out whether similar results could be achieved if naming a different set of pictures from the same semantic category after switching into L1. Particularly, whether the semantic blocking effect generalizes within a semantic domain during language switching or is it only specific to the lexical items that have been previously named in the other language. We predict that, consistent with Belke's finding, inhibition would extend beyond the similar lexical items retrieval and it would build-up across the entire language or to the whole semantic system.

Another noteworthy issue for future research is to examine other effects of language similarity on language switching. The current study focused on the level of lexical selection and lexical retrieval in bilingual speakers. There are several levels of language representation that might affect language switching and our study only focused on the level of lexical selection. Future studies could investigate more thoroughly the relationship between the language switching cost and the level of similar or different syntactic structure generation. Although there is research on cross linguistic effects of syntactic similarity (e.g., Foucart & Frenck-Mestre, 2011), the effect of syntactic similarity in language switching has not been explored. This raises questions such as when language switching also involves syntactic change, would this increased syntactic processing difficulty interact with direction of switching in the same way as lexical selection difficulty?

Conclusions

In summary, this thesis reported a series of studies to examine lexical retrieval in bilingual spoken word production. This thesis aimed to test the effects of bilingual language similarity on bilingual lexical selection process by testing two different groups of bilinguals. This thesis reports the first assessment of the effect of language similarity on cognitive control abilities in language selection and switching by examining a group of bilinguals with typologically related languages (L1 German and L2 English) and another group of bilinguals with typologically unrelated languages (L1 Arabic and L2 English).

The experimental paradigm employed in this thesis combines, for the first time, the semantic blocking paradigm with the language switching paradigm in order to investigate the relationship between the language switching cost and the level of lexical semantic interference during lexical selection. In addition, these two paradigms assessed the relationship between domain-general cognitive control, and bilingual lexical production in a language switching task. The findings from this thesis have theoretical consequences for accounts of bilingual lexical processing and for the relationship of bilingualism to non-linguistic executive functioning skills in language selection and switching.

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APPENDIX 1

Please provide the following information about yourself

All information that you provide is confidential in accordance with the Data Protection Act (1998) and The British Psychological Society Code of Ethics and Conduct (2006).

Language Experience and Proficiency Questionnaire (LEAP-Q)

Section 1

<u>General Information:</u>

1. Age: ___________

2. Gender: Male Female (please circle)

3. Dominant hand: Left [ ] Right [ ]
   (that you usually write with)

4. Have you ever been diagnosed with a speech or language disorder?

   Yes [ ] No [ ]

5. Have you been diagnosed with dyslexia?

   Yes [ ] No [ ]

6. Country of origin/nationality: ___________________

7. What is the highest level of certificate that you have now?

1. GCSE or below	
2. A level	
3. Bachelor's degree	
4. Master's degree	
5. Doctorates or above	
6. Others(please specify)	

Section 2

<u>Language history:</u>

8. What is your first language?

____

9. Language(s) of parents (or primary caretaker, guardian, etc): ____________________

10. What is/are the other language (s) that you speak?

____

11. Please list all languages you speak; in the order you began to acquire them (since born). Indicate at what age you began to learn each and at what age (approximately) you mastered each. Also state the overall level of proficiency on a scale of 7. (1 = poor, 4= average (i.e., you can get by OK), 7 = excellent).

	Language	Age began to learn	Age mastered	Overall proficiency
1				
2				
3				
4				

12. In what setting did you acquire the languages stated above? (E.g., at home, through school, living abroad, other)

First language	**Second language**	**Third language**	**Forth language**
o At home	o At home	o At home	o At home
o Through school	o Through school	o Through school	o Through school
o Living abroad	o Living abroad	o Living abroad	o Living abroad
o Other (please specify)	o Other (please specify)	o Other (please specify)	o Other (please specify)

__________________ __________________ __________________ __________________

13. Please indicate the percentage of the time you are currently using each language in **oral communications** at home and outside home. (Your percentages should add up to 100%)

Overall

List language here				
List percentage here				

At home

List language here				
List percentage here				

Outside home

List language here				
List percentage here				

14. Write down the name of the language in which you received instruction in school, for each schooling level:

Primary/Elementary School		
Secondary/Middle School		
High School		
College/University		

Section 3

<u>Language Proficiency:</u>

15. In your **<u>first language</u>**, how proficient do you think you are on a scale of 1 to 7. (1 = poor, 4= average (i.e., you can get by OK), 7 = excellent). (Please circle).
    The far-left end stands for little knowledge in our first language, and the far-right end stands for 100% native-like proficiency.

