Inter-Individual Variability in Language Experience and Its Effects on Metalinguistic Awareness and Non-Verbal Cognitive Control in Bilingual and Monolingual Adults in the Context of Multicultural Australia

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Statement of Originality

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

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Abstract

Bilingual practice in managing two languages has been regarded as a possible candidate for boosting control processes across cognitive domains (e.g., Bialystok, 2017). Given the multidimensional nature of bilingualism (Bialystok, 2001; Laine & Lehtonen, 2018; Zirnstein, Bice, & Kroll, 2019), it has been suggested that the metalinguistic and cognitive consequences of bilingualism are a function of bilingual experience rather than of bilingualism *per se* (de Bruin, 2019; Green & Abutalebi, 2013; Kaushanskaya & Prior, 2015). In the current study, we aimed to contribute to this analysis by exploring whether and in what ways language experience affects metalinguistic awareness and non-verbal cognitive control (i.e. proactive and reactive control processes).

With this aim, we recruited 20-40-year-old bilinguals ($N = 60$) from varied non-English speaking backgrounds and suitably matched English-speaking monolinguals ($N = 24$), all residing in Australia. The participants were screened on key demographic and language variables. Following that, they were tested on the Metalinguistic Awareness Test (Bialystok, 1986; Bialystok & Barac, 2012; Bialystok, Majumder, & Martin, 2003; Davidson, Raschke, & Pervez, 2010) to assess their metalinguistic skills and the Colour-Shape Switching Task (Miyake et al., 2004; Prior & MacWhinney, 2010) to measure mixing costs and switching costs.

The data obtained from the participants were analysed using linear mixed-effects and multiple regression analyses to answer the following research

questions: (1) whether and in what ways *language context* (monolingual, bilingual dual- or bilingual separated-language contexts) affects bilinguals' and monolinguals' metalinguistic and task-switching performance; (2) which (if any) dimensions of bilingual experience – *typological proximity/distance* between two languages, *age of L2 acquisition, onset age of active bilingualism*, *language proficiency* and/or *language entropy* – account for the variance in bilinguals' metalinguistic and task-switching data.

The results from the data analyses revealed that variations in participants' metalinguistic and task-switching performance could be explained in terms of differences in language experience, in particular language context. The bilingual dual-language context was associated with lower scores relative to the monolingual language context and higher scores relative to the bilingual separated-language context. Language context also accounted for the variance in mixing and switching costs. The use of language(s) in the monolingual and bilingual dual-language contexts was associated with reduced mixing costs as compared to the bilingual separated-language context. On the other hand, switching cost advantages were found only among those who used two languages in the dual-language context.

The dimensions of bilingual experience under consideration also accounted for bilingual participants' metalinguistic and task-switching performance. In particular, higher levels of language proficiency, the use of typologically close languages and an earlier onset age of active bilingualism were predictive of higher metalinguistic scores and lower mixing costs. On the other hand, reduced switching costs were related to an equal use of two languages in the same contexts but with different interlocutors.

The results of the present study suggest that the use of two languages in a dual-language context may boost reactive control processes (i.e. switching costs advantages). When combined with typological proximity between two languages and an earlier onset of active bilingualism, such use of two languages is likely to enable bilinguals to obtain/maintain higher levels of language proficiency. This, in turn, may allow them to develop/maintain enhanced metalinguistic skills and experience mixing costs advantages (i.e. advantages in proactive control processes).

Dedication

To all inquisitive minds with a passion for science and love for languages :-).

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CHAPTER 1
INTRODUCTION

1.1. Overview

There is a growing recognition of the role that bi-/multilingualism can play in promoting a socially and cognitively healthy population and, in view of this, exploring language-cognition interfaces in bi-/multilinguals is an important research priority. This is especially true in today's globalised world, in which multiculturalism and bi-/multilingualism are a growing reality for most modern societies (Warren & Benbow, 2008, p. 9). Delving into linguistic and cognitive dimensions of bilingualism – and, more generally, multilingualism – therefore is also crucial for understanding matters concerning the integration and socialisation of people in an increasingly pluralistic world, as well as for political and educational decision-making.

Indeed, our aspiration to advance knowledge in this area was what essentially motivated the study reported on in this thesis. We endeavoured to do that by investigating the possible effects of various dimensions of bilingualism on metalinguistic awareness and cognitive control in 20-40-year-old adults residing in Australia. These dimensions included (1) typological proximity/distance between their two languages, (2) age of L2 acquisition, (3) onset age of active bilingualism, (4) language proficiency, (5) language entropy and (6) language context.

The following sections outline the context of the research: they start with a theoretical background and move on to the study setting. After that, the chapter introduces the research objectives and hypotheses driving the investigation. This is followed by a brief description of the structure of the thesis.

1.2. Research Background

Research findings provide evidence that lifelong experiences modify our brain and cognitive abilities (e.g., Green & Bavelier, 2003; Bialystok & Depape, 2009; Maguire et al., 2000; Lappe, Trainor, Herholz, & Pantev, 2011). With this in view, bilingual practice in managing two languages can be regarded as a possible candidate for exerting its influence on executive control processes across the cognitive domains (Bialystok, 2017).

The idea of bilingualism leading to long-term benefits that extend beyond the sphere of language was first expressed by Vygotsky (1962), a psychologist who was also the first to point to the possible mechanism underlying such an effect. According to him, the ability to express the same thought in different languages leads to an increased awareness of various formal and substantive properties of language. This awareness, in turn, generalises to other areas of cognition, and the effect it has on their development depends largely on the metalinguistic skills.

This view was supported by subsequent research (Bialystok, 1987, 1988; Cummins, 1978; Ianco-Worrall, 1972; Peal & Lambert, 1962; Tunmer & Myhill, 1984; Mohanty, 1994), which demonstrated the superior performance of bilingual children on metalinguistic tasks requiring executive functions. This led some researchers to the hypothesis that bilingualism boosts the development of metalinguistic processes, which, in turn, results in enhanced performance on a variety of non-verbal control tasks (see de Angelis & Jessner, 2012).

A deeper insight into language processing and non-verbal executive functioning in bilingual speakers shed light on the possible effects of bilingualism on cognitive control. According to recent behavioural and functional neuroimaging studies, the brain networks that support domain-general cognitive control in bilinguals overlap with those involved in managing their two languages (Abutalebi & Green, 2007; Branzi, Della Rosa, Canini, Costa, & Abutalebi, 2016; Crinion et al., 2006; Garbin et al., 2011; Hernández, 2009). These findings suggest that intense ongoing use of two languages may furnish bilinguals with a superior and more efficient mechanism that extends beyond language and into other cognitive domains (Bialystok, Craik, Green, & Gollan, 2009; Green & Abutalebi, 2013; Wiseheart, Viswanathan, & Bialystok, 2016).

The idea of bilingual language experience leading to domain-general executive control benefits has provoked a strong interest among linguists and psychologists. The growing body of research notwithstanding, the findings regarding the effects of bilingualism on a speaker's cognitive operations remain mixed and inconclusive. One of the possible reasons for that may be the multidimensional nature of bilingualism (Luk & Bialystok, 2013) and the possibility that at least some of the cognitive consequences of bilingualism are a function of bilingual experiences (Green & Abutalebi, 2013; Kaushanskaya & Prior, 2015).

Bilingualism is a dynamic diverse experience: bilinguals may differ in history of language acquisition (e.g., Luk, De Sa & Bialystok, 2011), language proficiency (e.g., Mishra, Hilchey, Singh & Klein, 2012; Tse & Altarriba, 2014) and/or language usage (e.g, Luk & Bialystok, 2013; Prior & Gollan, 2011), even if they share similar demographic characteristics. Such variation in bilingual experience may affect the way brain networks are adjusted and, therefore, may lead to different functional and structural consequences.

However, most previous studies examining the effects of bilingualism on cognitive control have treated bilinguals and monolinguals as two distinct groups, with their members categorised either as a homogenous whole or in terms of binary oppositions (e.g., early vs late, simultaneous vs sequential, more proficient vs less proficient, L1-dominant vs L2-dominant, balanced vs unbalanced; Yow & Li, 2015). Moreover, most of them did not take into account the differences between the participants' language factors/experiences while interpreting their performance on metalinguistic and non-verbal switching tasks, which may have contributed to the inconclusive nature of the earlier findings. Some studies established bilingual advantages in mixing costs (Barac & Bialystok, 2012; Wiseheart, Viswanathan, & Bialystok, 2016); another revealed switching-cost benefits (Prior & MacWhinney, 2010); and the others did not find any (Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2013, Experiment 3; Paap & Greenberg, 2013).

In view of the very diverse nature of the phenomenon of bilingualism, it seems reasonable to assume that the linguistic and cognitive consequences of bilingualism are a function of bilingual experience rather than of bilingualism per se (de Bruin, 2019; del Maschio & Abutalebi, 2019; Green & Abutalebi, 2013; Kaushanskaya & Prior, 2015; Kroll & Bialystok, 2013). Thus, to model the consequences of bilingualism, it is necessary to look into different dimensions of bilingual experience and the way they interact with domain-general cognitive control. This requires research extending into bilinguals with different language experiences and examining those differences while comparing them with suitable matched monolinguals and interpreting their cognitive performance.

1.3. Study Setting

One of the possible ways of reducing confounds and shedding light on the cognitive dimensions of bilingualism is to study countries and communities whose populations include a significant proportion of bilinguals (Bak & Alladi, 2016, p. 315). In this respect, Australia appears to be a fruitful avenue for exploration.

Australian society has a heterogeneous population compared with other countries in the world. It consists of Indigenous people, descendants of the original UK settlers and a diverse group of immigrants, who either come to Australia as bilinguals or develop bilingual knowledge in the years following their arrival. Considering this, Australia is a multilingual and multicultural country, with the official language, English, coexisting with Aboriginal and immigrant languages.

In order to coordinate different languages harmoniously, Australia officially issued a *National Policy on Languages* in 1987. As pointed by Lo Bianco (1987), its purpose was to replace the trend towards English monolingualism with a trend towards widespread bilingualism. This implied the acceptance of not only Australian English, but also all Aboriginal and immigrant languages as unique heritages of Australia, and the availability and accessibility of bilingual and bicultural education to both English and non-English speakers.

Since that time, Australia has become even more culturally and linguistically eclectic. Among the approximately 400 languages used in the homes of Australia's residents are English, Indigenous languages and a variety of community languages (Clyne, 2011).

According to the 2016 Census data (Australian Bureau of Statistics, 2016), one in five Australians now speaks a language other than English at home. Among them, the most commonly spoken are Mandarin, Arabic, Cantonese, Vietnamese and Italian, as compared to Italian, Greek, Cantonese, Arabic, Mandarin and Vietnamese in 2006 (Australian Bureau of Statistics, 2006). This points to two opposite tendencies in Australian society: a substantial decrease in the home use of a number of European languages (in particular German, Italian and Greek) and a great increase in Asian languages, especially Mandarin. In other words, the linguistic diversity of Australia is shifting away from the European languages of the post-war period to languages of new migration waves, mainly from Asia and the Middle East (Kipp & Clyne, 2003; Clyne, Hajek, & Kipp, 2008).

The substantial number of non-English languages notwithstanding, Australia remains a strongly Anglocentric country, where the dominance of English is largely unchallenged (Rubino, 2010). As pointed out by Clyne (2005), the ‘monolingual mindset’ is still one of the key challenges of modern Australian society. The majority of its native English speakers do not speak any other language. Moreover, they show limited interest in languages and/or language study (Liddicoat & Curnow, 2009). In addition to cultural and social attitudes, the limited availability and accessibility of language programs in Australian institutions is another possible barrier to cultivating Australian bilingualism/multilingualism (Rubino, 2010).

In this light, bilingualism and multilingualism in Australia appear to be represented mainly by Aboriginal people and immigrants from non-English speaking backgrounds (individual bilingualism). However, even they tend to abandon their native languages relatively quickly as a consequence of lack of opportunities to apply their native language in broader social contexts (mostly single-language contexts) and lack of institutional support.

1.4. Research Objectives

The empirical purpose of this research is to establish whether and in what ways language experience affects metalinguistic awareness and non-verbal cognitive control (i.e. proactive and reactive control processes) in bilingual adults. To do so, the project aims at the following objectives:

1) To review and critically evaluate existing approaches to the notion of bilingualism and instruments used to assess bilingual language profiles.

2) To review and critically evaluate existing conceptualisations of metalinguistic awareness and instruments used to assess it.

3) To review and critically evaluate existing conceptualisations of non-verbal cognitive control and tasks used measure to measure it.

4) To obtain language and demographic background data from a group of bilingual adults from non-English speaking backgrounds and a suitably matched control group of English monolinguals residing in Australia.

5) To assess the levels of metalinguistic awareness and to measure non-verbal cognitive control, i.e. reactive and proactive control processes, in bilingual and monolingual adults.

6) To examine the capacity of several language variables to predict metalinguistic and task-switching performance of bilingual and monolingual adults.

1.5. Research Questions

In our psycholinguistic exploration of metalinguistic and cognitive dimensions of bilingualism, we sought to answer two research questions:

1) How (if at all) does language context affect the metalinguistic and task-switching performance of bilingual and monolingual adults? For this, we investigated three language contexts among bilingual and monolingual participants: (1) the bilingual dual-language context (the use of two languages in the same context(s), but with different speakers), (2) the bilingual separated-language context (the use of two languages in different contexts) and (3) the monolingual language context (the use of one language across all contexts).

2) Which dimensions of bilingual language experience (if any) account for the variance in the metalinguistic and task-switching performance of bilingual adults and how (if at all) does each of these dimensions affect the bilingual participants' performance? In particular, we considered (1) typological

proximity/distance between the two languages of bilinguals (Germanic languages/smaller distance and non-Germanic languages/larger distance), (2) age of L2 acquisition (the age at which bilinguals started learning the second language), (3) onset age of active bilingualism (the age at which bilinguals began using both languages actively on a daily basis), (4) language proficiency in two languages and (5) language entropy (the proportional L1 and L2 use).

1.6. Research Hypotheses

Our predictions regarding the effects of language experience on metalinguistic and task-switching performance were as follows.

1) Given the possibility of metalinguistic awareness and proactive control processes being affected by language proficiency (e.g., Bialystok & Barac, 2012; Green & Abutalebi, 2013), we expected a language context with higher levels of language proficiency to be related to higher levels of metalinguistic awareness and reduced mixing costs. On the other hand, a language context with an equal use of two languages was expected to be linked to reduced switching costs, if reactive control processes are sensitive to the way and extent to which language(s) are used (e.g., Bialystok & Barac, 2012; Hartanto & Yang, 2016).

2) Given the previously reported effects of language proficiency on the level of metalinguistic awareness in children (e.g., Bialystok & Barac, 2012)

and proactive control processes across the lifespan (Green & Abutalebi, 2013), we hypothesised that *language proficiency* would explain most of the variance in metalinguistic performance and mixing costs. In particular, we expected that higher language proficiency would result in a higher level of metalinguistic awareness and enhanced proactive control processes.

On the other hand, given the previously reported effects of language use on reactive control processes (Bialystok & Barac, 2012; Hartanto & Yang, 2016), we expected *language entropy* to explain most of the variance in switching costs. In particular, we hypothesised that more equal use of two languages in the same contexts but different interlocutors would result in reduced switching costs.

Besides *language proficiency* and *language entropy*, *typological proximity/distance* between two languages was hypothesised to shape the metalinguistic awareness and task-switching performance of bilingual participants. In this case, the following scenarios were considered. If the management of two typologically close languages involves greater analysis and/or control demands, then the use of two Germanic languages by the same speakers in the current study would be related to higher metalinguistic scores, lower mixing and/or switching costs. If the opposite is the case, then the use of typologically close language pairs would result in lower metalinguistic scores and higher costs.

In line with previous studies (e.g., Luk, De Sa, & Bialystok, 2011; Tao, Taft, Asanowicz, & Wodniecka, 2011), *onset age of active bilingualism* (as opposed to age of L2 acquisition) was also regarded as a potential predictor of metalinguistic awareness and cognitive control in bilinguals. We expected to find higher metalinguistic awareness scores and lower costs for an earlier onset age of active bilingualism.

Such findings would thus reinforce the role of language experience in shaping metalinguistic awareness and non-verbal cognitive control in adults.

1.7. Significance of the Study

Given the gaps/limitations of previous metalinguistic awareness and task-switching studies (see Section 1.2), a number of design decisions were made to eliminate these gaps/limitations in the present study. First of all, we targeted a linguistically diverse sample of bilingual participants. The bilinguals were heterogeneous in terms of L1 backgrounds (but had the same L2 – English). They also differed in the age at which they started learning the second language, in the age at which they began using two languages actively on a daily basis, in language proficiency and in language use. We also considered the inter-individual variability in their language experience when interpreting their metalinguistic and task-switching performance. This way it was possible to investigate whether and in what ways bilingual experience – typological proximity/distance between two languages, age of L2 acquisition, onset age of active bilingualism, language proficiency and/or language entropy – affects metalinguistic awareness and non-verbal cognitive control in bilingual adults.

Furthermore, we also included monolinguals in our study to benchmark bilinguals' results. Together with the data on inter-individual variability in our bilingual participants, this enabled us to isolate mixing- and/or switching-cost advantages (if any) in bilingual adults, and thus to provide a starting point for understanding what the underlying mechanisms of metalinguistic and cognitive advantages might be. Moreover, we targeted young to middle age adults, an age group with less well established bilingual advantage than children and older people (Barac & Bialystok, 2012; Prior & MacWhinney, 2010).

What is more, our study is, to the best of our knowledge, the first one to explore the effects of bilingual experience on metalinguistic awareness and non-verbal cognitive control in adults in the context of multicultural Australia. Therefore, it was possible to make a range of distinct theoretical and practical contributions to the field of bilingualism.

1.8. Thesis Structure

The present study is organised as follows. Chapter 2 provides the background of the current research. It summarises the literature related to the concept of bilingualism and outlines the tools which have been used to assess bilingual language profiles. The chapter also reviews studies on metalinguistic awareness and cognitive control in general and in the context of bilingualism in particular, with special attention given to the tasks used to measure them.

Chapter 3 describes the specifics of the current study's research design and methodology. In the first place, the chapter provides comprehensive information about the participant sample, including the recruitment and screening procedures. Then it moves on to the tasks used to assess metalinguistic awareness (the Metalinguistic Awareness Test) and to measure non-verbal cognitive control, proactive and reactive control processes (the Colour-Shape Switching Task). The chapter ends with a statement of the procedures used for data analysis and interpretation.

Chapters 4 and 5 present the results of the research project, including the relevant variables obtained via background measures and data collection tasks, and statistical analyses conducted in R. Chapter 4 covers results in relation to both monolingual and bilingual data, while Chapter 5 focuses on results pertaining to bilinguals only. In both chapters, the data are given in the form of tables and figures together with a verbal summary of the most significant features.

Chapter 6 discusses and interprets the main findings of the study. It revisits the main research questions with reference to the capacity of language context and dimensions of bilingual language experience to predict the metalinguistic and task-switching performance of bilingual and monolingual (if applicable) adults. The chapter identifies the types of bilingual language experience which were found to have cognitive effects, and considers the extent to which these variables affected metalinguistic awareness and mixing and switching costs. It also outlines the place of the study's findings relative to previous research on bilingualism and cognition.

Chapter 7 provides a brief summary of the findings and highlights the present research's most important contributions to the study of bilingualism, particularly with reference to gaps/inconsistencies/problems which we identified in previous research. It also considers the theoretical and practical implications of the findings, particularly what these findings mean for the further advancement of the theory of the language-cognition interface in bilingual speakers, but also more broadly for the development of social and educational policies designed to support bi-/multilingual and multicultural practices. Finally, it identifies the limitations of the project and recommends areas and possibilities for future research on bilingualism.

CHAPTER 2

LITERATURE REVIEW

2.1. Overview

The purpose of the chapter is to provide the background information for the current study. It serves as a bridge between the research problem existing in the field and the original contribution of this project towards solving it.

The chapter starts with a broad overview and critical evaluation of the existing approaches to the notion of bilingualism and measures used to assess its degree. It goes on to explore metalinguistic awareness, with special attention to the tasks aimed at assessing it. This is followed by a detailed review of the studies focusing on metalinguistic awareness in bilinguals. Then the chapter draws attention to cognitive control and tasks used to measure it. It culminates in reviewing this concept in the context of bilingualism and draws attention to currently existing gaps in knowledge in this field.

2.2. Bilingualism

2.2.1. Bilingualism as a multidimensional concept. Bilingualism is concept with 'open-ended semantics' (Beardsmore, 1982, p. 1), which has been studied and defined from different perspectives, such as linguistic, cognitive and sociocultural ones. This has resulted in a variety of surprisingly vague and even contradictory descriptions and interpretations.

Most of the early definitions of bilingualism range from “a native-like competence in two languages to a minimal proficiency in a second language” (Hamers & Blanc, 1989, p. 7) i.e. a maximalist vs. a minimalist views.

From the maximalist perspective, bilingualism is seen as “a native-like control of two languages which results only if a perfect foreign-language learning is not accompanied by loss of the native language” (Bloomfield, 1933, p. 55-56). Compare the following other definitions: “complete mastery of two different languages without interference” (Oestreicher, 1974, p. 9); “a person who knows two languages with approximately the same degree of perfection as unilingual speakers of those languages” (Christopherson, 1948, p. 4). Although bilinguals who fit the indicated definitions do exist, they are regarded as a ‘rare species’.

In the minimalist approach, bilingualism is believed to emerge when “a speaker can first produce complete meaningful utterances in the other language” (Haugen, 1953, p. 7), with a minimal degree of competence in one of the four language skills (speaking, writing, reading and understanding speech) being regarded as sufficient (Macnamara, 1969).

Although these two views on the nature of bilingualism differ, they have something in common. First of all, they lack precision: they do not specify what is meant by native-like competence, nor by minimal proficiency in a second language (Hamers & Blanc, 1989). Secondly, both approaches refer to a single dimension of bilinguality – the level of proficiency in both languages – without taking into account other linguistic and non-linguistic aspects of this phenomenon. Thus, they fail to provide a valid comprehensive description of bilingualism.

In contrast to the earlier definitions, more recent ones tend to view bilingualism on a multidimensional continuum (e.g., Bialystok, 2001a; Grosjean, 1982; Paradis, 1986). According to Grosjean (1985), the bilingual speaker is not a double monolingual, because their speech shows characteristics (e.g. code-switching) that a monolingual speaker lacks.

Equally for Lüdi (1986) and Cook (1991), bilingualism is more than the mechanical sum of two monolingual competences. Instead, it is regarded as a "a conglomerate of linguistic and social trajectories" (Kroll & De Groot, 2005, p. 438) that play a significant role in determining the ways in which bilingualism affects language-related processes in particular and modulates the domain-general cognitive system in general (de Bruin, 2019; Green & Abutalebi, 2013; Kaushanskaya & Prior, 2015; Kroll & Bialystok, 2013).

As a complex multidimensional construct, bilingualism appears to be sensitive to a number of distinct but interacting language learning and use variables (del Maschio & Abutalebi, 2019; Laine & Lehtonen, 2018; Luk & Bialystok, 2013; Prior & Gollan, 2011; Sulpizio et al., 2020; Zirnstein, Bice, & Kroll, 2019).

One of the factors that is argued to be important for a comprehensive description of bilinguals is age and manner/setting of L1 and L2 acquisition (Dussias & Sagarra, 2007; Hyltenstam & Abrahamsson, 2003; Pliatsikas & Marinis, 2013; Reiterer, Pareda, & Bhattacharya 2009; Sabourin, Burkholder, Vīnerte, Leclerc, & Brien, 2016). However, age of language acquisition does not necessarily reflect the age of becoming bilingual and duration of bilingual experience. Having acquired two languages, an individual may not immediately start using both of them. Thus, in addition to age of language acquisition, it is necessary to assess onset age of active bilingualism, i.e. the age at which they began using two languages actively on a daily basis (Luk et al., 2011).

Besides the age of language acquisition and the onset age of active bilingualism, proper assessment of the linguistic profiles of bilingual speakers requires data on proficiency in both languages (Bedore, Pena, Joyner, & Macken, 2011; Blumenfeld & Marian, 2007; Dixon, Wu, & Daraghmeh, 2012; Proverbio, Adorni, & Zani, 2007; Sumiya & Healy, 2008) and functions of each of them (Grosjean, 1982; Mackey, 1968). Most bilinguals use L1 and L2 for different purposes and under different conditions. As a result, they develop the four basic skills in each language (speaking, listening, reading and writing) to the levels required by the environment (Grosjean, 1982). This implies the need to assess proficiency in speaking, listening, reading and writing in both languages while describing a person's bilingualism.

In addition to proficiency in both languages, the need for and use of two languages also appears to shape bilingual experience. A number of researchers have put stress on these aspects while defining bilingualism. For example, Weinreich (1968) and Mackey (1968) treat bilingualism as the alternate use of two languages. Following them, Grosjean (1982) emphasises that when and how bilinguals use their languages are as important or even more important than fluency.

The emergence of language use as an important dimension of bilingual experience fits well with the Adaptive Control Hypothesis (Green & Abutalebi, 2013), which emphasizes the role of sociolinguistic context in determining the nature of the bilingual effects. According to Green and Abutalebi, each of the interactional contexts engages different control processes and to a different extent, therefore, leads to different language and cognitive consequences of bilingualism (see Sections 4.2 and 5.2.6). This points to the need to include information on sociolinguistic context while creating the linguistic profiles of bilingual participants (Bak, 2016; Freedman et al., 2014; Luk & Bialystok, 2013; Paap, Johnson, & Sawi, 2016; Watson, Manly, & Zahodne, 2016).

Taken together with social and personal factors, inter-individual variability in language experience makes bilingualism deeply heterogeneous and undoubtedly shapes its language and cognitive consequences (e.g., Bialystok, 2001a; Bialystok, Craik, Green, & Gollan, 2009; Hilchley & Klein, 2011). Accordingly, a better conceptualization of bilingualism should not only be centered on a qualitative perspective, but also take into account quantitative measures such as the extent to which individuals vary as bilinguals (Laine & Lehtonen, 2018; Sulpizio et al., 2020). This offers a more ecological description of bilingualism and can improve our understanding of language-cognition interfaces in bilinguals.

2.2.2. Means of assessing bilingualism. Sampling is often one of crucial factors determining the pattern of findings (e.g., Hakuta & Diaz, 1985). For the results to be valid, it is necessary to identify and control all sources of extraneous variance, in other words to match participants on as many features as possible (Bialystok, 2001).

Considering the multidimensional nature of bilingualism, selecting participants is especially challenging when it comes to research on bilinguals. Along with variations in their language characteristics and bilingual experiences (Luk & Bialystok, 2013), bilinguals tend to differ in other relevant variables, e.g., socioeconomic and sociocultural backgrounds (Cox et al., 2016; Mohanty & Babu, 1983). This makes it difficult to analyse and interpret their performance on language and cognitive tasks and compare them with suitably matched monolinguals.

One of the methods used by researchers to describe an individual's bilingualism is administering language tests in both their languages (e.g., Bialystok & Barac, 2012; Gollan, Weissberger, Runngvist, Montoya, & Cera, 2012; Sheng, Lu, & Gollan, 2014). This way it is possible to compute a score that captures both the absolute and relative proficiency levels in each of the two languages.

Despite its merits, this approach can only be applied if it is possible to test proficiency in both languages. This can be done, for instance, when bilinguals speak same pair of languages, especially if there are existing standardized tests for proficiency in each language. However, objective testing may be difficult to implement when it comes to bilinguals with different pairs of languages. What is more, merely assessing proficiency in both languages fails to capture the whole variety of the bilingual experiences. In this light, it seems worth describing bilingual language profiles with the help of an extensive questionnaire tapping into different aspects of language use and proficiency (de Bruin, 2019).

Self-assessment tools have been used extensively in studies on bilingualism. In general they focus on language history and proficiency, including domain-general (e.g., Bahrick, Hall, Goggin, Bahrick, & Berger, 1994; Delgado, Guerrero, Goggin, & Ellis, 1999) and domain-specific proficiency (e.g., Flege, Yeni-Komishian, & Liu, 1999; Jia, Aaronson, & Wu, 2002; Vaid & Menon, 2000).

In spite of targeting similar aspects of bilingualism, most of the questionnaires differ in their approaches to determining and measuring them. Some researchers assess self-reported proficiency in comprehending, speaking, reading and writing (e.g., Vaid & Menon, 2000), while others measure proficiency only in some skills (e.g., Jia et al., 2002). In addition, the scales used across studies often differ as well: they range from a 4- to a 10-point scale. Taken together, the variation in assessment measures make it difficult to interpret and generalize findings across studies.

In this light, two new instruments have been introduced – the Language Experience and Proficiency Questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007) and the Language History Questionnaire (Li, Sepanski, & Zhao, 2006; Li, Zhang, Tsai, & Puls, 2014). The Language Experience and Proficiency Questionnaire (Marian et al., 2007) is based on language history and proficiency variables which have been revealed to significantly contribute to bilingual status, in particular, language competence (including proficiency, dominance and preference ratings); age and modes of language acquisition; and prior and current exposure to L1 and L2 across settings.

The fact that it covers a broad range of language experience makes the Language Experience and Proficiency Questionnaire a useful tool for measuring language status. Furthermore, its internal validity has been established (Marian et al., 2007). Pearson's correlation analyses demonstrated strong correlations between the students' self-rated language proficiency responses and the behavioural measures of their language proficiency. However, the fact that a cases-to-variables ratio fell below that recommended to estimate factor analysis models – over 70 items and only 50 participants – requires the resulting models to be interpreted cautiously. Besides, there is not enough information on how to definitively classify participants and differentiate between types of bilinguals (Anderson, Mak, Chahi, & Bialystok, 2018).

The Language History Questionnaire by Li et al. (2006) is based on the most commonly used questions in 41 published questionnaires. Its items provide information on the participants' language history (e.g., age at time of second language acquisition and length of second language education), self-rated first and second language proficiency and language usage in the home environment. In addition to covering a broad range of bilingual experiences, the questionnaire has been reported by Li et al. (2006) to have sound predictive validity and high reliability (split-half coefficient at .85).

To make the instrument more user-friendly, Li et al. (2014) revised its web-interface. The latest version enables researchers to select the length and the language of the questionnaire. However, it still lacks information on how to interpret responses collected via it. Therefore, researchers using the questionnaire have to determine their own methods for participant classification. This, in turn, may lead to variations in the findings among studies on bilingualism.

Besides the instruments described above, researchers targeting homogenous groups of bilinguals sometimes combine self-report, interviews and behavioural methods of assessment. For instance, Gollan, Weissberger, Runnqvist, Montoya, and Cera (2012) and Sheng, Lu, and Gollan (2014) administered a self-rated language proficiency questionnaire, interviews with participants and picture naming tasks in both languages as a behavioural measure of language proficiency.

Using both objective and subjective assessments can clearly provide a more reliable assessment of bilingualism. However, this approach is not always feasible. As mentioned above, it is restricted to cases with a limited range of languages in the sample and with a possibility to assess both languages through standardized measures. But when it comes to heterogeneous groups of bilinguals who live in diverse communities, an alternative universally applicable method is needed (Anderson et al., 2018).

The lack of an instrument for quantifying bilingualism has been identified as a significant methodological issue (Calvo, García, Manoiloff, & Ibáñez, 2016; Grosjean, 1998), especially in the case of young adults. To solve this methodological problem, Anderson et al. designed the Language and Social Background Questionnaire (2018). It is aimed at adults with varying degrees of language experience who live in diverse communities, i.e. communities with a lot of different ethnic groups.

The Language and Social Background Questionnaire contains three sections. The first one (Social Background) targets demographic information such as age, education, country of birth, immigration and parents' education (parents' education as a proxy for socio-economic status). Another section (Language Background) gathers information on language(s) spoken, context and age of language acquisition. In addition, there are questions asking participants to self-rate their proficiency for speaking, understanding, reading and writing the languages, which the subjects indicated they knew (0 indicates *no ability at all* and 100 indicates *native fluency*). There are also items related to the frequency of use for each language ranging from 0 *none of the time* to 4 *all of the time*. The third section (Community Language Use Behaviour) covers language use in different life stages (infancy, preschool age, primary school age and high school age) and in specific contexts (with different interlocutors, in different situations and for different activities). In addition, there are questions targeting language-switching in different contexts. In all cases, participants are asked to rate their language usage on a 5-point Likert scale (0 represents *all English*, 2 stands for *an equivalent use of English and the other language* and 4 represents *only the other language*).

Like the other available instruments, the questionnaire by Anderson et al. (2018) depends on self-reporting and self-assessment. However, potential deficiencies of self-reporting are minimised through multiple questions that are demonstrated through factor analysis to be reliably related. What is more, Anderson et al. provide instructions on how to code and interpret the data collected from the questionnaire. Thus, the questionnaire seems to provide a comprehensive and reliable assessment of bilingual language profiles, which can be used to quantify bilingualism and lead to evidence-based classifications across bilingual populations and settings.

2.3. Metalinguistic Awareness

2.3.1. The notion of metalinguistic awareness and tasks aimed at assessing it. Metalinguistic awareness is a unique construct which has been implicated in various linguistic and cognitive achievements (Ehri, 1979; Hakes, 1982; Scribner & Cole, 1981). However, the precise nature of metalinguistic awareness is still quite controversial.

2.3.1.1. Metalinguistic awareness as a specific type of linguistic competence. Earlier studies tend to broadly define metalinguistic awareness as the ability to think, analyse and inwardly reflect on formal aspects of language (Baker & Jones, 1998; Dillon, 2009; Lasagabaster, 2001). For example, Pratt and Grieve (1984) treat it as the ability to reflect upon language as a system of communication, bound to rules, as well as to evaluate it (cf. Thomas, 1992). This accords with Galambos and Hakuta's perception (1988, p. 141) of metalinguistic awareness as "the ability to attend and reflect upon the properties of language" as well as with James and Garrett's proposition (1991, p. 3) that it is "the ability to think about and to reflect upon the nature and functions of language".

In the same vein, Malakoff (1992, p. 518) suggests that metalinguistic awareness "allows the individual to step back from the comprehension or production of an utterance in order to consider the linguistic form and structure underlying the meaning of the utterance". Similarly, Jessner (2006, p. 42) considers it to be the ability to "focus attention on language as an object in itself or to think abstractly about language, and consequently, to play with or manipulate language”. Metalinguistic awareness is, therefore, regarded as the last stage of language development (Ter Kuile et al., 2011; Whitehurst & Lonigan, 1998). On reaching it, individuals are able to do the following: 1) identify phonological components and intentionally manipulate them (phonological awareness); 2) isolate words in utterances while being aware of the arbitrary relation between them and their meanings (word awareness); and 3) reason consciously about the syntactic aspects of language (syntactic awareness).

2.3.1.1.1. Phonological awareness. Most of the works dealing with the conscious discrimination and manipulation of phonological components focused on the identification of rhymes, phonemes and syllables, which are regarded as key aspects of phonological awareness (Davidson, Raschke, & Pervez, 2010; Wray, 1994).

Ianco-Worrall (1972) used a phonetic preference test. It consisted of eight one-syllable sets of words, which were verbally presented in two languages. Each set was made up of three words, with one being standard and the other two being choice. Subjects were asked to decide which of the choice words was phonetically related to the standard one (“I have three words: cap, can and hat. Which is more like cap, can or hat?”). A similar forced-choice technique can be found in the studies of Lenel and Cantor (1981) and Smith and Tager-Flusberg (1982). However, the technique used in the two studies has been criticised for not requiring a specific identification of a syllable (Content, 1985; Gombert, 1992).

Another experimental paradigm was applied by Fox and Routh (1975). Children were presented with syllables composed of two or three phonemes and then were asked to repeat ‘just a little bit of what I say’. If a subject produced insufficient segmentation, the tester continued to ask for an additional segmentation. Moreover, in two tests immediately preceding this stage, subjects had already been asked to segment sentences into words and then words into syllables using the same procedure. Even if these tasks were not specifically designed as training tasks by the authors, they might have influenced the levels of performance in a test for phonemic segmentation (Gombert, 1922, p. 24).

Liberman (1973) suggested a quite different method, which he applied to study children’s ability to discriminate consciously between phonemes. It required subjects to repeat a syllable or a monosyllabic word and then tap the table once for each phoneme. This experiment was faithfully reproduced by Hakes (1980). Similar method was used by Tunmer and Nesdale (1982). However, given “a possible risk of confusion between phoneme and letter” (Gombert, 1992, p. 20), the researchers replaced half of the test items with some containing phonemes that in the written language were represented by two letters.

To increase the complexity of the task, researchers asked their subjects not only to count but also to identify the individual phonemes in a given syllable.

For example, Goldstein's experiment (1976) required participants to isolate the components of monosyllabic words consisting of two or three phonemes by pronouncing each of the segments. Following that, subjects were asked to re-create words, which had been fragmented into their constituent phonemes.

Another quite sophisticated method, which was frequently used for studying children's capacity for phonemic segmentation, required subjects to repeat words or syllables in which one phoneme had been omitted. One of the first researchers to apply it was Bruce (1964). This method was also integrated into the study carried out by Rosner and Simon (1971). The researchers orally presented a number of words to their subjects, who had to repeat each of them twice. While doing it for the second time, the children were asked to omit one syllable, an initial, medial or final one, with the remaining segment being a meaningful or non-meaningful one. According to Gombert (1922, p. 23), the task of removing the initial syllable can be regarded as the most reliable subtask.

Calfee, Lindamood, and Lindamood (1973) developed a more creative task. It called for arranging colour cubes to reflect the position of phonemes in syllables, which were presented to participants orally. In the first subtest, subjects were told to arrange the colour cubes to represent the positions of the phonemes, which they just heard. In the second subtest, they were provided orally with more complex syllables while being shown corresponding arrangements of cubes. What they had to do was to create other syllables using the same phonemes.

A quite different technique was suggested by Bialystok (1986). The so-called forced-choice method required participants to decide which of two given words was longer. The point was that in some pairs the longer word corresponded to the referent with the larger size, while in others the opposite was the case.

Kolinsky, Cary, and Morais' (1987) study was carried out in a similar way. They asked their subjects to provide examples of short and long words as well as to designate which of two pictures represented the object with the longer name. As with Bialystok's (1986) study, the difference in the size of the objects correlated with the difference in the length of their names only in some pairs, while in others there was no correspondence between the linguistic and extralinguistic dimensions. The second part of their experiment, i.e. judging the length of the names of the objects in the pictures, was later reproduced in Yelland, Pollard, and Mercuri's study (1993).

2.3.1.1.2. Word awareness. The studies looking at word awareness approached the concept from two related perspectives. One was awareness of the segmentational process that isolates words in utterances, and the other was awareness of the arbitrary relation between words and their designated meanings (Bialystok, 2001b).

Awareness of segmentational process was assessed with the help of the tasks, which required subjects to segment sentences or word sequences into words or to count the number of words in a sentence or sequence of words.

As in their tasks of breaking down syllables into phonemes, Fox and Routh (1975) asked children to repeat 'just a little bit' of a sentence said to them, with the length of sentences ranging from two to seven words. However, according to Gombert (1992), their tool cannot be considered reliable, since the researchers continued to ask their subjects for further segmentation until a sound sequence corresponding to one word was produced.

Another segmentation task was used by Tunmer and Bowey (1981). It required subjects to identify each word by tapping on the table (word-tapping task). The actual experiment was preceded by the training phase, during which subjects were provided with feedback. However, as Bowey and Tunmer (1984) mentioned, the fact that only words containing a single stressed syllable were used in the experiment casts doubt on the validity of the results.

A number of researchers integrated into their studies a task based on counting the number of words in a sentence (Berthound-Papandropoulou, 1978, 1980; Hall, 1976; Karpova, 1966). A somewhat different technique was used by Christinat-Tieche (1982). It required participants to make up a story in pairs, with each subject taking turns to invent 'a tiny little bit'. To demonstrate what could be added to the story, two examples were given: the first was a single word and the second was a phrase composed of nominal and verbal groups.

Realisation of the arbitrary nature of name-object relationship by children was first studied with the help of the sun-moon problem (Piaget, 1929). The task was based on a set of questions concerning the origin of names and the possibility of substituting other words for the names of objects. The participants were asked if it was possible to change the names for the sun and moon, and if so, what would be up in the sky at night. In addition, they had to say what the sky would look like at night.

A similar technique was used by Vygotsky (1934). It required subjects to explain whether a number of names could be interchanged. Then they had to decide whether the attributes of the objects changed along with their names. Following Vygotsky's approach, Ianco-Worrall (1972) and Cummins (1978) carried out more systematic studies.

Ianco-Worrall (1972) developed a short questionnaire, consisting of three parts. Part I called for an explanation of six names: *dog*, *cow*, *chair*, *jam*, *book* and *water* (e.g., "Why is a dog called 'dog'?"). Part II required subjects to say whether the three pairs of names could be interchanged: *dog* and *cow, chair* and *jam, book* and *water* ("Could you call a dog 'cow' and a cow 'dog'?"). Finally, in Part III those names were interchanged in play ("Let us play a game. Let us call a dog 'cow'").

Cummins (1978) used a number of metalinguistic tasks aimed at word awareness. For instance, one focused on determining whether a child considered a word to be stable even when the object it referred to no longer exists. In another task, subjects were asked whether words possessed the physical properties of the objects they represented ("Is the word 'book' made of paper?").

Referential arbitrariness was assessed in a similar way by Edwards and Christophersen (1988). They integrated two tasks, with one requiring subjects to change the names for the sun and moon (as well as for cats and dogs) and the other calling for answering questions dealing with the tangible properties of words ("Does the word 'bird' fly in the sky?").

Ben-Zeev (1977) went further and designed an extended seven-item task. The first two items required subjects to recognise that a word can be substituted for another instead of being tied to its referent ("You know that in English this is named an airplane" [an experimenter shows a toy airplane]. "In this game, its name is turtle. … Can the turtle fly?" [Correct answer: Yes]. "How does the turtle fly?" [Correct answer: With its wings.]"). The remaining five items all called for the substitution word (a major part of speech was substituted for another major one or a minor one) to violate selectional rules of the language ("In this game, the way to say 'we' is with 'spaghetti'. How would you say, "We are good children?" [Correct answer: Spaghetti are good children]).

Awareness of referential arbitrariness was sometimes assessed by asking subjects to explain what a word was and to give examples of words possessing particular characteristics (Berthoud-Papandropoulou, 1978, 1980; Francis, 1973; Osherson & Markman, 1975; Smith & Tager-Flusberg, 1982; Templeton & Spivey, 1980).

Tasks involving lexical ambiguity and synonymy were similarly used to reveal the ability to dissociate a word from its referent. Manipulation of lexical ambiguity, which presupposes a recognition that at least two referents can have the same phonological realisation, was studied mainly by asking subjects to paraphrase or designate the referents in pictures (Bialystok, 1986). Tasks of judging lexical synonymy (or quasi-synonymy) required deciding which of two words (e.g., *frog* or *puppy*) had the same meaning as a given one (e.g., *dog*).

2.3.1.1.3. Syntactic awareness. The prototypical task assessing syntactic awareness required subjects to make a judgement about the grammatical acceptability of a sentence and correct it if necessary. However, the task was manipulated by each researcher to create more precise tools. The changes usually involved the level of detail of examination required or the length and complexity of sentences.

The sentence-judgement task was effectively applied by de Villiers and de Villiers (1972). They showed children a puppet to which they attributed a number of different utterances, including correct ones, semantically abnormal ones, and imperatives that were rendered ungrammatical by an inversion of verb and object. Subjects were informed that the puppet was liable to make utterances 'all the wrong way round' and they were asked to say those ones in the proper way. In order to fulfil the task, it was necessary to judge the given sentences as ‘right’ or ‘wrong’, with the correction being proposed for those ones that were judged incorrect.

This experiment was repeated by Smith and Tager-Flusberg (1982). They used two puppets – Cedric, who was learning to speak, and Raggedy Ann, who had to teach Cedric to speak correctly. Although Smith and Tager-Flusberg used only correct imperative sentences and inverted imperatives, the task remained the same. Subjects had to help Raggedy to decide whether Cedric’s utterances were ‘right’ or ‘wrong’, with the picture being given to aid the identification of each item and provide a correction if necessary.

The task was somewhat modified in the study of Hakes (1980). It included a set of six sentences containing three simple declarative sentences of the form subject-verb-object and three sentences of the same nature but inverted to the form object-verb-subject. Subjects were asked not only to make judgements concerning word order, but also to distinguish between sentences containing violation of the rules of lexical selection and subcategorization concerning transitive and intransitive verbs. Following the preceding experiments, Hakes used a fictional speaker – a toy elephant – whose utterances were sometimes ‘all mixed up’. Subjects were required to judge them and to correct them if they were judged to be incorrect.

The method used in the three studies to assess syntactic awareness was criticised by Scholl and Ryan (1980). The researchers doubted that the children are aware of the significance of the adjectives ‘right’ and ‘wrong’. Moreover, the fact that the children were asked only to correct the sentences which they considered ‘wrong’ made the results biased. According to Scholl and Ryan, subjects might have been tempted to accept sentences so that they did not have to correct them.

In order to avoid such semantically charged terms as ‘right’ and ‘wrong’, Scholl and Ryan (1980) designed a non-verbal experiment. In this experiment, subjects had to indicate the photograph of the presumed author of a proposed utterance, with one being a picture of a child who was said to be a bad speaker and the other of an expert adult speaker. However, the sentences provided by Scholl and Ryan were rather complex and the grammatical mistakes found there were common in the language of children.

A somewhat different approach was suggested by Bohannon (1976). The researcher asked children to attribute utterances, well-formed or with a distorted word order, to one of two adult speakers, Norman or Ralph. Subjects had heard both of them speaking before the experimental phase, although the difference between two of the speakers had not been explained to them. In comparison with the previous studies, Bohannon confronted his target group with much longer sentences whose distortion of word order was also much more pronounced.

Pratt and Grieve (1984) ascribed two more sources of bias to sentence-judgement tasks. According to them, there was the possibility that children’s understanding of grammatical rules might be confused with their ability to express them and that subjects might reject a particular sentence simply because ‘it does not sound right’. To avoid these potential risks, Pratt and Grieve designed a procedure aimed at focusing the attention of subjects on form rather than content: they provided only ungrammatical sentences, with the type of mistake being specified, and, thus, all of them had to be corrected (cf. Tunmer, Nesdale, & Wright, 1987).

The studies following the just discusses works were marked by their tendency to use a series of tasks. Bowey (1986) and Ryan and Ledger (1979) used the twin tasks of correcting ungrammatical sentences and repeating errors. If subjects gave a correction, which changed the meaning of the sentence or completely changed its structure, they were asked to start again. If the second attempt was not successful either, the item was moved back to the end of the series and had to be dealt with again.

Galambos and Hakuta (1988) also suggested integrating two kinds of metalinguistic tasks. The first was a standard version of the sentence-judgement task, which called for judging and correcting the syntactic structure of sentences. The second required the target group to identify ambiguous sentences and to paraphrase the various interpretations.

A study conducted by Galambos and Goldin-Meadow (1990) was based on a similar technique. Subjects were asked to note any errors in a set of sentences and correct and explain them. The order of the sentences presented to the subjects in the study revealed the level of awareness from the lowest to the highest one.

2.3.1.2. Metalinguistic awareness as a form of language processing: The dual component model. Later studies on metalinguistic awareness followed the dual component model suggested by Bialystok and Ryan (1985). According to it, metalinguistic awareness is a reflection of the growth of two skill components involved in language processing: the analysis of representation and the control of attention.

The analysis of linguistic knowledge is responsible for “restructuring and recoding conceptual representations organized at the level of meanings … into explicit representations of structure organized at the level of symbols” (Bialystok, 1993, p. 221). As for the control of selective attention, it is regarded as “the ability to selectively attend to specific aspects of language and to reject any distractions or misleading information” (Elaine, 2015, p. 98). Taken together, these metalinguistic skills allow speakers to focus attention, think, analyse and inwardly reflect on the linguistic form and structure of an utterance/sentence while suppressing interference from the meaning (Baker & Jones, 1998; Bialystok 2001a; Dillon, 2009; Malakoff, 1992).

Regarding metalinguistic awareness in processing terms, Bialystok designed tasks aimed at assessing its underlying skill components – analysis of representational structures and control of selective attention – rather than its subcomponents – phonological, word and syntactic ones. According to

Bialystok (2001a), greater involvement of each skill component makes tasks more difficult, which results in behaviour that can be treated as metalinguistic.

In collaboration with fellow researchers, Bialystok transformed the available tasks used for studying phonological, word and syntactic awareness. For instance, on the basis of existing word awareness tests, Bialystok, Majumder and Martin (2003) developed three tasks, which differed in the demands they made on cognitive components involved in their solution. One was the sound-meaning task, in which subjects had to select which of two words matched a target for either the sound (rhyme) or meaning (synonym). Another was the segmentation task, which required participants to count the number of phonemes in common words. The other was the phoneme substitution task, which enabled the researchers to assess the ability to make computations with the segmented sounds.