	poor			average			excellent
Speaking	1	2	3	4	5	6	7
Understanding speech	1	2	3	4	5	6	7
Reading	1	2	3	4	5	6	7
Writing	1	2	3	4	5	6	7

16. In **<u>English</u>**, how proficient do you think you are on a scale of 1 to 7. (1 = poor, 4= average (i.e., you can get by OK), 7 = excellent). (Please circle).
    The far-left end stands for little knowledge in English, and the far-right end stands for 100% native-like proficiency.

	poor			average			excellent
Speaking	1	2	3	4	5	6	7
Understanding speech	1	2	3	4	5	6	7
Reading	1	2	3	4	5	6	7
Writing	1	2	3	4	5	6	7

17. Using the scale below from 0 to 10, please indicate how much the following factors contributed to your learning (the middle of the scale 5=moderate).

0	1	2	3	4	5	6	7	8	9	10
Not a contributor	Minimal contributor				Moderate contributor					Most important contributor

Interacting with friends		Language tapes/self-instruction	
Interacting with family		Reading	
Watching TV		Listening to the radio	

Section 4

Frequency of switching between languages:

18. Do you **now**: **(check the one that applies)**

_______use primarily one language? If so, which one? __________

_______use both languages regularly but in different settings (i.e., one at home and one at school, one with friends and one with family, etc.)

_______use both languages every day within the same setting (i.e., use both at home)

19. How often do you switch between your languages?
    ______________ Frequently
    ______________ only rarely
    ______________ Never

20. When speaking with friends or family who are also speaking in the two languages you speak, do you ever find yourself using both languages within the same conversation or even in the same sentence?
    ______________ Yes, frequently
    ______________ Yes, but only rarely
    ______________ No, never

20. Do you accidentally use your other language while you are in a setting that requires the other one?

_______________ Yes, frequently
_______________ Yes, but only rarely
_______________ No, never

21. **True/False:**

T F I mix languages only when talking to friends or family.

T F I mix languages in conversations with other bilinguals because this enables me to express myself better.

T F I mix languages because of other reasons (please specify):

____

T F I try not to mix languages in the same conversation.

22. When you are speaking, do you ever mix words or sentences from the two or more languages you know?

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

If yes, which ones? _________

23. How often do you use words and structures from your first language when speaking the second?

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

Researcher: Asma Assaneea
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APPENDIX 2

CONSENT FORM

Experiment number: Participant number:

Please answer the following questions to the best of your knowledge
PART 1

	YES	NO
Do you confirm you are:		
(i) Normal or corrected-to-normal vision?	O	O
(ii) Normal hearing ability?	O	O
Have you:	**YES**	**NO**
(i) had an opportunity to ask questions and discuss this study?	O	O
(ii) received satisfactory answers to all your questions?	O	O
(iii) received enough information about the study?	O	O
Do you understand:	**YES**	**NO**
that you are free to withdraw from the study and free to withdraw your data from any future analysis		
• within 2 months after you completed this study	O	O
• without having to give a reason for withdrawing	O	O

PART 2

I hereby fully and freely consent to participate in a study entitled:
Picture naming in bilingual speakers

- I understand the nature and purpose of the procedures involved communicated to me. I understand that some of the tasks involve audio recordings.
- I understand and acknowledge that the investigation is designed to promote scientific knowledge and that the University will use my data for no purpose other than research.
- I understand that a numerical code will replace my name so that my data can remain confidential and that I will not be identified in any way when the research is published.
- I understand that the University of Birmingham may use the data collected for this project in a future research project but that the conditions on this form under which I have provided the data will still apply.
- I understand that audio recordings of my responses will be made during the experiments. I allow processing of the data I provide during the course of this study unless I state otherwise. I understand that this information will be used only for the purpose(s) set out in the information sheet, and my consent is condition upon the University complying with its duties and obligations under the Data Protection Act.
- I understand that my data will be stored anonymously and archived on CD-ROM and that my data may be made available to other researchers in appropriate archives.

Name in BLOCK Letters: ______________________ Experimenter Name:
Signature Participant: ________________________ Experimenter e-mail:
Date: _______________________________________

Please be informed that you can withdraw from the study within 2 months after you completed this study. This means that you data will be permanently deleted. In case you want to withdraw from the study, or you want your data to be excluded, please contact following:

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