Looking at word awareness, Bialystok (1986) used verbal material with which she tried to distinguish between a number of factors. She controlled the analytic demands by including words of four levels of complexity – monosyllabic, bisyllabic, polysyllabic and double morpheme words. The control demands were modified by presenting items in meaningful sentences (items based on high control) or scrambling the order in which the words occur (low control).

While manipulating the characteristics of the sentence-judgement task, Bialystok (1986) followed the idea of knowledge demands increasing when sentences are ungrammatical and of control demands being higher when meaning must be ignored (de Villiers & de Villiers, 1972; Hakes, 1980). Her task consisted of sentences that were grammatically correct, grammatically incorrect but meaningful or semantically anomalous but grammatical. By introducing grammatical errors to sentences, Bialystok increased the analytic demands, while by inserting distracting information irrelevant to the solution, she created a need for a high level of control (Bialystok, 1999, 2001a).

In light of the previous research, metalinguistic awareness appears to be a collection of abilities rather than a single skill (e.g., Hamers & Blanc, 1989; Jessner, 2007; McBride-Chang, 1995). As Scribner and Cole (1981) conclude, metalinguistic skill cannot be conceptualised as a "general orientation to language or a unitary set of skills"; instead, it is "a highly diversified array of knowledge and skills" (p. 156) that develop at a higher level of creativity and reorganisation of information (Hamers & Blanc, 1989).

2.3.2. Studies on metalinguistic awareness in bilinguals. Metalinguistic awareness is not an exclusively bilingual experience. Monolingual speakers – mainly professionals, who work with language on a daily basis – can also have an enhanced conscious awareness of the nature of language and sensitivity to its formal and functional properties. Nevertheless, the degree and quality of awareness in bilingual users is argued to surpass the ones developed in monolinguals (Jessner, 2008). As Lambert (1990, p. 212) postulates, "bilingualism provides a person with a comparative, three-dimensional insight into language … that the monolingual rarely experiences".

The idea of bilingualism leading to an advantage in the development of metalinguistic awareness was first expressed by Vygotsky (1934). According to him, the ability to express the same thought in different languages may enable "the child to see their language as one particular system among many, to view its phenomena under more general categories", leading to awareness of their linguistic operations (Vygotsky, 1962, p. 110). For Vygotsky, this early awareness generalises to other areas of cognitive abilities and the effect it has on their development depends largely on the metalinguistic skills induced by the use of more than one language.

The first evidence for rather early and superior metalinguistic awareness of bilingual speakers in comparison with their monolingual counterparts was provided by a number of records and studies (Fantini, 1985; Kessler, 1984; Leopold, 1949; Ronjat, 1913; Saunders, 1982). According to their findings, the exposure to two different linguistic codes results in a more analytic orientation to linguistic operations, which enables bilinguals to recognise the arbitrary basis of meaning in language. As indicated by Leopold (1961, p. 358), there is "a noticeable looseness of the link between the phonetic word and its meaning". As a result, bilinguals were regarded as having a higher metalinguistic awareness than monolinguals.

The claims of bilingualism leading to an earlier realisation of the basically arbitrary relationship between a word and the object it denotes were not confirmed until Peal and Lambert's study (1962). Their findings provided evidence of the positive effects of mastering two languages in general and of metalinguistic awareness contributing to bilingual advantages in particular.

The following decades were marked by extensive research on the development of metalinguistic awareness in bilingual children. A number of studies showed the superiority of bilingual speakers in word awareness (Ben-Zeev, 1977; Cummins, 1978; Yelland et al., 1993), syntactic awareness (de Villiers & de Villiers, 1974; Galambos & Goldin-Meadow, 1990; Galambos & Hakuta, 1988; Ricciardelli, 1992; Smith & Tager-Flushberg, 1982) and, to a lesser extent, phonological awareness (Bialystok et al., 2003; Bruck & Genesee, 1995; Campbell & Sais, 1995; Caravolas & Bruck, 1993; Chen et al., 2004; Cummins, 1993; Eviator & Ibrahim, 2000; White & Genesee, 1996).

Feldman and Shen's study (1971) is considered to be the first one to clearly document metalinguistic advantages in bilingual children. They compared five-year-old Spanish-English bilinguals and English monolinguals on tasks assessing their understanding of object constancy, the arbitrary nature of words and their ability to use three types of labels (standard, non-words and common-switched) in sentences. On the basis of the participants' performance, Feldman and Shen came to the conclusion that bilinguals are better than monolinguals in their ability to switch familiar labels and use various types of labels in the context of sentences. In their view, this is due to bilinguals' operating on two language codes.

In the same vein, Ianco-Worrall's study (1972) demonstrated bilinguals' more analytic orientation to certain properties of language. It included a word substitution task (cf. the sun-moon problem in Piaget, 1929), whose results correlated with Leopold's observations and Vygotsky's findings on the earlier separation of sound and meaning among bilingual children. The conclusion was also supported by Ben-Zeev (1977). The performance of Hebrew-English bilinguals and monolinguals on the Verbal Transformation and Symbol Substitution Tests in his study indicated that bilingual speakers were more ready to impute structure and reorganise it than monolinguals. Similarly, Segalowitz (1977) argued that the internalisation of two languages rather than one would result in a more complex mental calculus, thus enabling a child to alternate between two systems of rules in the manipulation of symbols.

The claim of childhood bilingualism speeding up concept formation skills was challenged by Clark (1978) and Aronsson (1981). They suggested that bilinguals' superior performance on the tasks aimed at establishing the sound:meaning and meaning:referent distinctions were more likely to be caused by a sensitivity to formal linguistic features than by deeper conceptual insights. In a similar vein, Mohanty and Babu (1983) ascribed bilinguals' better understanding of the arbitrariness of language, the nonphysical nature of words and the relationship between the meaning and its referent to their ability to analyse objectively certain properties of language. Thus, learning two ways of constructing the same linguistic form, in their view, makes structural patterns more noticeable and hastens bilingual children's metalinguistic awareness.

Bialystok studied the issue in much closer detail by integrating and transforming word concept and sentence-judgement tasks. Her empirical investigations (e.g. 1986, 1987, 1988) provide evidence that bilingualism does not have a direct effect on metalinguistic awareness; rather, it influences its two components (i.e. the analysis of representation and control of attention) and, what is more, in different ways.

In Bialystok's studies, the bilingual advantage was seen primarily in tasks demanding a high level of control of linguistic processing. In these tasks, the specific skills of the participants in L1 and L2 were not shown to affect their performance. Thus, a superior performance of bilinguals was seen to be due to the early bilingual experience of dual language systems and frequent attention to formal aspects of language. On the other hand, in tasks requiring high levels of analysis, findings were somewhat contradictory and depended on the combined proficiency of bilinguals in both languages. Bilinguals were shown to outperform monolinguals only if they had high levels of proficiency.

Bialystok's findings were supported by a number of subsequent studies on metalinguistic awareness (Cromdal, 1999; Cummins, 1993; Davidson et al., 2010; de Villiers & de Villiers, 1972; Foursha-Stevenson & Nicoladis, 2011; Hakuta & Diaz, 1985; Ricciardelli, 1992). In line with Bialystok, these researchers pointed to a positive influence of mastering two languages on children's ability to control the processing of linguistic information. These findings are also consistent with the 'threshold hypothesis' proposed by Cummins (1976, 1977), according to which an overall bilingual superiority in terms of metalinguistic abilities is found only for those children who have attained a high degree of bilingualism.

Bilinguals' better performance on the tasks requiring control of attention was also shown by Galambos and Hakuta's (1988) and Galambos and Goldin-Meadow's (1990) studies. The bilingual children recruited into them were able to detect and correct grammatical errors more readily than their monolingual peers. However, they were not better at explaining those errors than monolinguals. On the basis of these results, the researchers concluded that the experience of learning two languages hastens the development of metalinguistic awareness (as the children go from a content-based to a structure-based understanding of a language) but does not alter its course. This idea was supported by Bialystok (2001a, p. 143), who emphasised that "bilingualism itself is insufficient to fundamentally change the path of metalinguistic development".

To shed light on the factors that affect the development of representational structure and control of attention, Bialystok and Barac carried out an additional study (2012). By comparing bilingual and monolingual children on the Wug task, sentence-judgement task, flanker task and the test of task switching, they came to the conclusion that the two domains are influenced by different aspects of experience: representational structure depends on "the achievement of adequate linguistic proficiency", while control of attention is sensitive to "experience over a sufficient amount of time using two languages" (Bialystok & Barac, 2012, p. 72).

Taken together, the enhanced analysis of representation and control of attention lead to better awareness of linguistic operations, i.e. metalinguistic awareness (Bialystok & Ryan, 1985). This awareness, in turn, generalises to other areas of cognitive abilities (Bialystok, 1986; Mohanty, 1994; Peal & Lambert, 1962; Tunmer & Myhill, 1984; Vygotsky, 1962), and the effect it has on their development depends largely on bilingual experiences.

2.4. Cognitive Control

2.4.1. Conceptualisation of cognitive control and tools used to measure it. Despite the growing interest of psycholinguists in cognitive control, there is still much uncertainty about its nature. Alongside the view on cognitive control as a unitary construct, there are studies which conceptualise it as a multidimensional phenomenon encompassing diverse functions (van Aken, Kessels, Wingbermühle, van der Veld, & Egger, 2016; de Bruin, Bak, & Della Sala, 2015; Jurado & Rosselli, 2007).

The unitary nature of cognitive control is reflected in the supervisory attentional system by Norman and Shallice (1986). According to the researchers, the system is a contention scheduling based monitoring programme, which selects sets of actions competing for representation. The system, therefore, appears to be responsible for executive control of complex, goal-oriented behaviour.

On the other hand, a number of other researchers consider cognitive control to be a complex, many-faceted construct (van Aken et al., 2016; Banich, 2004; Elliott, 2003; Foster, Black, Buck, & Bronskill, 1997; Lezak, 1995; Miyake & Friedman, 2012; Tranel, Anderson, & Benton, 1994; Valian, 2015). They conceptualise it as a constellation of multiple cognitive processes that are responsible for controlling and regulating thoughts, emotions and behaviour and enable people to adjust to new situations as well as accomplish goals.

With the aim of finding some common ground between the unity and diversity approaches to cognitive control, Miyake et al. (2000) carried out a latent variable analysis across various executive control tasks. As a result of their findings, they proposed to regard it in terms of three subcomponents: updating (or working memory), inhibition and shifting (or task switching).

Inhibition is conceptualized as “the ability to block extraneous information in order to focus on the pertinent rules of interactions or tasks” (Rosselli, Ardila, Lalwani, & Vélez-Uribe, 2016, p. 491). It was widely examined within the field of bilingualism. The time spent to ignore the information irrelevant to the current stimuli was used as a measure of it. This time, expressed as a reaction time cost for misleading trials, was the interference effect.

Among the tools used to test inhibitory control are the Simon task, the Stroop task, the flanker task and the anti-saccade task.

The Simon task (Simon & Rudell, 1967) appears to be one of the most common means of assessing the degree to which one can override a habitual response and replace it with a more intentional choice. In this task, participants are instructed to press one key in response to visual stimuli presented on the right side of the screen when they see a picture (e.g., a blue circle) and the other key when a different picture (e.g., a red circle) appears on the left side of the display. Some of the stimuli are presented on the same side of the screen where the correct key is (the congruent condition), others are located on the opposite side (incongruent condition), and yet others appear in the center (neutral condition).

A task resembling the Simon task is a spatial Stroop task (Stroop, 1935), which differs from it in its use of language-specific mechanisms. The Stroop task requires participants to determine the direction)leftward or rightward) of an arrow. The target arrow's extracted form is a spatial attribute, which is either congruent or incongruent with the task-irrelevant location of the arrow.

The flanker task (Eriksen & Eriksen, 1974) is carried out in a similar way. In its standard version, participants are presented with a series of arrows on a computer screen and asked to indicate the direction of the target arrow occurring in the middle. In half of such trials, the flanking arrows point in either the same (congruent trials) or the opposite (incongruent trials) direction as the target arrow.

The ability of participants to overcome a habitual response by intentionally applying a rule is also measured by the anti-saccade task (Munoz, Broughton, Goldring, & Armstrong, 1998; Roberts, Hager, & Heron, 1994). In this task, two cues are incorporated, with one being flashing targets and the other presenting eye gaze direction. On the whole, the task of participants is to resist the automatic attention responses in which gaze is immediately directed to a flashing object while being influenced by the gaze direction of eyes in the schematic face on the screen (Friesen & Kingstone, 1998; Zorzi, Mapelli, Rusconi, & Umilta, 2003).

Shifting or task switching is another aspect of cognitive control (DiGirolamo et al., 2001; Kramer, Hahn, & Gopher, 1999; Miyake et al., 2000; Sohn & Anderson, 2001; Sylvester et al., 2003). It is described as "the ability to allocate attention to a single task in the context of two potential options, so that a correct task-specific response can be made" (Wiseheart, Viswanathan, & Bialystok, 2016, p. 141).

One of the tasks used to measure task switching is a dimensional change card sort task. When a single-task paradigm is applied (Bialystok & Martin, 2004; Bialystok & Shapero, 2005; Zelazo, Resnick, & Pinon, 1995), participants are required to shift from sorting based on one dimension (colour) to sorting based on a second dimension (shape). However, in the case of a dual-task paradigm (Bialystok, Craik, & Ruocco, 2006), participants usually have to classify visual images (e.g., letters or numbers and animals or instruments) during concurrent classification of auditory information.

Another way of assessing switching is to apply a task-switching paradigm (e.g., Paap & Greenberg, 2013; Prior & MacWhinney, 2010). Task-switching paradigms can differ in the type of switches (predictable or unpredictable) involved, the time interval between the cue and the target, the type of stimuli, the response mappings used (bivalent or univalent) and the response. However, most of them include two types of experimental blocks – single-task blocks and mixed-task blocks. This way mixing and switching costs can be computed (See section 2.4.2 for details).

In addition to inhibition and shifting, updating (or working memory) is also regarded as a subcomponent of cognitive control (Foster et al., 1997; Malloy, Cohen, & Jenkins, 1998; Royall et al., 2002; Salthouse, 2005). It is generally conceptualised as controlled retrieval from long term memory (Miyake & Friedman, 2012), a process responsible for maintaining "information in an active, quickly retrievable state" (Engle, 2002, p. 20) by replacing old, no longer relevant information with newer, more relevant information (Morris & Jones, 1990).

To assess updating researchers usually employ n-back tasks that require participants to constantly refresh the material in working memory (Valian, 2015), for example, to remember the location of the stimulus before the current one ('1-back') or the one before the previous one ('2-back'). Among the span tasks, those involving not only storage, but also an explicit concurrent processing task, appear to be the most frequently used ones. Examples of this include, Ospan, in which participants have to solve a series of arithmetic problems while trying to remember a set of unrelated letters (F, H, J, K, L, N, P, Q, R, S, T, Y); Symspan, which requires subjects to recall sequences of red squares within a matrix while performing a symmetry-judgment task; and Rspan, in which participants are required to read sentences while trying to keep in mind the same set of unrelated letters as in Ospan.

Dual-modality tasks are also used to measure updating. First, participants are asked to organise stimuli as letters or numbers (LN) and animals or musical instruments (AM). This is followed by the dual-task condition, with the stimuli being congruent – both auditory and visual would derive from either LN or AM – or unrelated – one stimulus from the AM and the other from the LN or vice versa (Rosselli et al., 2016, p. 491).

However, a number of other studies dealing with cognitive control in the context of bilingualism show that there is another process involved in it, i.e. monitoring (Bialystok, Craik, Klein, & Viswanathan, 2004; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009). Given that cognitive control "dynamically changes in response to changing goals and changing affordances" (Paap & Greenberg, 2013, p. 235), managing attention to one's performance, internal states and current environment appears to be relevant for cognitive processing. Conceived of as the ability to solve tasks that involve mixed trials of different types (Costa et al., 2009), monitoring is usually tested in tandem with switching or/and updating. For this, the dual-task procedures are used (see above).

The main issue related to the cognitive control tasks is their impure nature: most of them require a number of executive functions (e.g., Burgess, 1997; Friedman et al., 2008; Marton, Campanelli, Eichorn, Scheuer, & Stepanoff, 2013, Valian, 2015). This fact points to high interrelationship between cognitive processes, implying that their successful application requires them to operate in coordination with each other. What is more, it raises the question of the validity of the tasks (Sekerina & Spradlin, 2016; Valian, 2015) and calls for reconsideration of the cognitive mechanisms involved in them.

2.4.2. Research on bilingualism and cognitive capacity. Research indicates that lifelong experiences modify our brain and cognitive abilities. Music training (Bialystok & Depape, 2009; Lappe, Trainor, Herholz, & Pantev, 2011), action video game playing (Bavelier & Davidson, 2013; Green & Bavelier, 2003) and spatial navigation (Maguire et al., 2000) have all been shown to shape our brain structure and executive control processes. Given the intense and all-encompassing nature of language, it seems reasonable to assume that variations in language experiences may lead to differences in brain structure and mental organisation (Bialystok, 2017).

The possibility of language experiences affecting cognitive control is supported by recent behavioural and neuroimaging studies. They provide evidence for shared mechanisms between non-linguistic and linguistic control in monolinguals (e.g., Braver, et al., 2003; Corbetta & Shulman, 2002; Hyafil, Summerfield, & Koechlin, 2009; Jimura & Braver, 2009; Lungu, Binenstock, Pline, Yeaton, & Carey, 2007) and bilinguals (e.g., Abutalebi & Green, 2007; Crinion et al., 2006; Hernandez, 2009; Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Hosoda, Hanakawa, Nariai, Ohno, & Honda, 2012; Wang et al., 2013). This implies that linguistic control in monolingual and bilingual speakers is accomplished through domain-general control processes. Considering the variability in the way and the degree to which those processes are engaged both between and within monolinguals and bilinguals, monolingualism and bilingualism have been suggested to shape cognitive control in different ways.

Unlike monolinguals, bilinguals have to select between the alternatives existing in two active languages (Bialystok, 2017; Costa, Caramazza, & Sebastian-Galles, 2000; Costa, Santesteban, & Ivanova, 2006; Dijkstra, Grainger, & van Heuven, 1999; Hermans, Bongaerts, de Bot, & Schreuder, 1998; Marian & Spivey, 2003; Thierry & Wu, 2007). The fact that both of a bilingual speaker's representational systems are constantly active implies a repeated and sustained involvement of control processes in bilingual speakers. This has led researchers to suggest that language use in bilinguals is more cognitively demanding than in monolinguals. If control processes adapt to such demands, then this argument provides a basis for expecting possible bilingual advantages in the cognitive control of non-verbal tasks (Green & Abutalebi, 2013).

The idea of bilingualism leading to long-term cognitive benefits that extend beyond the sphere of language has provoked strong interest among linguists and psychologists. An increasing number of works notwithstanding, the findings on the cognitive effects of bilingualism are still controversial.

Prior to the 1960s, bilingualism was viewed as having harmful effects on cognitive development (Ausubel, Sullivan, and Ives 1980; Darcy 1953). According to Bak (2016), such a negative perception was caused by the then existing deep-rooted bias against knowing more than one language and fear of the 'other'. Researchers and educationalists strongly opposed the idea of bilingualism (Petitto et al., 2001), reporting that it would not only create linguistic confusion and delay language development in young children ('linguistic handicap' (Pintner & Keller, 1922) or 'language handicap' (Darcy, 1946)), but would also lead to intellectual failure (cf. 'mental confusion' (Saer, 1923, p. 38) and 'mental retardation' (Goodenough, 1926, p. 39)) and damage the psychological wellbeing of immigrants (Hoffmann, 1991, Petitto et al., 2001; Saer 1923; Smith 1923).

However, the results of earlier works cannot really be taken as evidence for the superiority of the monolingual mind or the detriments of bilingualism, since they were severely flawed along a range of dimensions: test bias, failure to control for the level of the skills in the language of testing, cultural and socio-economic differences, etc. (Lambert, 1977). Despite this fact, they had considerable influence, and by the middle of the twentieth century the opinion that bilingualism was detrimental to cognitive functioning was firmly established.

The turning point came in 1962, when Peal and Lambert carried out their ground-breaking study in Montreal. Unlike the earlier studies, they strictly controlled for the socioeconomic status, age, sex and language background of the 364 bilingual and monolingual participants and included a much wider range of intelligence measures than just the standard IQ test. Their findings indicate that bilinguals are not cognitively inferior to monolinguals, but in fact are able to outperform monolinguals on measures of verbal intelligence as well as on non-verbal tasks "involving concept formation and symbolic flexibility" (Peal & Lambert, 1962, p. 14).

In spite of a number of weaknesses, Peal and Lambert's research marked a new era in research on bilingualism and cognitive control. In Baker's words (1988), it "… provided an appetizer, stimulant and menu for future studies" (p.

17) – studies looking at the interplay between bilinguals' language-specific system and a variety of domain-general executive functions.

In addition to studying the effects of bilingualism on cognitive control, researchers started exploring the nature of the bilingual language-specific system. The first appealing explanation of how the system operates comes from the Inhibitory Control model proposed by Green (1998). According to it, there is a supervisory attention system, which facilitates inhibition of the non-target (i.e. irrelevant for the current interaction) language during bilingual language production. With it, bilingual speakers are able to use contextually and linguistically appropriate representations in the context of two jointly activated languages. The implication is that bilinguals' considerable practice in managing their two languages modifies the inhibitory processes and affects them in non-language domains (Bialystok et al., 2004, p. 291).

An account based on the inhibition of the non-target language remained the dominant explanation for bilingual effects on cognition (e.g., Bialystok et al., 2009) until studies revealed a bilingual advantage in congruent trials as well as incongruent trials – those without or with misleading cues (Bialystok et al., 2004; Costa, Hernandez, & Sebastian-Galles, 2008). This led to the assumption that inhibition alone is insufficient to explain bilingual processing differences (Bialystok, Craik, & Luk, 2012).

The idea of inhibition being only a part of the mechanism for bilingual effects on cognition was further supported by Miyake et al. (2000). Having carried out a latent variable analysis across various executive control tasks, they proposed three subcomponents of executive function: inhibition, updating (or working memory) and shifting (or task switching). However, a strong correlation between the inhibition subcomponent and the common one (i.e. shared by the different subcomponents) made Miyake and Friedman (2012) revise the three-component model: they separated executive control into two specific factors – updating and shifting – and a factor that is common to both of them.

At the same time, a number of other studies show that in addition to executive control there is another functionally separable process, monitoring. This possibility was first suggested by Bialystok et al. (2004); see also Costa et al. (2009). On comparing the performance of their participants on the Simon task, Costa et al. came to the conclusion that the bilingual advantage lies in the ability to manage attention to rapidly changing task demands rather than inhibiting misleading spatial cues. Taking into account the fact that cognitive control "dynamically changes in response to changing goals and changing affordances", managing attention to one's performance and current context appears to be relevant for cognitive processing (Paap & Greenberg, 2013, p. 235).

In this light, the cognitive effects of bilingualism seem to go beyond the explanatory power of a single cognitive process. This becomes more obvious if we look at the way bilinguals manage their two jointly active languages. To achieve fluent linguistic performance bilingual speakers must constantly monitor currently occurring language stimuli. Once they decide which language is relevant for a particular interaction (the target language), they would switch to it while suppressing interference from the other (non-target) language. At the same time, they must be constantly ready to switch languages in case the language stimuli change – this can happen when a person using the other language joins the conversation.

Such a complex operation of language management has been suggested to be governed by a cortico-subcortical network which overlaps with the neural infrastructure for domain-general executive functions (Abutalebi & Green, 2007; Branzi, Della Rosa, Canini, Costa, & Abutalebi, 2016; Crinion et al., 2006; Garbin et al., 2011; Hernández, 2009; Khateb et al., 2007). According to recent neuroimaging studies, bilinguals typically recruit brain regions associated with domain-general cognitive control when regulating their two languages (for review see Hervais-Adelman, Moser-Mercer, & Golestani, 2011).

This is in line with the results obtained by Anderson, Chung-Fat-Yim, Bellana, Luk and Bialystok (2018), who compared the brain activation of bilinguals and monolinguals on verbal and non-verbal switching tasks. They found distinct networks for the two types of task in monolinguals, but a common shared network in bilinguals, and concluded that the experience of using two languages leads to the recruitment of brain networks involved in language control during non-verbal control processes.

As bilinguals continue to gain experience in switching between and regulating their two languages, they learn to reduce the costs that arise when their L1 and L2 compete for selection (Kroll & Dussias, 2013). This implies that with increased bilingual experience the relevant control processes adapt in a manner that should support future, controlled language use (Green & Abutalebi, 2013; Hsu & Novick, 2016, and Teubner-Rhodes et al., 2016).

Given the demanding nature of language management and functional overlap between linguistic and non-linguistic executive control in bilinguals, researchers have suggested that an intense ongoing involvement of the control processes in managing two languages can potentially enhance them across other cognitive domains – even those that are not related directly to linguistic performance (Bialystok et al., 2009; Green & Abutalebi, 2013; Wiseheart et al., 2016). In other words, complex language use in bilinguals might contribute to cognitive ability more broadly.

The idea of language switching practice leading to domain-general executive control benefits has provoked a strong interest among linguists and psychologists. In an attempt to test this hypothesis, researchers have recently made use of cued non-verbal switching tasks. The reason for that is that this type of tasks enables researchers to activate the actual processes involved in managing two languages in single- and/or dual-language contexts and to measure those processes independently of language tasks (Barac & Bialystok, 2012; Meiran, Chorev, & Sapir, 2000; Meuter, 2005; Prior & MacWhinney, 2010).

In standard cued task-switching paradigms, participants are typically asked to perform two interspersed subtasks: single-task trials and mixed-task trials. In the single-task trials, one type of stimuli (e.g., either colour or shape) is provided for the whole block of trials. In the mixed-task trials, participants are presented with two types of stimuli simultaneously (e.g., both colour and shape) and they are asked to make a decision on the basis of the cue preceding the stimulus. This affords the computation of two measures of cognitive performance: (1) mixing and (2) switching costs, which have been shown to be related to bilingual experience (Morales, Gómez-Ariza, & Bajo, 2013).

Mixing costs (or global switch costs) are considered to reflect sustained, proactive control mechanisms that enable to keep two competing tasks in mind (Braver, Reynolds, & Donaldson, 2003; Rubin & Meiran, 2005). These costs are associated with the resolution of task-set interference, caused by the stimulus on each and every trial (Philipp, Kalinich, Koch, & Schubotz, 2008; Rubin & Meiran, 2005); therefore, they include not only working memory load (updating), but also an incongruence effect (interference). As for switching costs (or local switch costs), these are regarded as transient, reactive control processes (Braver, Reynolds, & Donaldson, 2003; Mayr & Kliegl, 2003) involved in the preparation and execution of the actual switch. In addition to updating and inhibiting, these costs include monitoring, reconfiguration of the task set and switching.

Given the variability in bilingual language experience and possible role of its variables in determining the quality/magnitude of the ‘bilingual effect’ (de Bruin, 2019; Green & Abutalebi, 2013; Kroll & Bialystok, 2013; Laine & Lehtonen, 2018), proactive and reactive control processes might be affected by different language experiences differently. However, most of the previous task-switching studies have disregarded these important dimensions and simply compared groups of people designated as bilingual or monolingual. The unexplored variations in samples (between and within studies) in demographics and language experiences have inadvertently led to (spurious) differences in findings.

Take, for instance, Prior and MacWhinney’s (2010) pioneering study examining the effects of bilingualism on task switching. They compared the performance of bilingual adults with different pairs of languages and native English speakers on a non-verbal switching task and found a switching-cost advantage in bilinguals but no mixing-cost advantage. A similar study by Prior and Gollan (2011) only partially replicated these findings. Their results showed that Spanish-English bilingual adults incurred lower switching costs, while Mandarin-English bilinguals were equivalent to monolinguals in both mixing and switching costs.

Subsequent research by Hernández, Martin, Barceló and Costa (2013, Experiment 3) found a pattern of results quite similar to that of Prior and Gollan's Mandarin-English group: Catalan-Spanish bilinguals and Spanish monolinguals in their study did not differ significantly in either type of costs. Similarly, Paap and Greenberg (2013) failed to find bilingual mixing or switching benefits when comparing the performance of three groups of bilinguals (native English language, native other language and native both languages) and English monolinguals on a nearly identical task-switching paradigm.

To address the threats to validity in earlier studies, a few task-switching studies have targeted bilinguals varying in potentially relevant background factors. Bialystok and Barac (2012) found that cognitive performance of bilinguals improved with increased experience in a bilingual immersion environment. In a similar vein, the research by Hartanto and Yang (2016) provided evidence for the pattern of language use being an important dimension of bilingualism. Nevertheless, neither of the studies could isolate mixing- and/or switching-cost advantages in bilinguals, because they had no monolingual control group in their designs to benchmark bilinguals' results.

Thus, studies on the cognitive effects of bilingualism have generated both excitement and controversy. Despite the existing inconsistencies in their results, they make it clear that the consequences of bilingualism go beyond the explanatory power of a single cognitive process; they can be seen in the way the processes are coordinated. Moreover, different bilingual experiences affect components of cognitive control in a different way.

2.5. Chapter Summary

As our review of literature in this chapter has revealed, bilingualism is an extraordinarily complex phenomenon. Even though in recent years a substantial research effort has been devoted to studying it, many of its dimensions remain not properly understood. This particularly seems to be the case with the presumed cognitive effects of bilingualism. Along with studies reporting bilingual benefits, there are works that reveal null or negative effects.

These inconsistent and inconclusive results notwithstanding, the reviewed studies make it clear that the cognitive outcomes of bilingualism go beyond the sphere of language. However, in order to examine the fine-grained effects of bilingual experiences on metalinguistic awareness and executive functioning, extensive assessment of the participants' language experiences is required. Moreover, it is necessary to employ tasks, which recreate the conditions of bilingual language use and, thus, allow one to tap the relevant control components. This is indeed what the current study has endeavored to do.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1. Overview

The purpose of the chapter is to provide insight into the research design and methodology chosen for the current study. The chapter starts with outlining sampling procedures and participants. It concentrates on the way participants were recruited and screened. In addition, it describes the sampling itself, including the number of bilinguals and monolinguals, their social and language backgrounds.

The chapter goes on to provide information on the techniques used to collect data, in particular to assess metalinguistic awareness and to measure non-verbal cognitive control, i.e. proactive and reactive control processes. This is followed by the section outlining the ways background, metalinguistic and task-switching data were analysed.

3.2. Sampling Procedures

3.2.1. Participant recruitment. To address the research questions, bilingual and monolingual adults (20-40 years old) were to be recruited from the research sites located in the Newcastle/Hunter area, NSW, Australia (the University of Newcastle, Hunter Community Language Schools and the Ethnic Communities

Council). The monolinguals had to be English speakers while bilinguals had to be from non-English speaking backgrounds, with English being their second language.

Approaching potential participants required approval from the University's Human Research Ethics Committee. Once it was obtained (Approval No. H-2017-0336), the recruitment process commenced. With the permission and in the presence of the administration of the indicated institutions, the researcher approached potential participants on a preliminary specified day and time at the physical spaces of the research sites. To inform the members about the study, including inclusion criteria, and the meeting, a flyer (see Appendix B) had been posted on the websites and/or Facebook pages of the institutions. As a way of providing an incentive for participation, all eventual participants were entered into a draw to win one of five $100 Westfield vouchers. The winners were selected randomly using the Excel RAND function and notified by email after the data collection session.

The face-to-face communication with potential participants was aimed at introducing them to the study and inviting them to participate. Potential participants were provided with key information on the design and objectives of the study and a detailed description of what participation would involve. They were reassured that their participation was strictly a matter of their choice and that their decision would not have any negative consequences for them. They were told that they would have an option to withdraw at any time without having to indicate the reason, even after signing and submitting the consent form.

In the face-to-face meeting, it was also stressed that privacy and confidentiality would be ensured, i.e. the identity and responses of the participants would not be revealed in any form. After the initial collection, each participant would be assigned a unique code and all information that could reveal the identity of individual participants would be removed. Subsequent processing of the data and data analyses would deal only with the anonymised coded papers.

Potential participants were further informed that copies of the participant information statement and the consent form (see Appendix B) were left at the exit of the room. That way they could collect one each on their way out in case they were interested. Those who chose to participate were instructed to leave the signed consent form in a designated collection box in front of the administration office. Within the next 4 months, we received the signed Consent Forms from 110 bilingual and monolingual speakers.

3.2.2. Participant screening. The prospective participants were screened on key demographic and language variables using the Language and Social Background Questionnaire by Anderson et al. (2018). This specific instrument was chosen because it allows one to categorise potential participants along the monolingual-bilingual continuum. Secondly, it captures the full complexity of bilingual language competencies and experiences. Moreover, it applies to adults living in diverse communities. Notably, its reliability and validity have been demonstrated in analyses with 408 participants, including 364 from English-speaking backgrounds (Anderson et al., 2018).

The questionnaire by Anderson et al. (2018) was considered on an item-by-item basis, with some of their questions being slightly modified in order to better suit the current study's sample. All changes made to the original instruments are described in detail below.

In line with the original tool, the Language and Social Background Questionnaire (LSBQ) in our study consisted of three sections. The Social Background Section captured demographic information, including age, gender, highest level of education, immigration status and occupation. In addition to answering questions about themselves, the participants were asked to provide information about their parents' education as a proxy for socio-economic status (SES), occupations and known languages. As opposed to the original tool, the questions specific to neuroimaging were not included, and references to Canada were replaced with Australia.

The Language Background Section focused on language(s) spoken. The section included questions relating to the age and modes of English and other [non-English] language acquisition (if applicable), with the participants being required to describe their two languages in order of dominance. In addition, this section asked about the onset age of active bilingualism, i.e. age at which they started using both language on a regular basis. This question was added on the basis of research data showing that the onset age of active bilingualism is strongly associated with subsequent cognitive performance (e.g., Luk, De Sa, & Bialystok, 2011).

Consistent with Anderson et al. (2018), our version of LSBQ also elicited proficiency for speaking, listening, reading and writing the indicated language(s). The participants were asked to assess their proficiency for each activity on a scale of 0-10, with 0 indicating *no ability at all* and 10 standing for *high, native-like proficiency*. They had to indicate on a 5-point Likert scale the relative proportions of time they spent engaged in speaking, listening, reading and writing (1 represented *all English*, 3 represented *half English and half the other language* and 5 represented *only the other [non-English] language*).

Finally, the Community Language Use Behaviour Section elicited information on language usage at different life stages, with different interlocutors, in different situations and for different activities. In each case, the participants had to rate their language usage on a 5-point Likert scale where 1 represented *all English*, 3 represented *half English and half the other language* and 5 represented *only the other [non-English] language*. Monolinguals – those of the participants who had no knowledge of a second language – were instructed to indicate *all English*.

The question targeting prior and current exposure to each of the two languages both inside and outside home was taken from Anderson et al.'s

(2018) questionnaire. However, the life stages were adapted for adults and clearly defined with year cut-offs: infancy (0-3 years old), childhood (4-12 years old), adolescence (13-19 years old) and early adulthood (20-40 years old).

The two questions from the original version, which dealt with the proportion of using English and another [non-English] language (if applicable) and the extent of switching between them within a sentence, were also slightly modified. Besides (grand)parents, partner, other relatives, neighbours and friends, the item ‘colleagues’ was added to the list. The other small adjustment was made to the question in which the participants were asked to indicate which language(s) they generally used in different situations. In this case, the item ‘school’ was replaced with ‘education’, a broader term covering all levels of education.

To administer the LSBQ, face-to-face sessions were run by a researcher/linguist with up to ten people at once so that questions could be clarified and responses discussed. The sessions took place on the premises of the University of Newcastle and lasted up to 30 minutes.

A copy of the complete Language and Social Background Questionnaire can be seen in Appendix C.

3.2.3. Participant characteristics. On the basis of the LSBQ, the potential participants (N = 110) were categorised as bilinguals (n = 80) or monolinguals (n = 30) and either selected or excluded from further participation in the study.

Three bilinguals and two monolinguals were eliminated from the study as they did not meet the age requirements (they were above the age of 40). Two monolingual participants were excluded because they reported receiving some exposure to another language at home or school. Ten bilinguals were eliminated from the study because English was their first language. Finally, seven bilinguals and two monolinguals were excluded as they did not attend the data collection session.

This resulted in 84 adults, including 60 bilinguals and 24 monolinguals. There were 32 males and 52 females in total, with a mean age of 31.06 years. The participants had normal or corrected-to-normal visual acuity (no cases of colour-blindness were reported) and no language or hearing impairment. As shown in Table 3.1, the participants had relatively comparable SES levels and had all obtained a university degree – a bachelor's or master's degree.

Table 3.1

Descriptive Statistics for Demographic Variables

Variable	*N*	Mean	*SD*
Language status	monolingual – 24 bilingual – 60	–	–
Gender	male – 32 female – 52	–	–
Age	84	31.06	4.70
SES	84	3.07	.94
Education	84	4.00	.00

Note. Age in years. SES and education on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education).

The monolinguals were English-speaking Australians. According to the self-reported proficiency and language use data, they had a high level of language proficiency (*M* = 9.93, *SD* = .10, on a 10-point scale) and exclusively used English in all situations throughout their life (monolingual language context). Means and standard deviations for language variables are given in Table 3.2.

Table 3.2
Descriptive Statistics for Language Variables

Language context	*N*	Language proficiency		Language use	
		English	Non-English	Close social context	Broad social context
Monolingual	24	9.93 (.10)	N/A	1.00 (.00)	1.00 (.00)
Bilingual separated	36	8.53 (.88)	9.69 (.45)	3.89 (.32)	2.00 (.17)
Bilingual dual	24	9.32 (.31)	9.94 (.22)	3.00 (.00)	2.00 (.00)
Total	84	9.16 (.84)	9.79 (.39)*	2.81 (1.23)	1.7 (.46)

Note. Means followed by standard deviations in parentheses. Language proficiency on a 10-point scale (0 = no proficiency, 10 = high proficiency). Language use on a 5-point scale (1 = all English; 3 = half English, half the other language; 5 = only the other language). * Total on the basis of bilingual data only.

As opposed to the monolinguals, the bilinguals in the current sample were born outside Australia and were from varied non-English speaking backgrounds. Their first language belonged to one of the following language branches: Germanic (11); Romanic (13); Slavic (7); Iranic (9); Indo-Aryan (5);

Sino-Tibetan (6) and other (9), including Vietnamese (2), Greek (1), Cambodian (1), Azerbaijani (1), Malay (1), Filipino (1), Malayalam (1) and Shona (1).

Being L2 learners of English, most bilinguals had started acquiring English in childhood (M = 9.35 years, SD = 4.64) in a single first language-oriented environment. However, they had begun using both languages on a regular basis (in the same or different contexts) later in life, i.e. shortly before or upon arriving in Australia (onset age of active bilingualism; M = 21.33 years, SD = 7.83).

Our bilingual participants rated their language use on a 5-point Likert scale (1 = *all English*; 3 = *half English, half the other language*; 5 = *only the other language*). As they were found to differ in the way they used their two languages in a close social context, $p < 0.5$, we differentiated between *dual-* and *separated-context bilinguals*. Those, who reported an equal use of their two languages (3-3.4 on a 5-point scale), were classified as dual-context bilinguals; those, who rated their language usage as 3.5 and above, were treated as separated-context bilinguals. However, all participants reported using mostly English in a broad social context (e.g., commercial, healthcare, government services, etc.); dual- and separated-context bilinguals did not differ on this, $p > .05$.

It is worth noting that the dual- and separated-context bilinguals also varied on language proficiency. The dual-context bilinguals were equally proficient in their two languages and were more proficient in both their first [non-English] language (*M* = 9.94, *SD* = .22) and English (*M* = 9.32, *SD* = .31) than separated-context bilinguals (*M* = 9.69, *SD* = .45 and *M* = 8.53, *SD* = .88, respectively), *ps* < .05. This pattern points to systematic co-variations between language proficiency and language use in our data, which was further supported by a correlation analysis ($r = .50$, $p < .001$). This co-variation between language proficiency and language use in second-language contexts is very much in accord with the literature (Luk et al., 20111; Singh & Kar, 2018; Sun, Li, Ding, Wang, & Li, 2019).

3.3. Data Collection Procedure and Instruments

The participants were invited to attend a data collection session, during which they completed the Metalinguistic Awareness Test (Bialystok, 1986; Bialystok & Barac, 2012; Bialystok et al., 2003; Davidson et al., 2010) to assess their metalinguistic awareness and the Colour-Shape Switching Task (Miyake et al., 2004; Prior & MacWhinney, 2010) to measure mixing costs (proactive control processes) and switching costs (reactive control processes). This took place in a computer-equipped room on the premises of the University of Newcastle (Room HC47, Hunter Building, Callaghan campus). Taking into account the number of computers in the room (35 desktops) and the availability of the participants, we divided the participants into three groups and ran three sessions in total. Each of them lasted for 95 minutes, including a 10-minute break between the tasks.

3.3.1. The Metalinguistic Awareness Test. The Metalinguistic Awareness Test (MAT) consisted of two tasks: the sound-meaning and grammaticality judgement tasks. Being developed in accordance with the cross-validated dual component model of metalinguistic awareness (Bialystok & Ryan, 1985), both tasks targeted two skill components involved in language processing, i.e. the analysis of representation and control of attention.

A draft version of the MAT was piloted with 10 educated bilingual and monolingual adults (25-35 years old). The pilot participants were representative of the target and control groups: they were either bilinguals speaking English as their second language or English-speaking monolinguals.

Each pilot participant was personally provided with a paper copy of the MAT (the items were in the same order for all adults tested) and was instructed what to do and how they were required to do it. They were encouraged to take as much time as they needed to examine the instructions and examples. However, once they started the task, they were encouraged to do it as quickly as possible and to time themselves (with each task being timed separately). As soon as they were done, they were asked to bring their answers back to the researcher's office.

The sound-meaning task was developed on the basis of the procedure introduced by Bialystok and her colleagues (2003) to assess metalinguistic awareness in bilingual and monolingual children. The task consisted of 36 questions, i.e. lexical items, which were selected using purposive sampling.

Following Bialystok and her colleagues, we constructed questions requiring participants to decide which of two words matched a target word taken for either the sound(s) (SOUND) or meaning (MEANING).

In the case of sound being the determining feature, one variant represented a synonym while the second one matched the target word in one or more sound(s) (Sm; 9 items; see Table 3.3). When it came to meaning being the determining feature, there were three different scenarios. In one of them, the provided items varied in the same way as in the case of sound being the determining feature (Ms; 9 items). In another case, neither of the answers had the same sound(s) as the target one (MM; 9 items). In the third case, one option was a near-synonym, which also matched the target word in some sound(s), and the other one matched the target word only in some sound(s) (MS; 9 items). This was done to further increase the analysis and control demands of the task: MM required a higher level of analysis than Ms and Sm; and MS placed the greatest burden on both analysis and control.

After receiving the answers from the pilot participants, the sound-meaning task was analysed and reconsidered on an item-by-item basis. As a result, three items with SOUND being a determining feature were changed to avoid ambiguity and decrease/increase the level of complexity. In particular, the items which either were interpreted by the subjects as a wrong part of speech (e.g., *(to) choir* or *(to) quince* were presented as verbs instead of nouns) or were not widely known (e.g., *dentine* or *(to) condensate*).

Table 3.3

The Sound-Meaning Task

Types of stimuli	Examples
SOUND (Sm)	*revenue* (trigger word) vs *income* (similar meaning) and *avenue* (same sounds)
MEANING (Ms)	*revenue* (trigger word) vs *income* (similar meaning, different sound) and *avenue* (different meaning, same sounds)
MEANING (MM)	*debacle* (trigger word) vs *fiasco* (similar meaning, different sound) and *argument* (different meaning, different sound)
MEANING (MS)	*ruthless* (trigger word) vs *worthless* (different meaning, same sound) and *merciless* (similar meaning, same sound)

Taking into account the time each of the pilot participants spent doing the sound-meaning task, a time limit was set up. Only four minutes were given to complete the task. In addition, a marking scheme was established. Participants got one point for each correct answer they provided. This way the total number of points for this task was 36.

The grammaticality judgement task included sentences (N = 24) presented in context, as part of three short passages. The passages were adapted from three texts of different genres and modified to make them suitable for the objectives of the study. Some sentences were slightly changed to target a certain grammatical or semantic aspect, while the others were shortened or completely excluded to make the task less time-consuming.

In line with previous studies using this type of task to assess metalinguistic awareness (e.g., Bialystok, 1986; Bialystok & Barac, 2012; Davidson et al., 2010), the sentences were constructed along two linguistic dimensions: a semantic one and a grammatical one. As shown in Table 3.4, this resulted in four sentence frames: grammatical, meaningful (GM; 6 items), grammatical anomalous (Gm; 6 items), ungrammatical, meaningful (gM; 6 items) and ungrammatical anomalous (gm; 6 items), which enabled us to target analysis and control components separately.

Table 3.4
The Grammaticality Judgement Task

Sentence frame	Example
Grammatical, meaningful (GM)	*The land is being used to feed the majority and to produce wealth that circulates through the financial markets of the cities.*
Grammatical, semantically anomalous (Gm)	*The land is being used to feed the majority and to produce technology that circulates through the family markets of the cities.*
Ungrammatical, meaningful (gM)	*The land is been used to feed the majority and to produce wealth that circulates through the financial markets of the cities.*
Ungrammatical, semantically anomalous (gm)	*The land is been used to feed the majority and to produce technology that circulates through the family markets of the cities.*

By introducing grammatical errors to the sentence, it was possible to increase the analytical demands, while by inserting distracting information irrelevant to the solution, the need for a high level of control was created

(Bialystok, 1999, 2001a). Thus, the greater burden for gM was involved analysed knowledge, while the greater burden for Gm was involved control.

The ungrammatical sentences contained errors in word order (incorrect sentence structure), verb forms (wrong tense, aspect, voice, subject-verb disagreement, incorrect form of infinitive or gerund, use of infinitive instead of gerund), adverbs (incorrect adverb or incorrect insertion of an adverb between a verb and its direct object), pronouns (incorrect case form), prepositions (lack of a preposition or wrong use of one) and articles (wrong use). The decision to target the indicated aspects was based on advanced English grammar requirements (Swan & Walter, 2012). To further increase the level of complexity, up to two errors could be found in each ungrammatical sentence.

The participants were asked to judge whether the given sentences were grammatical or ungrammatical irrespective of their meaning. In other words, they had to accept GM and Gm and reject gM and gm. The key point was that judgements had to be made on the basis of how each of the sentences was used in the given text. In case the ungrammatical option was selected, correction and explanation were required. Each error could be repaired by the alteration of a single feature in the sentence.

On the basis of the pilot participants' responses and comments, the grammaticality judgement task was slightly modified. The majority of the pilot participants had trouble finding errors in some sentences, which they marked as grammatical. To make the errors more obvious, additional context/explicit markers were added and/or some words/phrases were changed or even excluded. Furthermore, the monolinguals failed to explain the errors in the ungrammatical sentences even though they were able to identify and correct them. This may have been due to 'whole language' approach to teaching English, which replaced a more systematic and rigid one in Australian schools (Australian Council for Educational Research, 2005). Therefore, the explanation subtask was excluded.

In addition, a time constraint was placed on performance – only 16 minutes were given to fulfil the task – and a marking scheme was introduced. As the primary task concerned the detection of grammatically erroneous sentences, only grammar-related judgments were scored as correct (0.5 for each grammar-related judgement). Accordingly, a rejection of an ungrammatical anomalous sentence followed by a correction of meaning was considered a judgment of semantics, not grammar, and, thus earned no points. A correction point (0.5 for each grammar-related correction) was given if a participant managed to correct the sentence without changing its meaning. Thus, the total number of points for this task was 22.5.

A copy of the complete Metalinguistic Awareness Test can be seen in Appendix D.

3.3.2. The Colour-Shape Switching Task. The Colour-Shape Switching Task (CST) was programmed and controlled by Millisecond Software (see

Millisecond Software, 2013). The design, materials and procedure were closely modelled by them on those described by Miyake et al. (2004), except for a few adjustments.

Firstly, the secondary task conditions (articulatory suppression, foot tapping, and saying the task name) used by Miyake et al. (2004) were not implemented. They were excluded as evaluating the involvement of inner speech in the process of goal retrieval and activation was not the objective of the current study. For the same reason, only the word cue type (COLOUR or SHAPE) was chosen. As opposed to the letter cue type (C or S), explicit word cues such as COLOUR and SHAPE have been revealed to minimise the role of inner speech in retrieving and activating the task goal (Miyake et al., 2004).

Thirdly, a short cue-to-stimulus interval of 200 ms was set for all trials to allow for robust mixing and switching costs. Control-long conditions with a cue-to-stimulus of 1200 ms were not chosen, as long preparation times have been shown to result in significantly lower costs (Meiran et al, 2000; Rogers & Monsell, 1995). Finally, the number of trials was changed to allow the four conditions (2 shapes x 2 colours) to be presented equally. The updated task was presented on Dell desktop computers running MS Windows 10, with the participants being seated approximately 50-55 cm from the monitor.

The task consisted of two parts: single-task trials and mixed-task trials. In both cases, the participants were provided with a stimulus (colour and/or shape) and they were asked to respond to it as quickly and as accurately as possible by using one of two response keys (A-key for circle/red and L-key for triangle/green or vice versa). The response keys were randomly determined for each participant at the beginning of the experiment and were kept constant throughout the session.

As shown in Figure 3.1, the single-task trials were based on univalent stimuli – either shape (circle vs. triangle) or colour (red vs. green) – presented without any cue in the middle of the computer screen until a response was given. In one block of single-task trials (shape trials), a black line drawing of either a circle or a triangle shape was displayed on each trial, whereas in the other block (colour trials), a square-shaped colour patch (red or green) appeared in the middle of the screen. As for the mixed-task trials, they involved bivalent stimuli (circle or triangle superimposed on a square-shaped colour [red or green] patch). In this case, each of the trials was designated either as a repeat trial if the cued decision was the same as in the previous trial (two consecutive colour or shape decisions) or as a switch trial in case it was different (switching between colour and shape decisions). As opposed to the single-task trials, in the mixed-task trials a word cue printed in capital letters (COLOUR or SHAPE) was assigned randomly by the computer and given 200 ms before a stimulus was presented on the screen.

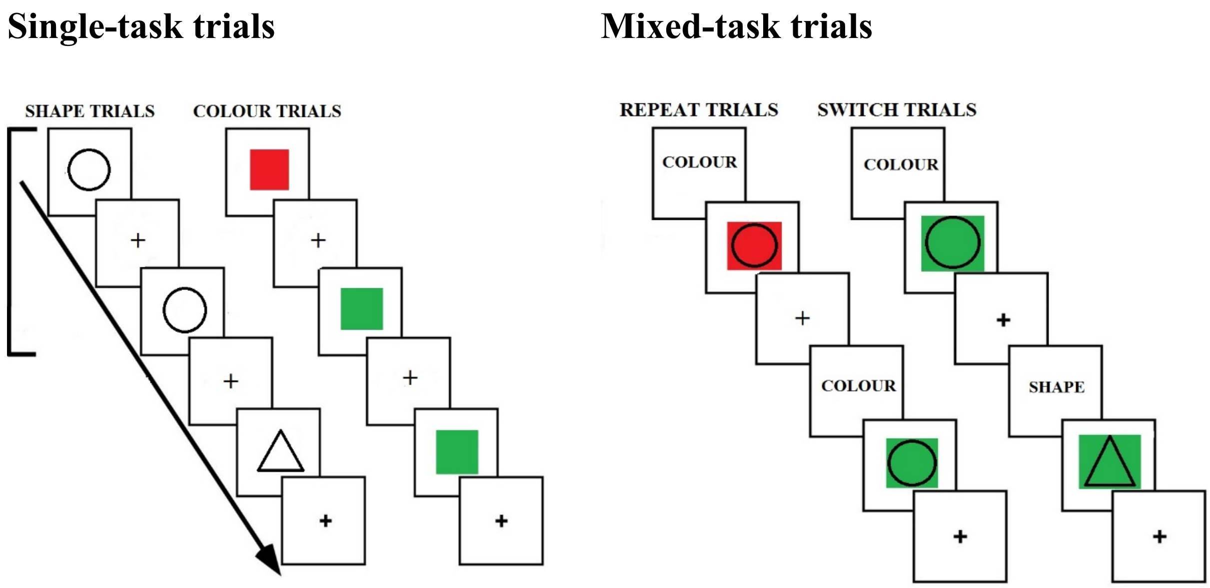


Figure 3.1. Sequence of trials for the Colour-Shape Switching Task.

First, the participants completed 32 single-task training trials and 48 (+ start trial) mixed-task training trials to master the response-mapping rules. Then they performed 64 single-task test trials and 100 (+ start trial) mixed-task test trials with one and two brief breaks, respectively. As opposed to the training trials, participants no longer received an error message (i.e., ‘incorrect’) for incorrect responses in the test trials but were informed of their accuracy (percentage correct) at the end of each sequence of trials.

Accuracy and reaction times (RTs) were recorded by Millisecond Software for every trial, except for the first ones following the break. In both single-task and mixed-task trials, RTs were recorded for the correct trials only. On the basis of the RTs, mixing and switching costs were computed (specific information on how the costs were computed is provided in the next section).

3.4. Data Screening and Data Analysis Overview

The background, metalinguistic and task-switching data were organised and formatted in Microsoft Excel. First, we checked for accuracy in data entry items. Secondly, we standardised the background items that were of heterogeneous formats (e.g., some checklists, some scales, some yes/no questions). Then we tabulated the frequency distributions (numbers) for all questions with a categorical response and descriptive statistics (means and SD) for all questions with a continuous response.

Following that, we extracted meaningful demographic and language variables from the questionnaire and added them to two dataframes in R to answer the two research questions. Both dataframes contained the same demographic (gender, SES and age), metalinguistic and task-switching variables, but different language variables. Dataframe 1 covered language context to explore the effects of language context in bilinguals and monolinguals. Dataframe 2 contained typological proximity/distance between two languages, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy to examine the impacts of bilingual language experience among the bilingual participants alone.

Given that data-cleansing procedures may skew the data (see Zhou & Krott, 2016), we decided not to trim our data. However, we applied a number of techniques to reduce the MAT and CST data. The sound-meaning task items (N = 36) were clustered into four distinct factors according to the stimulus (MS, MM, Ms and Sm). Each factor consisted of nine items. A similar procedure was used to reduce the grammaticality judgement task data. The 24 items were combined according to the sentence frame (GM, Gm, gM and gm). This resulted in four factors consisting of six relevant components. Means and standard deviations are provided in Table 3.5.

Table 3.5
Descriptive Statistics for Metalinguistic Awareness Test Data

Variable	*N*	Mean	*SD*
Sound-meaning task items			
MS	84	8.27	.896
MM	84	8.04	1.04
Ms	84	8.18	1.22
Sm	84	8.49	1.17
Grammaticality judgement task items			
GM	84	4.32	1.28
Gm	84	4.51	1.40
gM	84	4.04	1.52
Gm	84	3.98	1.42

Note. Number of correct sound-meaning task items out of 9. Number of correct grammaticality judgement task items out of 6.

Considering the importance of the reliability of research tools (Norris & Ortega, 2003) and the view on reliability as a context-dependent factor rather than an inherent property of an instrument, we evaluated the reliability coefficient of the MAT. The results showed that Cronbach's alpha for the eight MAT items was .75. What is more, each of the items was shown to fit in the scale: exclusion of none of them would significantly increase Cronbach's alpha.

To check if there were any differences in means between the sound-meaning task items and between grammaticality judgement task items, we performed preliminary two-way repeated measures ANOVAs using the aov function from the car package. In all cases, *language context, gender, SES* and *age* were entered as between-subject factors. As for within-subject factors, *stimulus* (MS, MM, Ms and Sm or GM, Gm, gM and gm) was included.

The results showed that the main effect of *stimulus* was not significant for either sound-meaning task items ($F[3, 48] = 1.812$, $p = .158$, partial $\eta^2 = .102$) or grammaticality judgement items ($F[3, 48] = 1.872$, $p = .147$, partial $\eta^2 = .105$; see Appendix E). Moreover, the effects of the interactions between the *stimulus* and between-subject factors were not statistically significant either, $ps > .05$. Considering this, the participants' results on the sound-meaning and grammaticality judgement task items were combined into the sound-meaning task scores (out of 36) and grammaticality judgement task scores (out of 22.5), respectively (see Table 4.2 in Chapter 4 and Table 5.2 in Chapter 5).

The CST data included accuracy and RTs on blocked, repeat and switch trials. Given that one sample t-test revealed no significant difference between the colour and shape tasks in single blocks ($p > 0.5$), the results were collapsed across the two tasks. Means and standard deviations are shown in Table 3.6. Cronbach's alpha for the CST items was .71, indicating the reliability of the research tool.

Table 3.6

Descriptive Statistics for Colour-Shape Switching-Task Data

Variable	*N*	Mean	*SD*
Blocked trials			
Accuracy	84	97.56	4.52
RTs	84	554.57	137.60
Repeat trials			
Accuracy	84	98.93	1.50
RTs	84	756.36	183.63
Switch trials			
Accuracy	84	97.54	2.61
RTs	84	891.93	223.79

Note. Accuracy out of 100%. RTs, mixing and switching cost are given in ms.

To check if there were any differences in accuracy and RT means between the trials, we performed preliminary two-way repeated measures ANOVAs for the data. In all cases, *language context, gender, SES* and *age* were entered as between-subject factors, while *trial* was included as a 3-level within-participant factor (blocked, repeat and switch trials).

The ANOVA for accuracy revealed that the main effect of *trial* was not significant ($F[1.31, 21.02] = 1.776$, $p = .198$, partial $\eta^2 = .100$), nor were the effects of the interactions between the *trial* and between-subject factors, $ps > .05$ (see Appendix E). On the contrary, the main effect of *trial* was statistically significant for RTs ($F[2, 32] = 136.134$, $p < .001$, partial $\eta^2 = .895$), as were the effects of the interactions between the *trial* and one of the between-subject factors, $p < .001$. In light of these results, accuracy was not considered in further analyses.

On the basis of RTs on blocked, repeat and switch trials, mixing and switching costs were calculated. *Mixing costs* were computed by subtracting mean RTs on single-task trials in single blocks from mean RTs on repeat trials in mixed-task blocks; *switching costs*, on the other hand, were calculated by subtracting mean RTs on repeat trials from mean RTs on switch trials in mixed-task blocks (see Table 4.3 in Chapter 4 and Table 5.3 in Chapter 5).

The reduced MAT and CST data were also added to the two dataframes. This resulted in 84 (dataframe 1) and 60 (dataframe 2) rows, with data for all participants. Then we checked whether the data in each dataframe met the assumptions for multiple linear regressions. Following that, we performed regression analyses to answer the two research questions. In particular, we built linear fixed-effects regression models with monolingual and bilingual data to determine whether and in what ways language context (i.e. monolingual, bilingual separated or bilingual dual) affects metalinguistic and task-switching performance of bilingual and monolingual adults. Also, we ran multiple linear regressions with bilingual data only to explore which (if any) dimensions of bilingual experience – typological proximity/distance, age of L2 acquisition, onset age of active bilingualism, language proficiency and/or language entropy – account for the variance in bilinguals' metalinguistic and task-switching performance.

3.5. Chapter Summary

This chapter discussed the research design and methodology of this project. It described the sampling and data collection procedures, including participants and instruments. The research involved 60 bilinguals from non-English speaking backgrounds and 24 English-speaking monolinguals residing in the Newcastle/Hunter area, NSW, Australia. Demographic and language data were collected with the help of the Language and Social Background Questionnaire (Anderson et al., 2018). Following that, the Metalinguistic Awareness Test was used to assess metalinguistic awareness, and the Colour-Shape Switching Task (Miyake et al., 2004) was employed to measure non-verbal cognitive control, i.e. proactive and reactive control processes. The obtained data were subjected to regression analyses to answer the research questions (see Chapters 4 and 5).

CHAPTER 4

BILINGUAL AND MONOLINGUAL SPEAKERS' LANGUAGE CONTEXTS AS PREDICTORS OF THEIR PERFORMANCE ON THE METALINGUISTIC AWARENESS TEST AND COLOUR-SHAPE SWITCHING TASK

4.1. Overview

Bilingualism and monolingualism are increasingly recognised as extremes of a multidimensional spectrum rather than as dichotomic phenomena (Luk, 2015). The distinction between them is not only a matter of quantity but also a matter of quality. It requires considering how well a person knows one or more languages and, most importantly, how (in what contexts) they use it (them). Considering the peculiarities of language context along the other potential variables (e.g., demographic ones) allows for a better understanding of bilingual and monolingual experiences and for a more precise modelling of their effects on metalinguistic awareness and non-verbal cognitive control.

In the current chapter, we explore whether and in what ways language context (monolingual, bilingual separated and bilingual dual) affects the performance of bilingual and monolingual adults on the Metalinguistic Awareness Test and/or the Colour-Shape Switching Task. The chapter starts by providing insight into language context as a potential predictor of metalinguistic awareness and non-verbal cognitive control. Following that, it investigates the capacity of three types of language contexts, i.e. monolingual, bilingual separated and bilingual dual, to predict metalinguistic and task-switching performance of bilingual and monolingual adults.

4.2. Language Context as Predictor of Metalinguistic and Task-Switching Performance

As outlined in Chapter 2, there is substantial controversy regarding the cognitive consequences of bilingualism and monolingualism, and the reliability of previous findings has regularly been questioned. However, there seems to be a general consensus that monolinguals and bilinguals differ in terms of language processing (Costa & Sebastian-Galles, 2014; Kousaie & Phillips, 2017).

Similar to bilinguals, monolinguals need to monitor the environment for cues and select from competing alternatives during communication, but this monitoring only involves alternatives existing within one language (Allopenna, Magnuson, & Tanenhaus, 1998; Schriefers, Meyer, & Levelt, 1990). Bilinguals, on the contrary, need to select from different representational structures (Anderson et al., 2018) and, what is more, they do this constantly, as both of their languages are active even when only one is being used (for review, see Bialystok et al., 2009). In addition, monolinguals have been shown to use distinct networks for verbal and non-verbal tasks, while bilinguals appear to have a shared network for them (Anderson et al., 2018).

Considering the variability in the way and the degree to which those processes are engaged both between and within monolinguals and bilinguals, monolingual and bilingual experiences have been suggested to shape cognitive control in different ways. This fits well with recent theorising about the role of context in determining the nature of the bilingual effect (the Adaptive Control Hypothesis; Green & Abutalebi, 2013).

Green and Abutalebi differentiate between three interactional contexts for bilinguals: dense code-switching (freely switching between languages), single-language contexts (using the two languages in different contexts and/or for different purposes) and dual-language contexts (using both languages in the same context, but with different speakers).

According to Green and Abutalebi, the interactional contexts come with different demands on different control processes and, thus, lead to different cognitive consequences. In particular, dense code-switching is argued to require the least cognitive control. On the contrary, single-language and dual-language contexts are supposed to impose higher demands on a number of control processes. In the case of single-language contexts, those control processes are goal maintenance and ongoing inhibition of the non-target language (proactive control processes); in the case of dual-language context, these are conflict monitoring, interference suppression, selective response inhibition, and task (dis)engagement (reactive control processes). Given the interactional contexts are coupled with quite different executive demands, the specific context(s), in which an individual predominantly operates, may, therefore, affect the emergence and nature of cognitive advantages. This has been explored and supported by a few recent studies on language and cognitive processing in bilinguals (see Chapter 5).

In the current study, we further explored the possible role of language context in shaping the metalinguistic and cognitive performance of bilinguals and monolinguals. In particular, we investigated bilingual dual-language context (use of two languages in the same context, but with different speakers); bilingual separated-language context (use of two languages in different contexts); and monolingual language context (use of one language across the contexts).

4.3. Linear Fixed-Effects Regressions

The data obtained from the monolingual and bilingual participants were used to examine whether and in what ways language context affects their metalinguistic and task-switching performance. In addition to that, we explored whether gender, SES and age added to the explanatory power of the model with language context. To answer these research questions, we generated two linear fixed-effects regression models for each dependent variable using the lm and glm functions (the car package in R). We applied regression analyses and took a data modelling approach to them because we had clear a-priori expectations about the impact of language context, but only had an exploratory interest in the added influence of the other – demographic – variables once language context was accounted for.

4.3.1. Predictors and dependent variables. As detailed in Chapter 3, there were 84 bilingual and monolingual adults (20-40 years old) in the present study. The demographic and language variables extracted from their self-reported data were added to dataframe 1. In addition, we included metalinguistic and cognitive variables obtained from their performance on the MAT and CST.

The demographic and language variables were used as predictors. The language context variable was extracted from the self-reported language use data (see Chapter 3) and was further expressed with two dummy variables: language context 1 (1 = *monolingual*, 0 = *bilingual dual*) and language context 2 (1 = *bilingual separated*, 0 = *bilingual dual*). Gender also used a dummy code: 1 = *male*, 0 = *female*. The other two demographic variables were entered as continuous variables: SES on a 4-point scale (1 = *upper secondary*, 2 = *post-secondary non-tertiary*, 3 = *short-cycle tertiary*, 4 = *tertiary education*) and age in years. Education was not considered because there was no sufficient variance in the current (highly educated) sample. Descriptive statistics are given in Table 4.1.

Table 4.1

Descriptive Statistics for Demographic and Language Variables

Variable	*N*	Mean	*SD*
Gender	male – 32 female – 52	–	–
SES	84	3.07	.94
Age	84	31.06	4.70
Language context	monolingual – 36 bilingual separated – 36 bilingual dual – 24	–	–

Note. SES and education on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Besides demographic and language variables, dataframe 1 contained bilingual and monolingual MAT and CST data, which were treated as dependent variables. The MAT variables were represented by scores on the sound-meaning task (out of 36) and grammaticality judgement task (out of 22.5). Descriptive statistics are provided in Table 4.2.

Table 4.2

Descriptive Statistics for Metalinguistic Awareness Test Variables

Variable	*N*	Mean	*SD*
Sound-meaning task scores	84	33.19	2.98
Grammaticality judgement scores	84	11.94	4.23

Note. Sound-meaning task scores out of 36. Grammaticality judgement task scores out of 22.5.

Task-switching data included: 1) RTs on blocked, repeat and switch trials and 2) mixing and switching costs, computed on the basis of RTs on each trial (see Chapter 3). Means and standard deviations are shown in Table 4.3.

Table 4.3

Descriptive Statistics for the Colour-Shape Switching Task Variables

Variable	*N*	Mean	*SD*
Blocked RTs	84	554.57	137.60
Repeat RTs	84	756.36	183.63
Switch RTs	84	896.82	221.01
Mixing costs	84	201.79	127.91
Switching costs	84	140.46	98.37

Note. RTs, mixing and switching cost are given in ms.

An examination of correlations between the predictors revealed that there was no statistically significant correlation between the demographic variables (see Table 4.4). Furthermore, the collinearity statistics were all within accepted limits ($VIF < 2$).

Table 4.4

Bivariate Correlations Between the Predictors

Variable	1	2	3
1. Gender	–		
2. SES	-.01	–	
3. Age	-.05	-.03	–

Note. Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

In all the analyses, the scatterplots of standardised predicted values versus standardised residuals revealed that demographic and language data met the assumptions of homogeneity of variance. Furthermore, normal Q-Q plots of each variable (see Figure 4.1) showed that the expected and observed cumulative probabilities, while not matching perfectly, were fairly similar. This suggests that the residuals were approximately normally distributed and the assumption of multivariate normality was not violated.

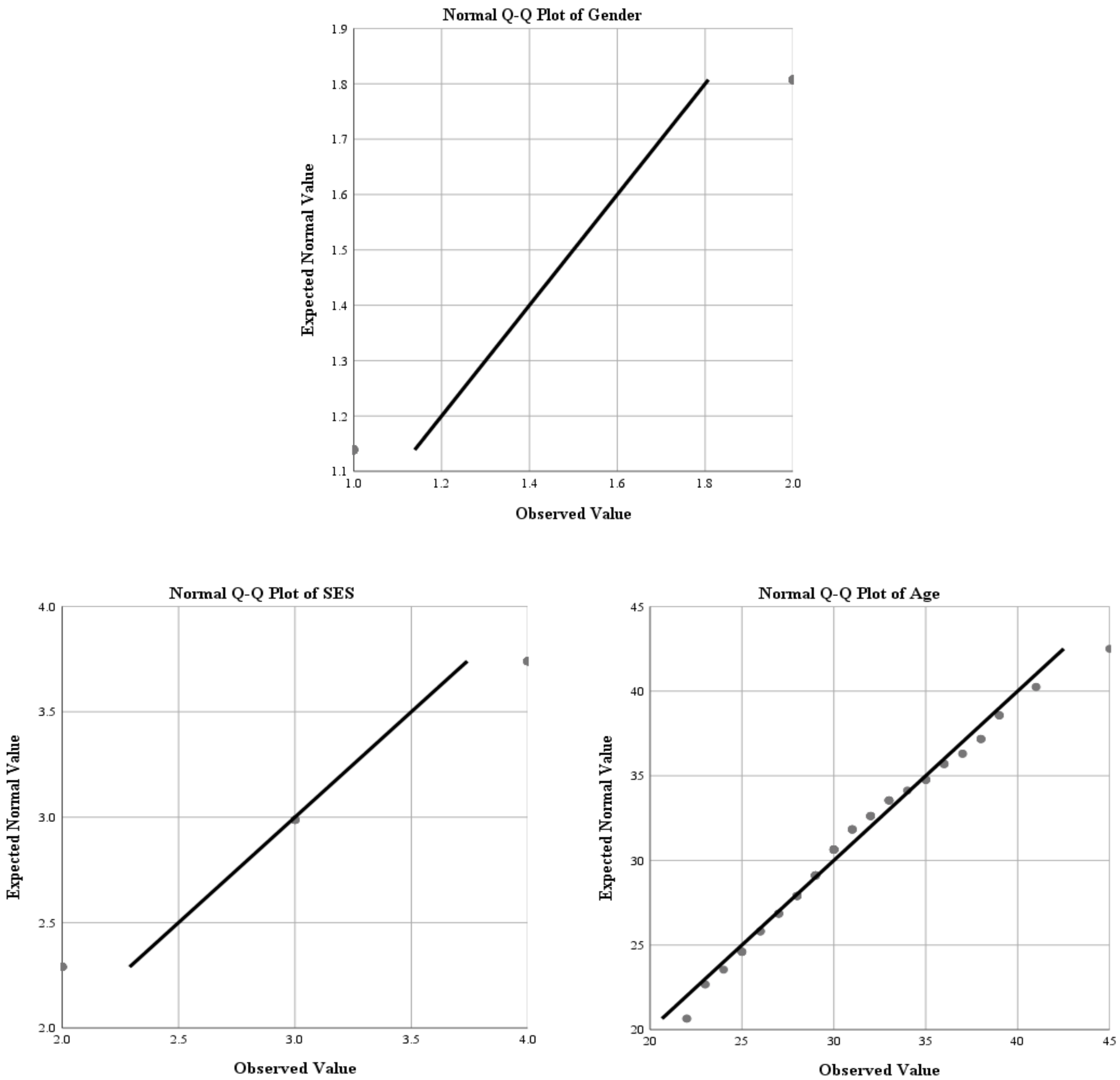


Figure 4.1. Normal Q-Q plots of the predictors.

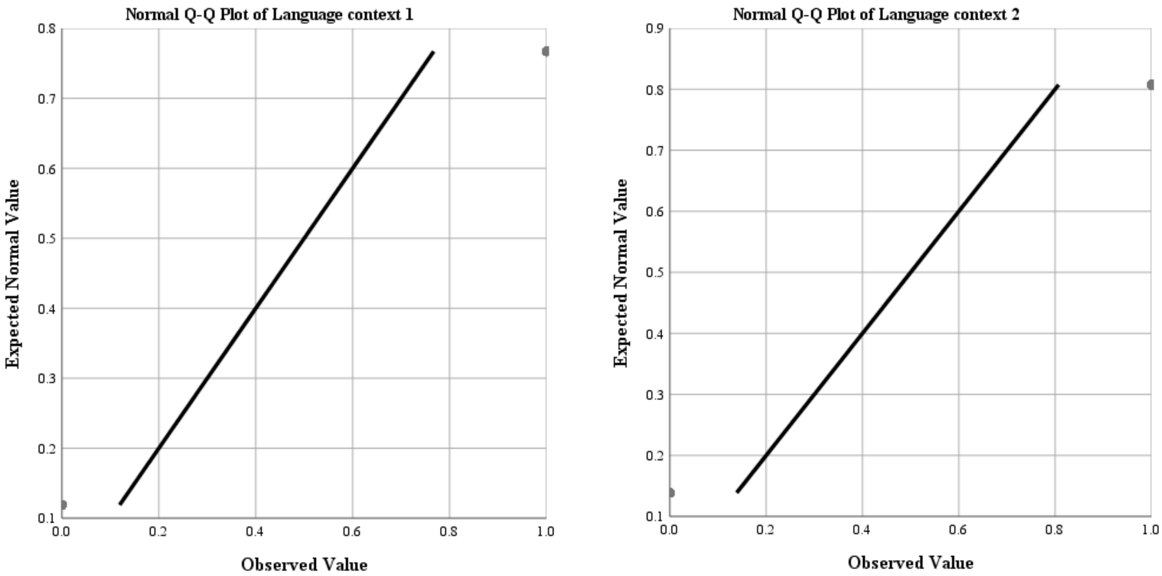


Figure 4.1 (continued). Normal Q-Q plots of the predictors.

4.3.2. Procedure. We started to implement linear fixed-effects regressions by creating a base-line model with *language context* variables as predictors for each MAT task, RTs on each trial and both costs. Following that, we generated one more model for each dependent variable. The enriched model contained *gender, SES, age* and once again *language context(s)* as predictors. Then we compared the second set of models with the base-line models. In particular, we explored whether or not the *p*-value for the Chi square of the difference between the enriched model and the base-line model was significant. Also, we examined which set of models had lower Akaike information criterion (AIC) and Bayesian information criterion (BIC), which are indicative of the variance and the mean-squared error of the residuals, respectively.

After that, we inspected the final minimal adequate model, i.e. the model that explains a maximum of variance with a minimum of predictors, for each dependent variable. In particular, we checked whether or not mathematical requirements and assumptions had been violated. Finally, we summarised the results of regression analyses.

4.3.3. Data analyses and results

4.3.3.1. Linear fixed-effects regressions with Metalinguistic Awareness Test data as dependent variables. For the MAT data, we created four linear fixed-effects models: two for the sound-meaning task (SMT) and two for the grammaticality judgement task (GJT). First, we generated two saturated base-line models with *language context* variables as predictors. Following that, we created two more models with *gender, SES, age* and once again *language context(s)* as predictors. Then, we compared the second set of models with the base-line models.

For all dependent variables, the model with added demographic variables among the predictors did not perform significantly better than the model with language context(s) as the only predictor: *ps* > 0.5, and AICs and/or BICs increased once demographic variables were entered (see Tables 4.5 and 4.6). The minimal adequate model for each dependent variable, therefore, was the model with language context variables.

Table 4.5

Model Fitting for Bilingual and Monolingual Sound-Meaning Task Scores (SMTs)

Model	AIC	BIC
SMTs ~ Language context	389.1	398.8
SMTs ~ Language context + Gender + SES + Age	394.1	411.1

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Table 4.6

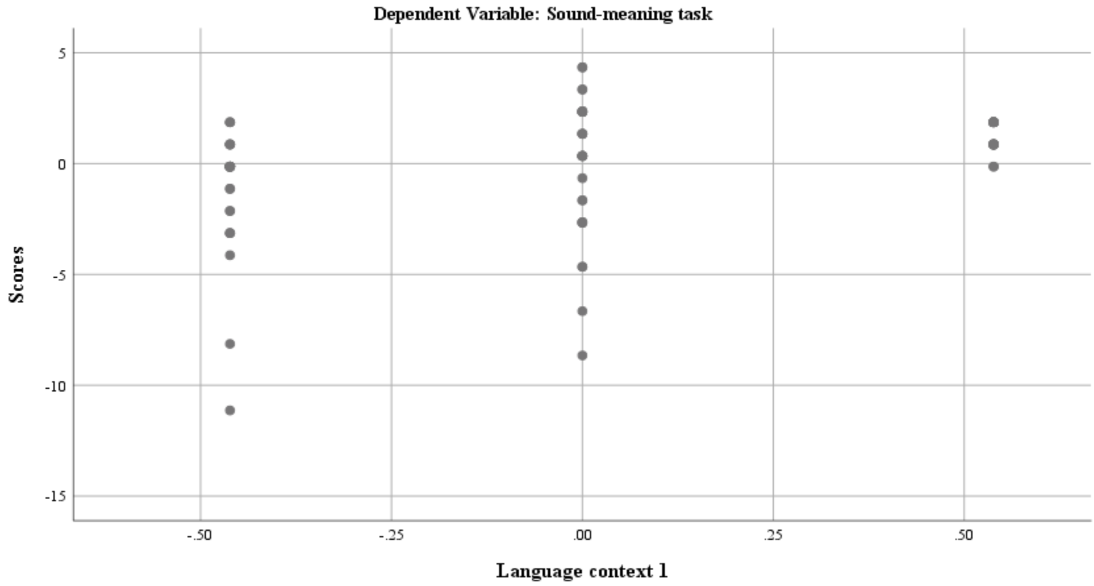
Model Fitting for Bilingual and Monolingual Grammaticality Judgement Task Scores (GJTs)

Model	AIC	BIC
GJTs ~ Language context	414.9	424.6
GJTs ~ Language context + Gender + SES + Age	414.0	431.0

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Next, we performed model diagnostics. As mentioned in Section 4.3.1, the explanatory data (i.e. predictors) met the assumptions of homogeneity of variance, multivariate normality and multicollinearity. In addition, we checked whether there was a linear relationship between the independent and dependent variables in the minimal adequate models. This was done by plotting scatterplots of the relationship between two language context variables – language context 1 and language context 2 – as predictors and scores on the

SMT and GJT as dependent variables. As shown in Figures 4.2 and 4.3, there was a good linear relationship between all of them.



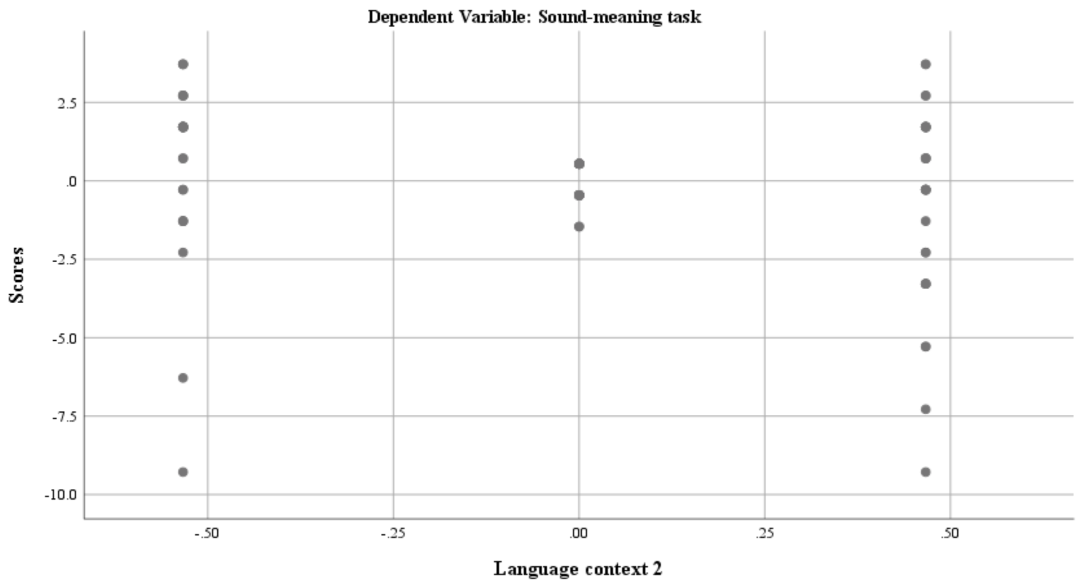
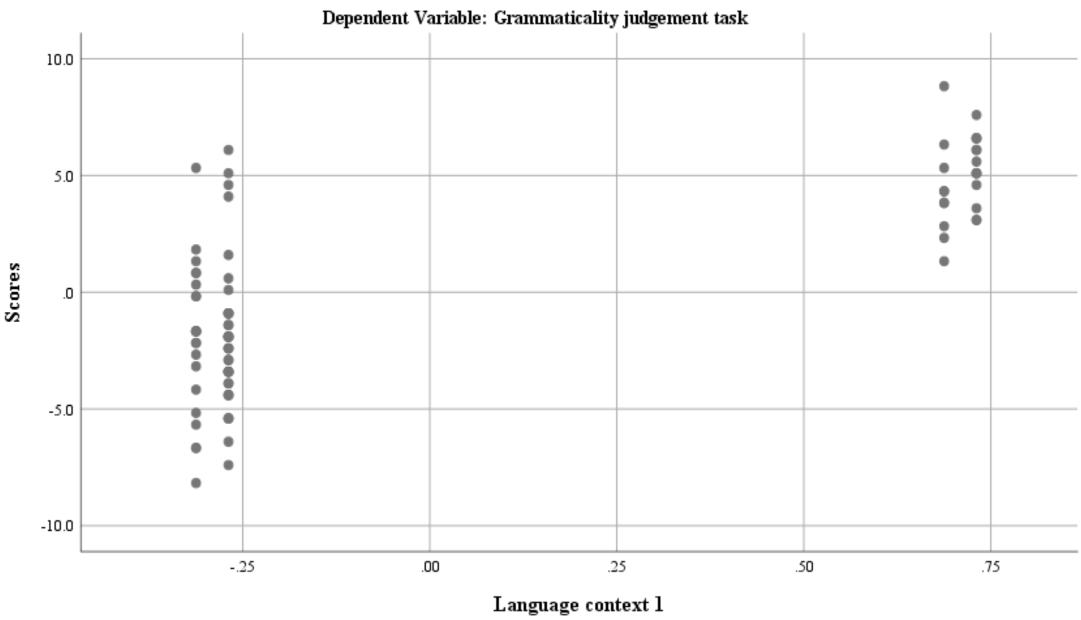


Figure 4.2. Scatterplots of the relationship between language context variables as predictors and sound-meaning task scores as a dependent variable.



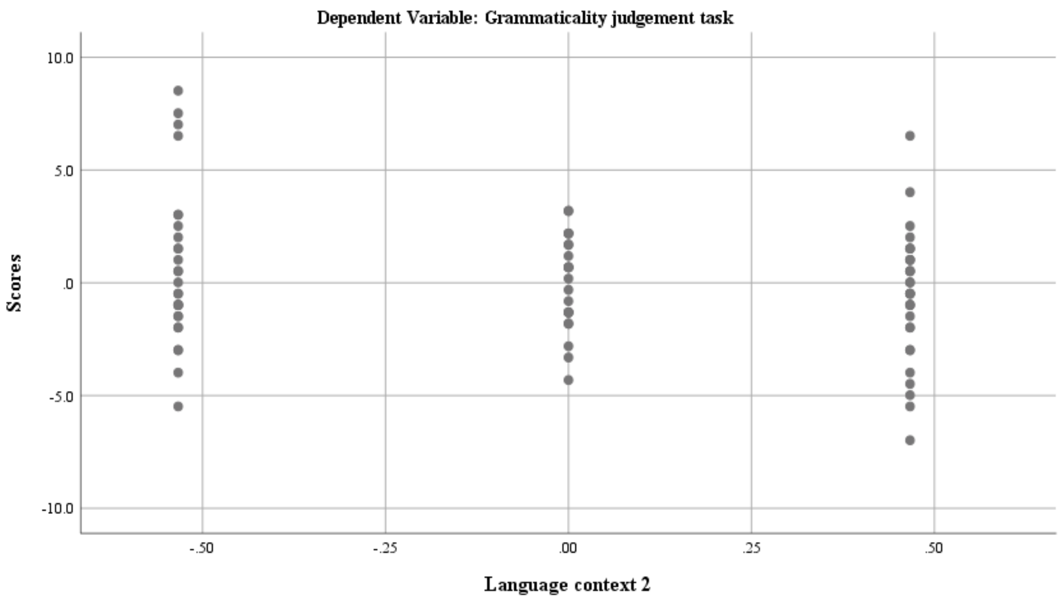


Figure 4.3. Scatterplots of the relationship between language context variables as predictors and grammaticality judgement task scores as a dependent variable.

Furthermore, we checked for normality of residuals with normal P-P plots. The plots in Figure 4.4 demonstrate that the points generally follow the normal (diagonal) line with no strong deviations. This indicates that the residuals were normally distributed.

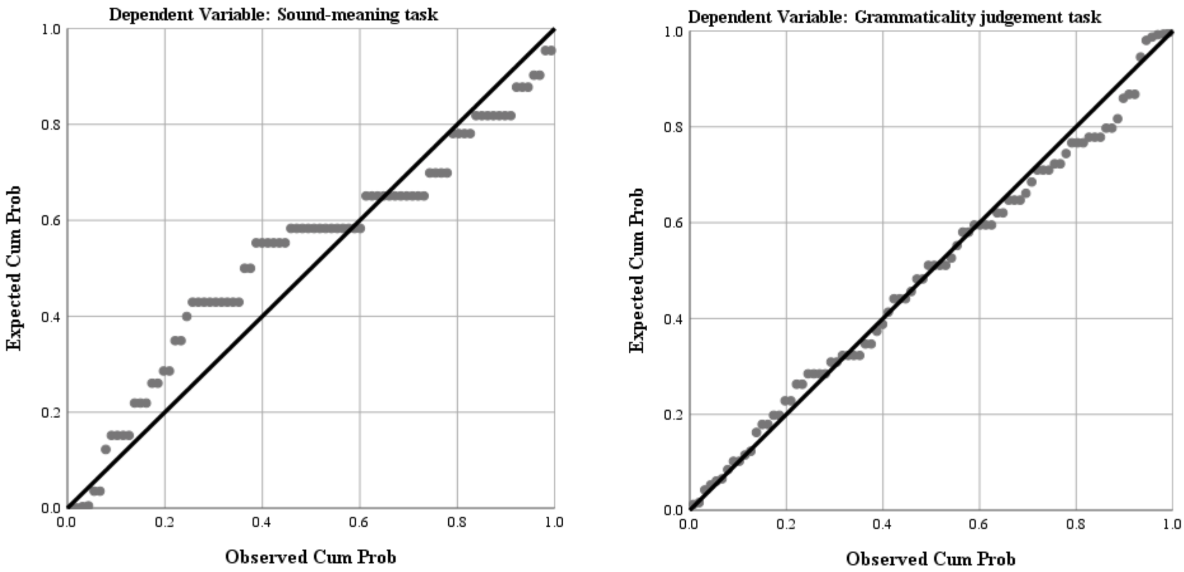


Figure 4.4. Normal P-P plots of regression standardized residuals.

Lastly, we tested the assumption of homoscedasticity. The plots of standardized residuals versus predicted values in Figure 4.5 show that data points are fairly randomly distributed across all values of the independent variables. This implies that the assumption of homoscedasticity was met.

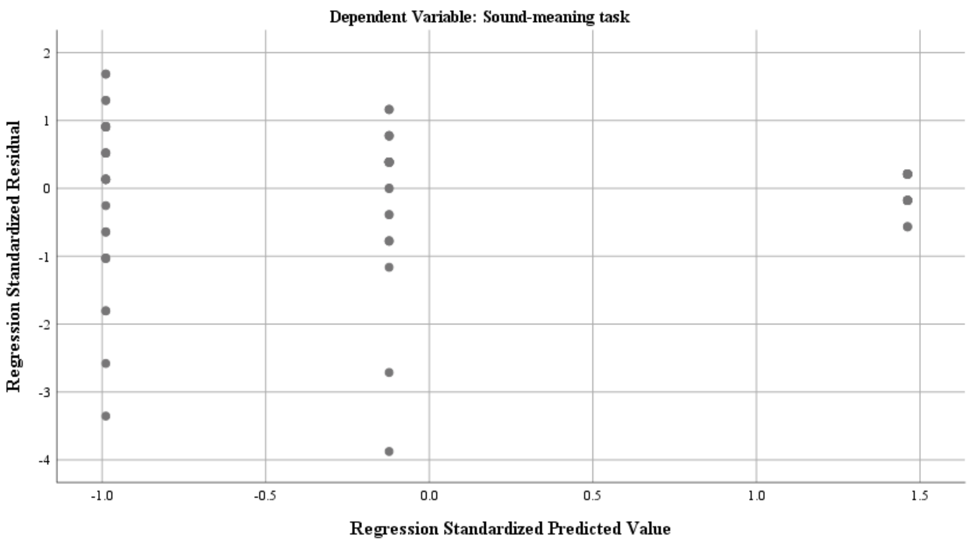


Figure 4.5. Scatterplots of standardized residuals versus predicted values.

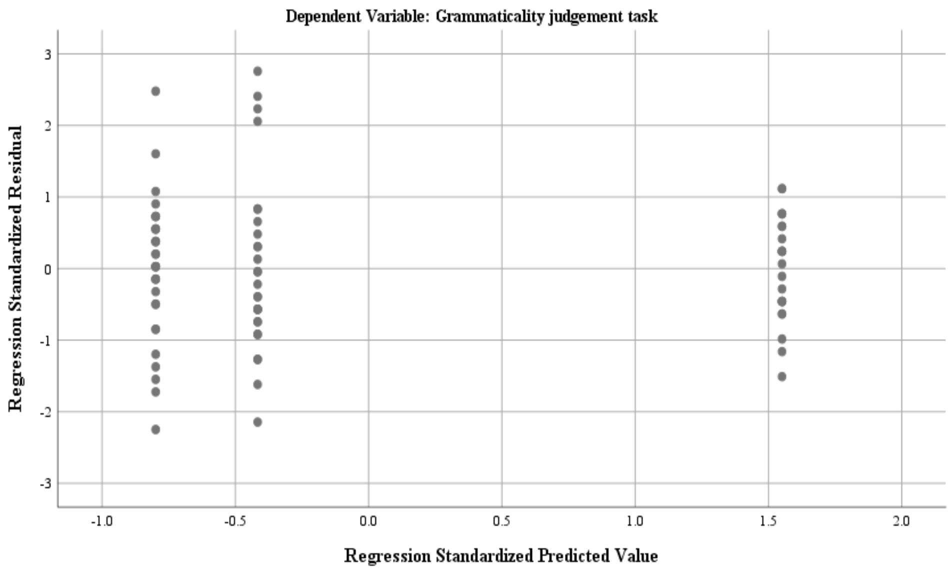


Figure 4.5 (continued). Scatterplots of standardized residuals versus predicted values.

Having performed model diagnostics, we computed the model with *language context(s)* for SMT and GJT scores. As shown in Table 4.7, the minimal adequate model for the SMT explained 27% of the variance in the dependent variable, $p < .001$. Both *language context 1* and *language context 2* significantly predicted the SMT scores, $p < .05$. This reflected the dual-context bilinguals displaying higher scores than the separated-context bilinguals ($B = 1.34$, $p < .05$) and lower scores than the monolinguals ($B = -2.46$, $p < .001$).

In the case of GJT scores, the minimal adequate model accounted for 54.3% of the variance in the dependent variable, $p < .001$. As opposed to the SMT model, only *language context 1* was statistically significant, $p < .001$. Once again the bilingual dual-language context was associated with lower GJT scores than the monolingual language context ($B = -6.19$, $p < .001$). Taken together, the results reveal that the bilingual dual-language context was predictive of higher metalinguistic scores than bilingual separated and lower scores than the monolingual language context.

Table 4.7

Minimal Adequate Model Showing the Capacity of the Variables to Predict the Sound-Meaning Task Scores

Variable	*B*	SE *B*	*Β*	*t*	Sig.
Model: R^2 = 27%, p < .001					
ΔR^2= 25.2%, p < .001					
Language context 1	2.46	.72	.37	3.43	.001
Language context 2	-1.34	.67	-.22	-2.01	.047

Note. Language context 1: 1 = monolingual, 0 = bilingual dual. Language context 2: 1 = bilingual separated, 0 = bilingual dual.

Table 4.8

Minimal Adequate Models Showing the Capacity of the Variables to Predict the Grammaticality Judgement Task Scores

Variable	*B*	SE *B*	*Β*	*t*	Sig.
Model: R^2 = 55.4%, p < .001					
ΔR^2= 54.3%, p < .001					
Language context 1	6.19	.80	.67	7.79	.000
Language context 2	-1.20	.74	-.14	-1.63	.107

Note. Language context 1: 1 = monolingual, 0 = bilingual dual. Language context 2: 1 = bilingual separated, 0 = bilingual dual.

4.3.3.2. Linear fixed-effects regressions with Colour-Shape Switching Task data as dependent variables. For CST data analysis, we used the same basic analytical and reporting approach as described in the previous section. First, we created a saturated base-line model with *language context* variables as predictors for RTs on each trial and for both costs. For each dependent variable, we then generated one more model with *gender, SES, age* and once again *language context(s)* as predictors. Following that, we compared the second set of models with the base-line models.

For all dependent variables, the model with added demographic variables among the predictors did not perform significantly better than the model with language context(s) as the only predictor: *ps* > 0.5, and AICs and/or BICs increased once demographic variables were entered (see Tables 4.9-4.13). The minimal adequate model for each dependent variable, therefore, was the model with language context variables.

Table 4.9
Model Fitting for Bilingual and Monolingual Blocked RTs (BRTs)

Model	AIC	BIC
BRTs ~ Language context	1066.5	1076.2
BRTs ~ Language context + Gender + SES + Age	1071.4	1088.4

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Table 4.10

Model Fitting for Bilingual and Monolingual Repeat RTs (RRTs)

Model	AIC	BIC
RRTs ~ Language context	1095.8	1105.5
RRTs ~ Language context + Gender + SES + Age	1098.4	1115.4

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Table 4.11

Model Fitting for Bilingual and Monolingual Switch RTs (SRTs)

Model	AIC	BIC
SRTs ~ Language context	1117.1	1126.8
SRTs ~ Language context + Gender + SES + Age	1117.5	1134.5

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Table 4.12

Model Fitting for Bilingual and Monolingual Mixing Costs (MCs)

Model	AIC	BIC
MCs ~ Language context	1041.8	1051.5
MCs ~ Language context + Gender + SES + Age	1044.6	1061.6

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Table 4.13

Model Fitting for Bilingual and Monolingual Switching Costs (SCs)

Model	AIC	BIC
SCs ~ Language context	999.7	1009.4
SCs ~ Language context + Gender + SES + Age	999.2	1016.2

Note. Language context (language context 1: 1 = monolingual, 0 = bilingual dual; language context 2: 1 = bilingual separated, 0 = bilingual dual). Gender: 1 = male, 0 = female. SES on a 4-point scale (1 = upper secondary, 2 = post-secondary non-tertiary, 3 = short-cycle tertiary, 4 = tertiary education). Age in years.

Having determined the minimal adequate model for each dependent variable, we moved to model diagnostics. As outlined in Section 4.3.1, the assumptions of homogeneity of variance, multivariate normality and multicollinearity were met. In addition, there was a good linear relationship between the predictors and dependent variables (see Figures 4.6-4.10).

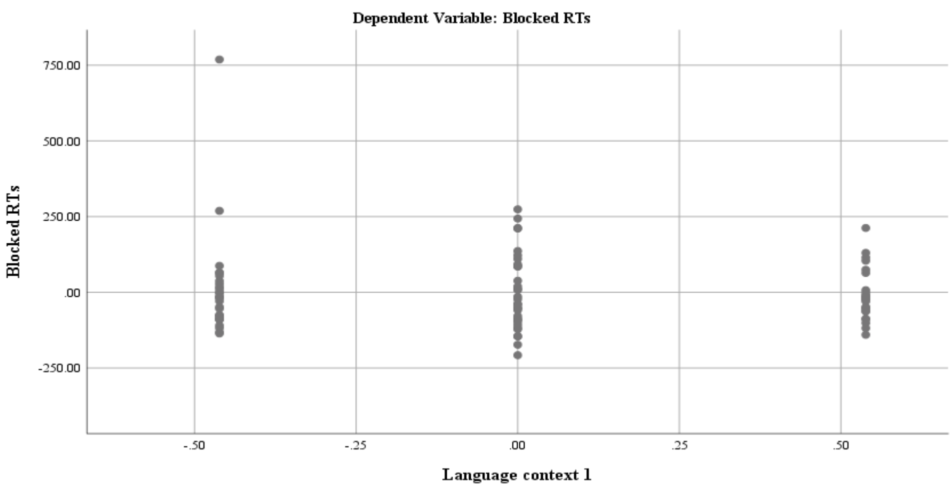


Figure 4.6. Scatterplots of the relationship between language context variables as predictors and blocked RTs as a dependent variable.

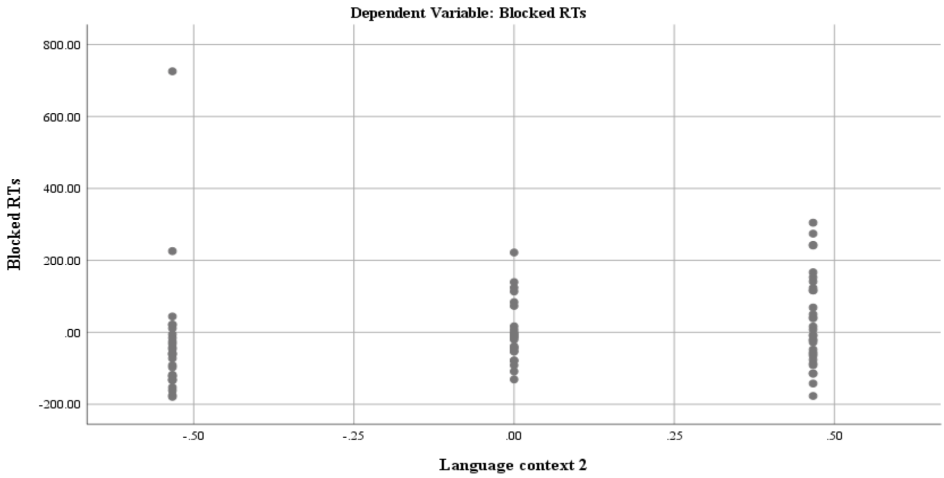
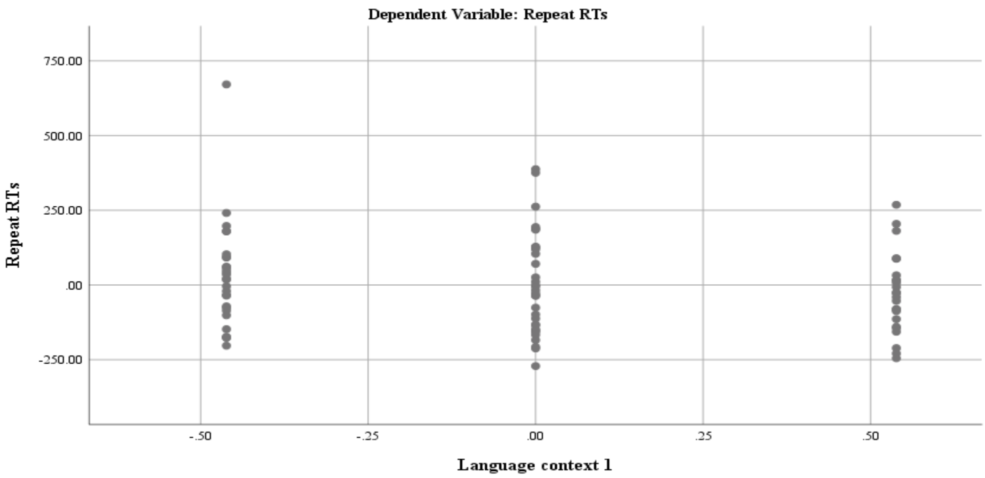


Figure 4.6 (continued). Scatterplots of the relationship between language context variables as predictors and blocked RTs as a dependent variable.



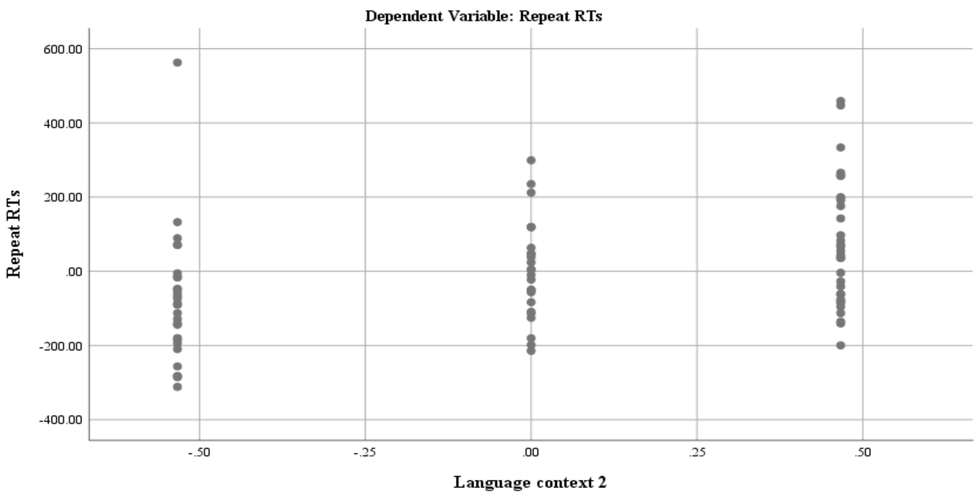


Figure 4.7. Scatterplots of the relationship between language context variables as predictors and repeat RTs as a dependent variable.

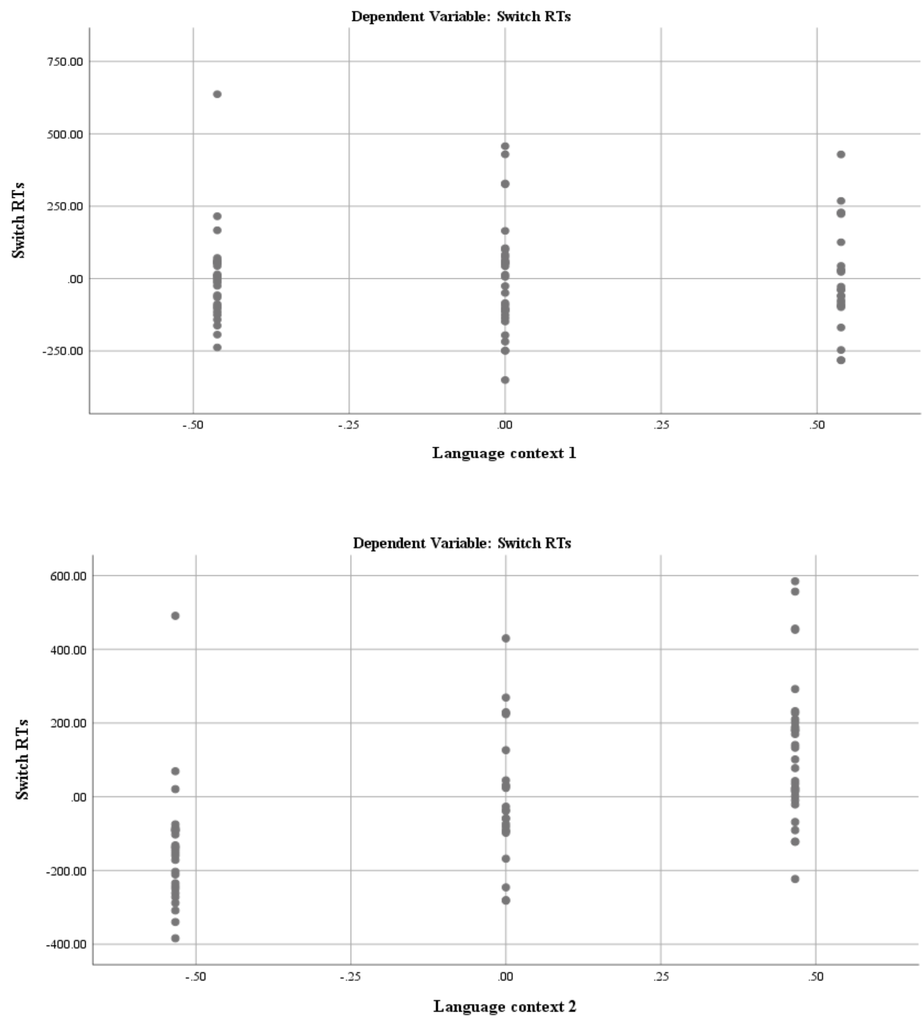


Figure 4.8. Scatterplots of the relationship between language context variables as predictors and switch RTs as a dependent variable.

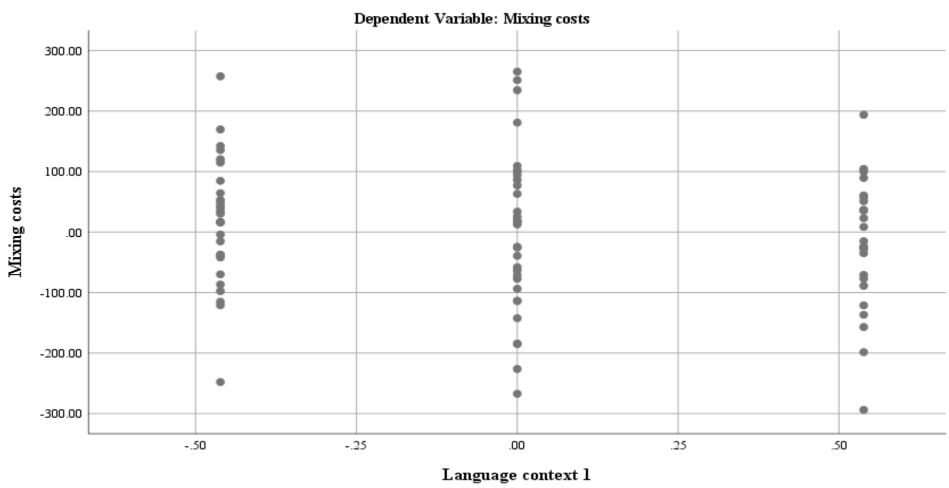


Figure 4.9. Scatterplots of the relationship between language context variables as predictors and mixing costs as a dependent variable.

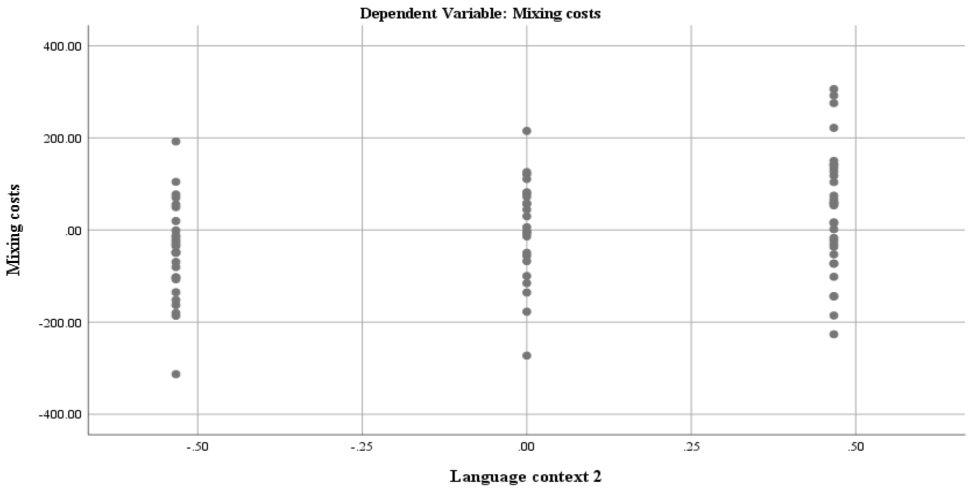


Figure 4.9 (continued). Scatterplots of the relationship between language context variables as predictors and mixing costs as a dependent variable.

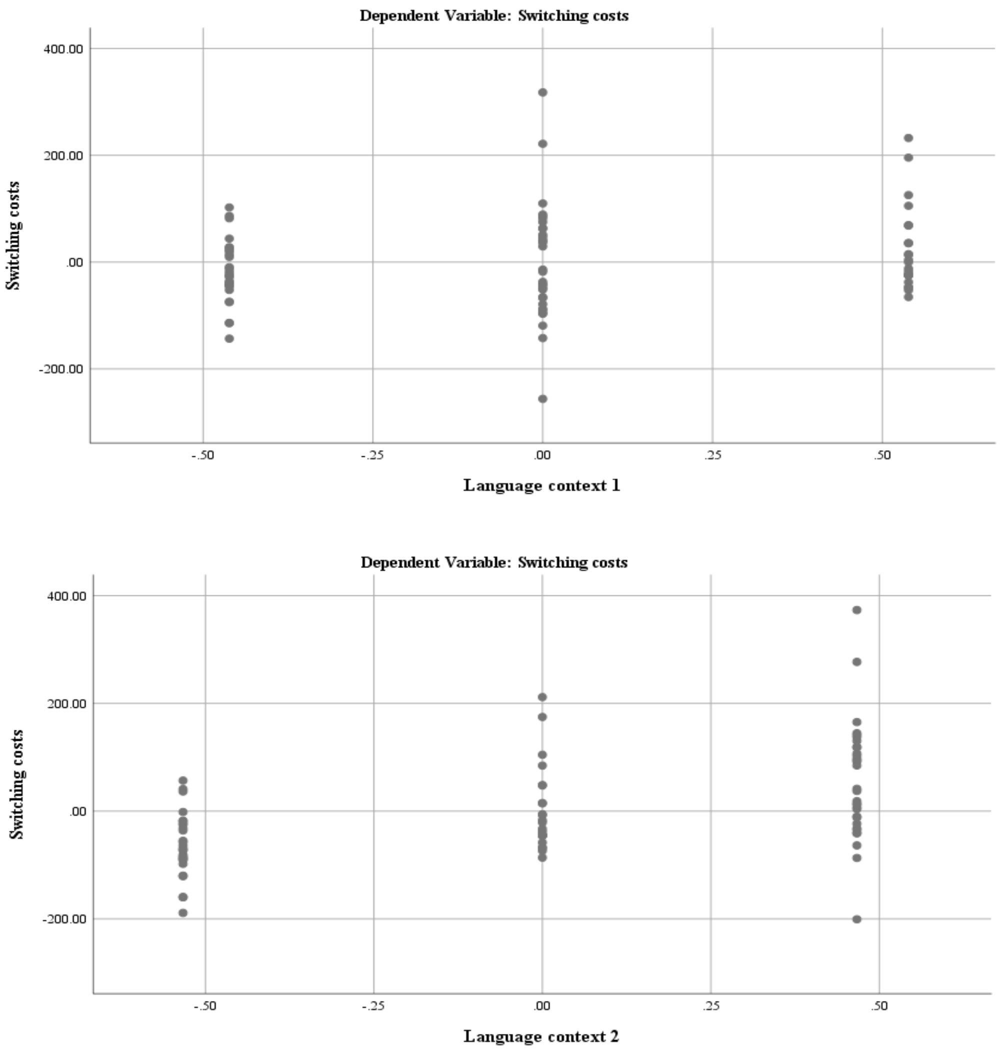


Figure 4.10. Scatterplots of the relationship between language context variables as predictors and switching costs as a dependent variable.

Also, we checked for normality of residuals. The normal P-P plots in Figure 4.11 show that the points generally follow the normal (diagonal) line with no strong deviations. This indicates that the residuals were normally distributed.

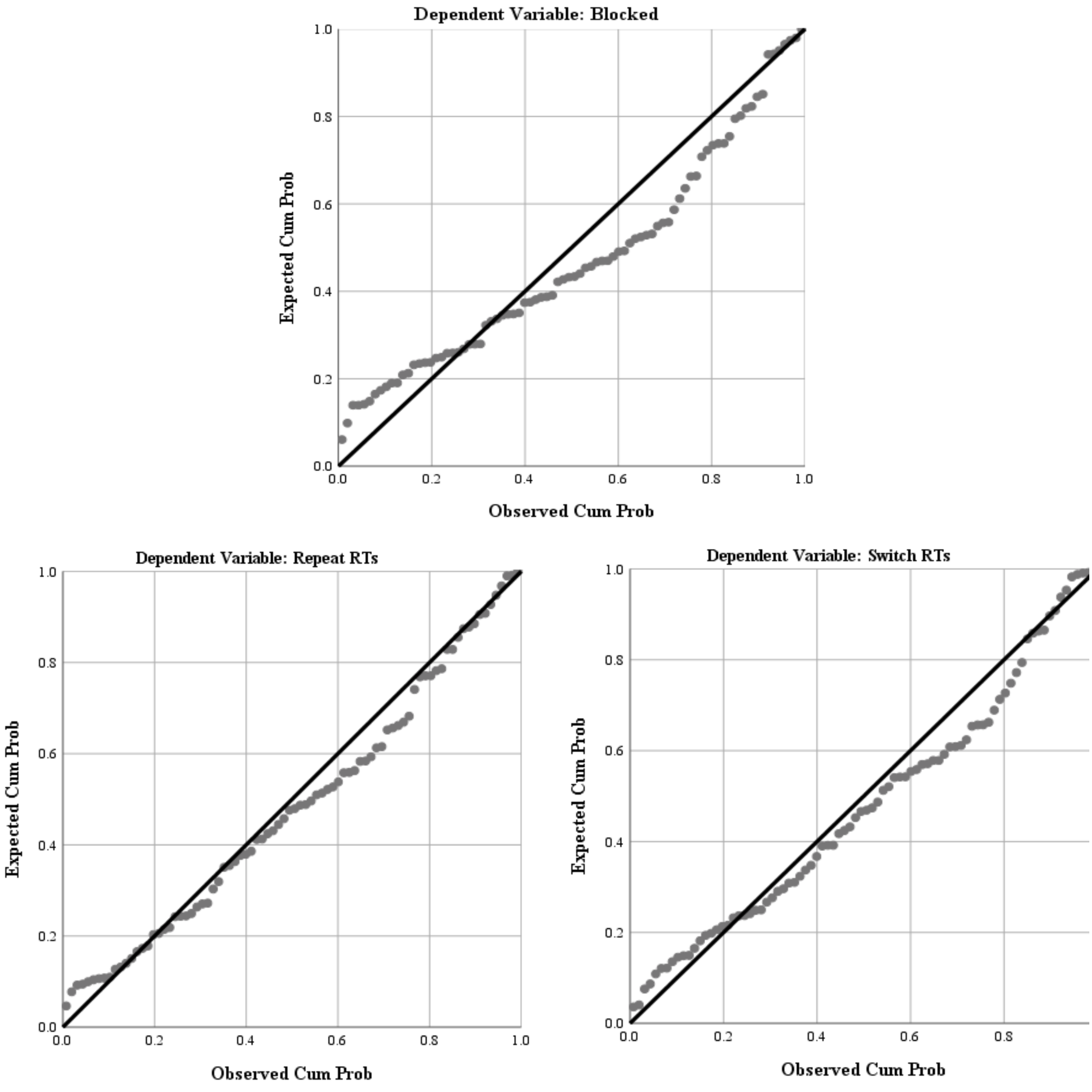


Figure 4.11. Normal P-P plots of regression standardized residuals.

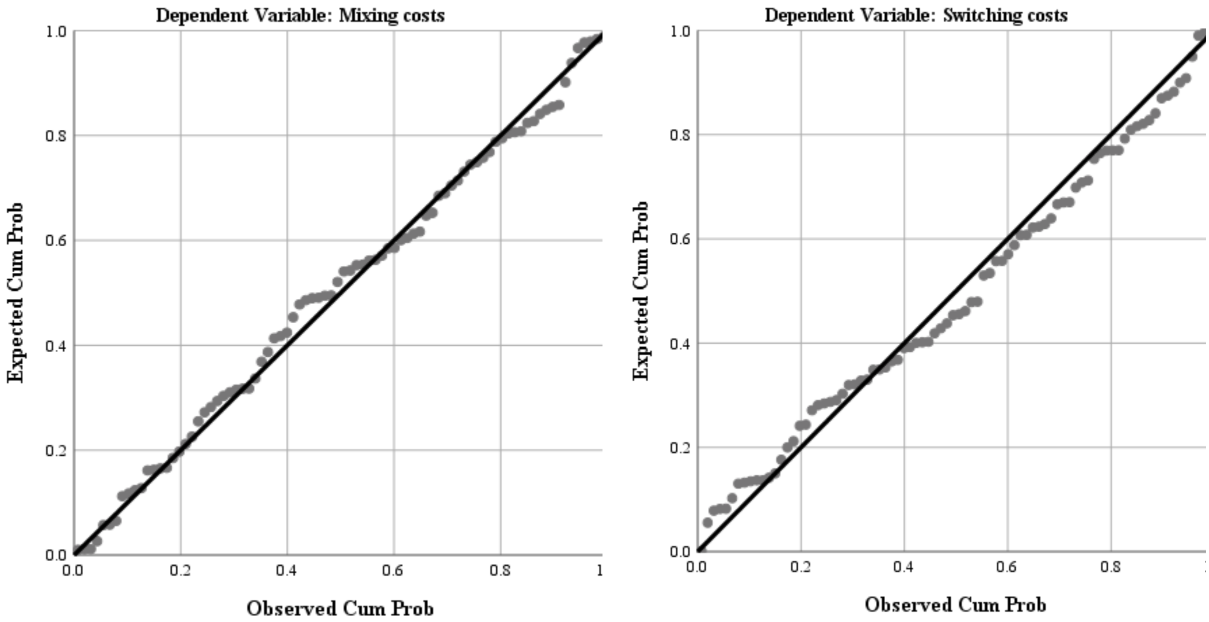


Figure 4.11 (continued). Normal P-P plots of regression standardized residuals.

Lastly, we tested the assumption of homoscedasticity with plots of standardized residuals versus predicted values. As shown in Figure 4.12, data points are fairly randomly distributed across all values of the independent variables; therefore, the assumption of homoscedasticity was met.

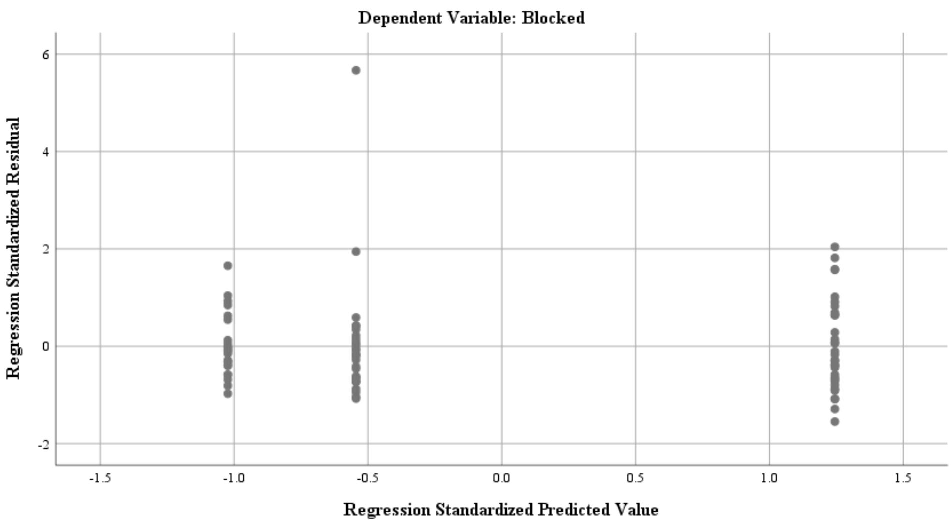


Figure 4.12. Scatterplots of standardized residuals versus predicted values.

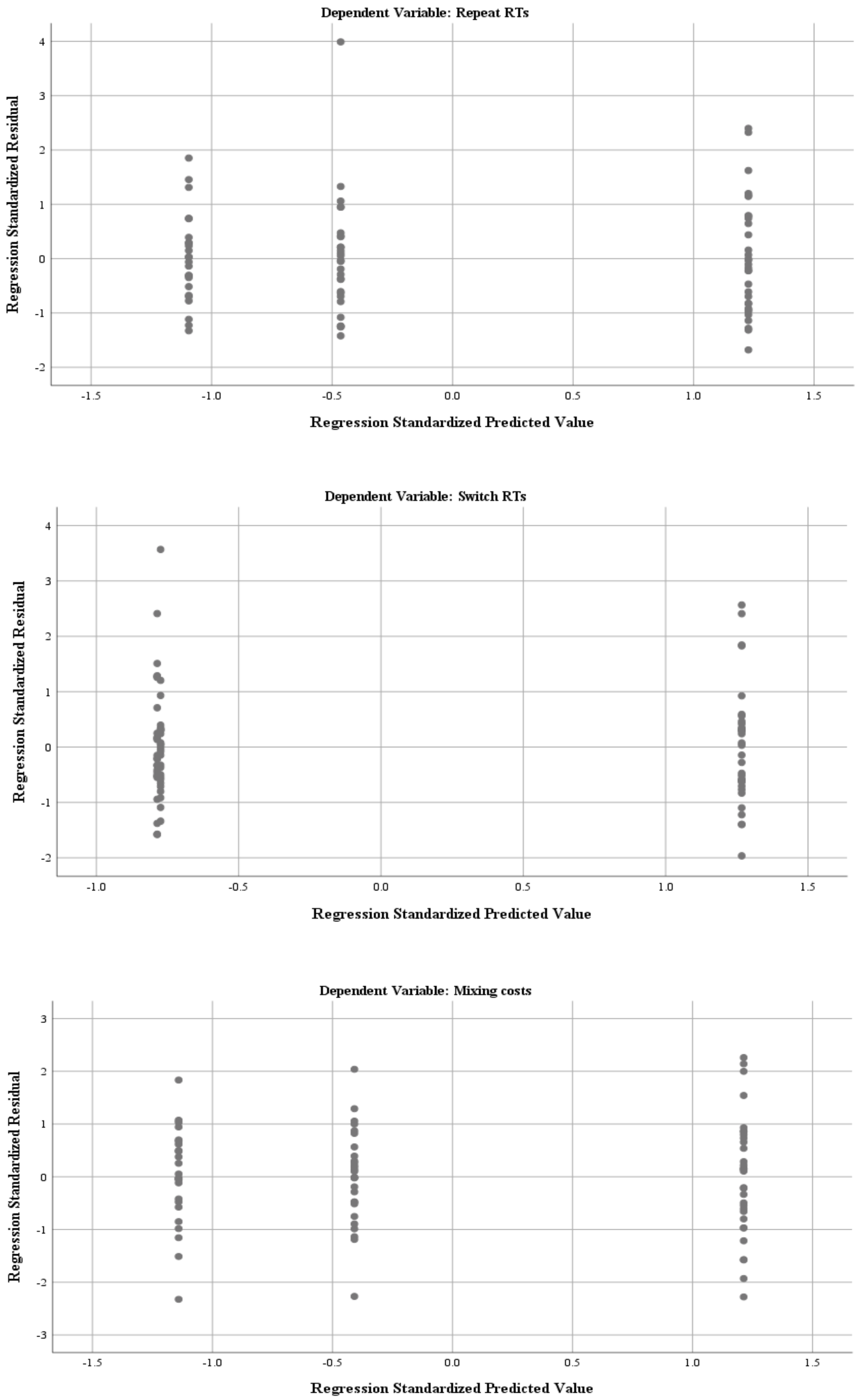


Figure 4.12 (continued). Scatterplots of standardized residuals versus predicted values.

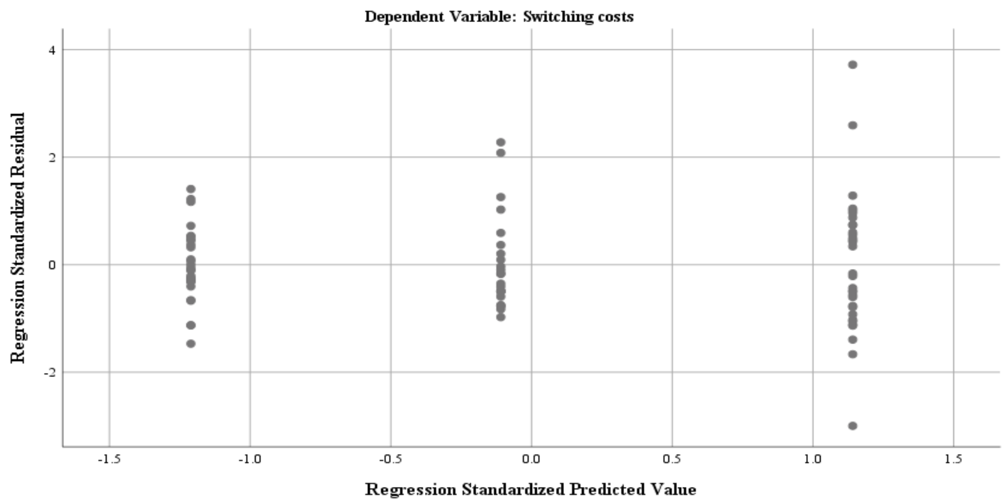


Figure 4.12 (continued). Scatterplots of standardized residuals versus predicted values.

After inspecting the models, we computed the model with *language context(s)* for RTs on each trial and both costs. Among the minimal adequate models for RTs on each trial, the one for blocked RTs explained the lowest percentage of the variance in the dependent variable, 4.9%, $p < .05$ (see Table 4.14). Furthermore, neither of the language context variables was a significant predictor, *ps* > .05.

In comparison with blocked RTs model, the minimal adequate model for repeat RTs accounted for a higher percentage of the variance in the dependent variable, 22.6%, $p < .001$. Moreover, one of the language context variables, i.e. *language context 2*, was revealed to significantly predict RTs on repeat trials: the bilingual dual-language context resulted in lower repeat RTs than bilingual separated ($B = -153.70$, $p < .001$).

Table 4.14

Minimal Adequate Models Showing the Capacity of the Variables to Predict RTs on Colour-Shape Switching Task Trials

Variable	*B*	SE *B*	*β*	*t*	Sig.
Blocked RTs model: R^2 = 7.2%, p < .05					
ΔR^2= 4.9%, p < .05					
Language context 1	-17.67	37.33	-.06	-.47	.637
Language context 2	65.97	34.73	.23	1.90	.061
Repeat RTs model: R^2 = 24.5%, p < .001					
ΔR^2= 22.6%, p < .001					
Language context 1	-57.27	44.94	-.14	-1.27	.206
Language context 2	153.70	41.80	.41	3.68	.000
Switch RTs model: R^2 = 36.5%, p < .001					
ΔR^2= 34.9%, p < .001					
Language context 1	-1.61	49.59	-.00	-.03	.974
Language context 2	272.57	46.13	.60	5.91	.000

Note. Language context 1: 1 = monolingual, 0 = bilingual dual. Language context 2: 1 = bilingual separated, 0 = bilingual dual.

Among the three RTs models, the model for switch RTs explained the highest percentage of the variance in the dependent variable, 34.9%, $p < .001$. As in the case of repeat RTs, only *language context 2* was a statistically significant predictor of RTs: the bilingual dual-language context was associated with lower switch RTs relative to the bilingual separated-language context (B = -272.57, $p < .001$). Taken together, three models show that the use of two languages in the dual-language context was predictive of lower repeat and switch RTs as compared to the use in the bilingual separated-language context.

Among the minimal adequate models for costs, the model for mixing costs accounted for the lowest percentage of the variance in the dependent variable, 15.9%, $p < .001$ (see Table 4.15). It had only one significant predictor: *language context 2*. This effect reflected the dual-context bilinguals displaying lower mixing costs than the separated-context bilinguals (B = -87.73, $p < .05$).

Table 4.15
Minimal Adequate Models Showing the Capacity of the Variables to Predict Mixing and Switching Costs

Variable	*B*	SE *B*	*B*	*T*	Sig.
Mixing costs model: R^2 = 17.9%, p < .001					
ΔR^2= 15.9%, p < .001					
Language context 1	-39.61	32.64	-.14	-1.21	.228
Language context 2	87.73	30.36	.34	2.89	.005
Switching costs model: R^2 = 26.4%, p < .001					
ΔR^2= 24.6%, p < .001					
Language context 1	55.67	23.76	.26	2.34	.022
Language context 2	118.87	22.11	.59	5.38	.000

Note. Language context 1: 1 = monolingual, 0 = bilingual dual. Language context 2: 1 = bilingual separated, 0 = bilingual dual.

In the case of switching costs, the best model explained 26.4% of the variance in the dependent variable, $p < .001$. As opposed to mixing costs, both *language context 1* and *language context 2* were significant predictors, *ps* < .05. The bilingual dual-language context was associated with significantly lower switching costs than both monolingual (B = -55.67, p < .05) and bilingual separated-language contexts (B = -118.87, p < .001). Hence, these two models indicate that the use of two languages in the dual-language context was predictive of lower mixing costs relative to the use in the bilingual separated-language context; and it was also predictive of reduced switching costs as compared to both bilingual separated- and monolingual language contexts.

4.4. Chapter Summary

The chapter examined the capacity of language context to predict metalinguistic and task-switching performance of bilingual and monolingual adults. The three language contexts considered were monolingual, bilingual separated and bilingual dual. To approach the research question, we generated a linear fixed-effects regression model with *language context(s)* as predictor, and in addition, a model with *gender, SES, age* and once again *language context(s)* to check if demographic variables added significantly to the explanatory power of the model with language context variables. The two models were created for each MAT task, for RTs on each trial and for two costs.

The regression analyses revealed that variance in participants' metalinguistic and task-switching performance could be best explained in terms of differences in language context(s) without considering the demographic variables. In the case of MAT data, the bilingual dual-language context was associated with higher scores than the bilingual separated-language context and lower scores than the monolingual language context. In the case of CST data, the use of two languages in the dual-language context was predictive of lower repeat RTs, switch RTs and mixing costs as compared to the use in the bilingual separated-language context; and it was also predictive of reduced switching costs relative to both bilingual separated- and monolingual language contexts. Given the differences between the two bilingual language contexts in metalinguistic and task-switching performance, we further explored inter-individual variability in our bilingual sample and the extent to which it affects metalinguistic awareness and non-verbal cognitive control (see Chapter 5).

CHAPTER 5

BILINGUAL LANGUAGE EXPERIENCE AS PREDICTOR OF BILINGUALS' PERFORMANCE ON THE METALINGUISTIC AWARENESS TEST AND THE COLOUR-SHAPE SWITCHING TASK

5.1. Overview

As the literature review (see Chapter 2) suggests, bilingualism is currently regarded as a continuous and multifaceted phenomenon sensitive to a number of distinct but interacting language learning and use variables (de Bruin, 2019; Laine & Lehtonen, 2018; Sulpizio et al., 2020; Zirnstein et al., 2019). The multidimensional nature of the bilingual language experience makes it more complex and fundamentally distinct from monolingualism.

The inter-individual variability in bilingual language experience yields heterogeneous profiles of bilinguals. Moreover, it has also been suggested to shape the engagement of domain-general cognitive control in language tasks and, therefore, lead to different functional consequences across the cognitive domains (Green & Abutalebi, 2013; Gullifer et al., 2018; Hartanto & Yang, 2016; Pot et al., 2018; Sulpizio et al., 2020). Therefore, delving into dimensions of bilingual language experience is important in advancing our understanding of language-cognition interfaces and bilingual behaviours in general. Given that some of the dimensions are not applicable to monolingual language experience and that there is little variability in them, this research requires within-group analyses of bilinguals (Laine & Lehtonen, 2018; Sulpizio et al., 2020).

In this chapter, we investigate the capacity of bilingual language experience to predict the performance of bilingual adults on the Metalinguistic Awareness Test and the Colour-Shape Switching Task. The chapter starts by discussing six dimensions of bilingual language experience that may drive bilingual cognitive performance. Then it examines the way and extent to which inter-individual variability in bilingual language experience in the current bilingual sample affects their metalinguistic and task-switching performance.

5.2. Dimensions of Bilingual Language Experience as Predictors of Metalinguistic and Task-Switching Performance

Bilinguals vary along many more dimensions of language experience and show more variability in each of them than monolinguals. Bilinguals may differ in typological proximity/distance between their two languages, age of L2 acquisition, onset age of active bilingualism, language proficiency and language use, among other variables. The role of each of these variables on bilinguals' cognitive performance has been considered in previous research but to a different extent.

5.2.1. Typological proximity/distance between L1 and L2. Among the presumed predictors, typological proximity/distance between L1 and L2 has received the least attention in the bilingual advantage debate. This state of affairs is probably, at least in part, due to the existing assumption that the potential cognitive benefits of bilingualism would generalise across the languages involved (Carlson & Meltzoff, 2008). That is why most previous research has worked with participant samples that were linguistically relatively homogeneous – same L1 and same L2 (e.g., Colzato et al., 2008; Costa et al., 2008; Hernandez et al., 2010; Tao et al., 2011). Even when bilinguals differed in their L1 or L2, typological proximity/distance was not taken into account while interpreting their performance (e.g., Bialystok et al., 2004; Carlson & Meltzoff, 2008).

However, the findings on bilingual benefits in executive functions in young adults suggest that typological proximity/distance between two languages may affect the cognitive consequences of bilingualism. Unlike children and the elderly, cognitive advantages in young adults were only found among bilinguals with language sets that were relatively similar in terms of lexical items and grammatical structure (e.g., Catalan-Spanish bilinguals in Costa et al., 2008 and in Hernandez et al., 2010). It may be, therefore, that usage of two typologically close languages requires a greater degree of cognitive control, in particular in young adults, leading to more efficient executive networks, than the usage of two typologically distant languages.

On the other hand, there is the study of Bialystok et al. (2005), in which Cantonese-English bilinguals outperformed French-English bilinguals and English-speaking monolinguals on a non-verbal cognitive task. However, considering the small number of participants in each group (n = 10), the researchers indicated that this result could be due to sampling variability rather than typological proximity/distance. Thus, it still remains an open question whether having two typologically distant languages will lead to similar advantages in young adults.

According to Antoniou and Wright (2017), there are two possible ways in which typological proximity/distance between two languages could mediate the cognitive consequences of bilingualism. The first one is the processing complexity effect, which implies that learning and using two typologically different languages could result in greater cognitive improvements. Given that the benefits are argued to be greatest when demands exceed the available cognitive resources (Schroeder & Marian, 2016), there is a possibility that more effortful processing of lexically and/or structurally distinct languages will lead to greater advantages in cognitive control.

The other way is the interference inhibition effect based on the idea that the acquisition and use of typologically similar languages are more likely to boost executive functions across the cognitive domains. The reason behind this idea is that similar languages interfere more with each other than dissimilar ones (Broersma & Cutler, 2011; Cutler, 2015), increasing demands on the executive function system and its associated brain structures (Abutalebi et al., 2012; Stein et al., 2012; Zou, Ding, Abutalebi, Shu, & Peng, 2012).

Although the potential role of typological proximity/distance in shaping the cognitive consequences of bilingualism has not been tested systematically yet, the findings from recent structural neuroimaging research indicate that this factor may result in distinct brain differences. For instance, in the study by Abutalebi, Canini, Della Rosa, Green and Weekes (2015), both ageing Cantonese-English and Cantonese-Mandarin bilinguals showed greater grey matter volumes for the right inferior parietal lobule. However, only Cantonese-Mandarin bilinguals showed greater grey matter volumes for the left inferior parietal lobule. This suggests that usage of two similar languages is likely to result in greater competition and place greater demands on the executive control system, in particular on inhibition, thus providing evidence for the hypothesized interference inhibition effect.

5.2.2. Age of L2 acquisition. Another factor that might influence the nature of cognitive processing in bilinguals is the age of L2 acquisition, i.e. the age at which they started learning their second language. This could be due not only to biological constraints on language learning, but to also the fact that age of acquisition may be a proxy for a set of environmental differences associated with early vs late second language learning (Tao et al., 2011).

Early studies on cognitive control in bilinguals concentrated mainly on early successive bilinguals, i.e. those who were consecutively exposed to each of their two languages in their first years of life (in most cases before the age of 6). The participants were compared with suitably matched monolinguals on a variety of cognitive tasks targeting different control processes. For instance, Bialystok and Martin (2004) tested early Chinese-English bilingual children and English monolinguals on the Dimensional Change Card Sort Task. The superior performance of the bilingual group in the study led the researchers to the conclusion that early childhood bilingualism modifies children's development of control of attention.

Bilingual cognitive benefits were also reported by Bialystok et al. (2004) and Martin-Rhee and Bialystok (2008). The performance of early bilingual and monolingual adults and children on the Simon task provided evidence for a bilingual advantage in control over attention to competing cues and working memory. Furthermore, early bilinguals were found to be faster than monolinguals on the behavioural anti-saccade task (Bialystok, Craik, & Ryan, 2006; Bialystok & Viswanathan, 2009) and the flanker task (Costa et al., 2008; Emmorey et al. 2008), in both congruent and incongruent trials. This pattern of results indicates the possibility of early bilingualism enhancing conflict monitoring and cognitive flexibility. This further suggests that early bilinguals are more likely to show larger executive control advantages than late bilinguals, i.e. those who started learning their L2 as adolescents (after the age of 6) or in early adulthood (after the age of 18).

5.2.3. Onset age of active bilingualism. The cognitive advantages produced by early bilinguals in previous studies have made researchers wonder whether those benefits were due to the participants' earlier exposure to both languages or to their having had more prolonged experience managing two languages (e.g., Bialystok et al., 2004; Bialystok et al., 2006).

In order to shed light on this matter, a number of studies assessed bilingual participants' onset age of active bilingualism in addition to their age of L2 acquisition. However, they conceptualised the variable in a slightly different way. As an indicator of the onset age of active bilingualism, some researchers used the age of immigration (the age of immersion in the L2 environment), while the others applied the age at which participants started using both languages on a daily basis.

For instance, Tao et al. (2011) classified their 66 Chinese-English bilingual participants into 36 early bilinguals and 30 late bilinguals on the basis of their age of arrival in an English-speaking country. On the other hand, Luk et al. (2011) used the age at which participants began using two languages actively on a daily basis. This resulted in 43 early bilinguals and 42 late bilinguals (those actively using both languages before and after the age of 10, respectively) from different non-English speaking backgrounds.

Toa et al. compared Chinese-English bilinguals (both early and late) and English-speaking monolingual adults (18-48 years old) on the Lateralized Attention Network Test (Greene et al., 2008). The results demonstrated that both early and late bilingualism showed improved cognitive control compared to monolingualism. However, there were differences in the executive functions, which were enhanced. Attentional monitoring advantages were limited to early bilinguals, while attentional inhibition benefits were found for both bilingual groups. This pattern of results led Toa et al. to suggest that advantages in attentional inhibition among late bilinguals may result from the need to avoid influence from their more solidified L1 during L2 acquisition. On the other hand, attentional monitoring advantages may be peculiar to early bilinguals who develop two languages simultaneously.

This is in line with Luk et al.'s (2011) findings. They tested young bilinguals (both early and late) and English-speaking monolingual adults on the flanker task. Replicating previous research (e.g., Costa et al., 2008; Emmorey et al., 2008), the early bilinguals showed smaller inhibition costs than monolinguals. The late bilinguals, in contrast, showed comparable inhibition costs to the monolinguals.

The fact that early and late bilinguals in Luk et al.'s study were the same age at the time of testing raises a question. It is not quite clear which variable was responsible for the different performance of the two bilingual groups, the age at which individuals became bilingual, differences in the duration of their bilingual experience, or both. The results of the correlational analyses carried out by Luk et al. seem to suggest that both age of acquisition and duration of bilingual experience are likely to contribute to the cognitive advantages, with earlier and continuing experience conferring larger effects.

Similar results were obtained by Kapa and Colombo (2013), who targeted Spanish-English bilingual and English monolingual children. Like Luk et al., they used the age at which participants began speaking two languages to classify the bilinguals into early and late one (those who began speaking both languages by and after the age of three, respectively). The performance of the three groups on the Attention Network Test replicated the previous results reported for adult bilinguals (Luk et al., 2011; Toa et al., 2011): an advantage in attentional monitoring was limited to early bilingual children. Considering that age of second language acquisition and duration of bilingual experience at the time of testing were intertwined in Kapa and Colombo's study (as in Luk et al.'s (2011) study), the researchers proposed that both variables could be driving the observed attentional monitoring advantage, rather than age of acquisition per se.

Together with the recent theories on bilingual language production (e.g., Abutalebi & Green, 2007; Hernandez, Li, & MacWhinney, 2005; Klein, Mok, Chen, & Watkins, 2014), the findings of Kapa & Colombo (2013), Luk et al. (2011) and Toa et al. (2011) provide grounds to suggest that both early and late bilingualism may affect domain-general cognitive control, just in a different way and to a different extent. The acquisition of a new language appears to be more effortful for late bilinguals than for early ones. It is argued to require more language control processes to support processing of a less automatic L2 and stronger inhibition over the first dominant language (Paap et al., 2014). Thus, later acquisition of a second language (i.e. after the consolidation of the first language) may have a greater impact on inhibitory control, while early (simultaneous) bilingualism is more likely to affect switching (Bak, Vega-Mendoza, & Sorace, 2014) and conflict monitoring (Tao et al., 2011).

5.2.4. Language proficiency. The age of language acquisition is often confounded with another possible mediator of the cognitive effects of bilingualism, proficiency. Given that the early bilinguals have also reported to have a higher language proficiency than later bilinguals (as reported in the studies reviewed above), it is difficult to tease apart the impact of the two variables. However, there are several studies that have assessed proficiency effects in high- and low-proficiency bilinguals with a comparable language background (including age of acquisition).

For example, Singh and Mishra (2012) targeted high- and low-proficiency Hindi-English younger adults, who had similar ages of acquisition for both languages and had acquired their L2 (English) at school starting around the age of four. The performance of the two bilingual groups on an oculomotor Stroop task that involved interference suppression showed an advantage related to monitoring in high-proficiency bilinguals. These findings were interpreted as indicating that higher second language proficiency can enhance goal-directed attention. This is in line with Kar, Khare and Dash's (2011) and Khare and et al.'s (2013) studies, which also reported advantages in the reactive component of cognitive control in high-proficiency bilinguals.

Also, Singh and Kar (2018) explored the possible impact of second language proficiency on proactive control mechanisms via a cued go/no-go task. The results revealed a significantly reduced proactive inhibitory control cost for high-proficiency Hindi-English adults as compared to low proficiency ones. Moreover, the findings of their study suggested the locus of that bilingual advantage: the performance of high-proficiency bilinguals showed evidence for the default state of proactive control, whereas low-proficiency bilinguals relied on the temporary state of proactive control.

The possibility of second language proficiency mediating the cognitive consequences of bilingualism was also suggested by Sun and et al. (2019). Using the Antisaccade task (Bialystok & Viswanathan, 2009), they compared high- and low-proficiency Chinese-English bilingual adults in terms of inhibition and cognitive flexibility. They found significantly smaller reaction time differences for high-proficiency bilinguals than for low-proficiency ones. On the basis of this, they suggested that high proficiency in the second language might contribute to better inhibition and cognitive flexibility.

The findings of behavioural studies are in line with functional neuroimaging studies, which documented differences in the neural involvement of different brain regions between high- and low-proficiency bilinguals. For instance, Luk and et al. (2010) and Rodriguez-Pujadas et al. (2013) reported that high-proficiency bilinguals showed a weaker resting-state functional connectivity of the right middle frontal gyrus in the neural network of inhibition, whereas low-proficiency bilinguals maintained regular recruitment and connection in the same regions. In a similar vein, the longitudinal fMRI study by Grant, Fang and Li (2015) showed that as L2 learners' proficiency increased, the brain network patterns changed, in particular losing connections in the cognitive control network. The impact of second language proficiency on the reconfiguration efficiency of the brain network was further supported by Sun et al. (2019) and Wu et al. (2019).

5.2.5. Language use. The consistency in the findings of the studies on language proficiency and executive functions notwithstanding, the possibility of the cognitive consequences of bilingualism being mediated by second language proficiency should be considered with caution. The reason for this is that the superior performance of high-proficiency bilinguals on the non-verbal control tasks may be not due (only) to language proficiency, but rather due to language use or both variables.

The possibility of the impact of language proficiency on executive functions being confounded with language use was suggested by some of the researchers cited here. For instance, Singh and Kar (2018) indicated that the subtle effects related to the interaction between proficiency and experimental variables in their study could be attributed to the language use differences between the high- and low-proficiency Hindi-English bilinguals. The high-proficiency bilinguals reported greater use of L2 (English) as opposed to the low-proficiency ones.

In addition to differences in the extent of language use, the two groups of bilinguals in different studies varied in how they used their two languages. For example, in the study by Sun et al. (2019), high-proficiency bilinguals showed a higher language switching score (in a revised bilingual switching questionnaire by Rodriguez-Fornells et al., 2012) and, therefore, had a higher frequency of language switching than the low-proficiency bilinguals. An additional analysis revealed a negative correlation between language switching frequency scores and resting-state functional connectivity in cognitive control regions, suggesting an intimate relationship between language switching and cognitive control in bilinguals.

The possible relationship between extent and/or pattern of language use and executive functioning has been examined in a number of studies comparing bilinguals with different language use experiences on non-verbal cognitive control tasks. In particular, Prior and Gollan (2011) targeted two types of bilinguals: those who frequently switched between their languages in daily life (Spanish-English bilinguals in their study) and those who did not (Chinese-English bilinguals). The performance of the bilingual and monolingual participants on a non-verbal switching task showed reduced switching costs for Spanish-English bilinguals but not for Chinese-English bilinguals, who performed similar to monolinguals. Given that the two groups of bilinguals also varied in their L1, the effect of language use experiences may have been confounded with typological proximity/distance between two languages. However, this possibility was not considered by Prior and Gollan.

Similar pattern of results were obtained when bilinguals were tested on tasks tapping into inhibitory control, such as the flanker and Simon tasks. Frequent language switchers have also been found to outperform other bilingual groups, including a group of balanced bilinguals with low daily life switching patterns (Verreyt, Woumans, Vandelanotte, Szmalec, & Duyck, 2016).

Alongside the research showing the role of language use variables on bilingual cognitive performance, there have been studies that revealed a lack of consistent differences between active and inactive bilingual language users (e.g., de Bruin, Bak, & Della Sala, 2015). This made researchers suggest that the effects of bilingualism on executive functioning may depend not so much on the extent to which bilinguals use each of their languages and/or switch between them, but rather on how they use and switch between languages in daily life – language context (Blanco-Elorrieta & Pylkkänen, 2017; de Bruin et al., 2018; Green & Abutalebi, 2013). The role of context was explored in detail in Chapter 4.

In line with the Adaptive Control Hypothesis (for more information, see Green & Abutalebi, 2013), recent research demonstrates the important role of context in mediating the consequences of bilingualism, for instance, Hartanto and Yang (2016). They tested single- and dual-language context bilinguals, who were comparable in terms of age of acquisition, language exposure/usage and self-rated proficiency, on a task-switching paradigm. They found smaller switching costs for dual-language context bilinguals, i.e. for the bilinguals who used their two languages in the same context and reported more frequent inter- and intra-sentential switching in daily life.

Similar findings were presented by Anderson et al. (2018), who correlated language proficiency and use data (the Language and Social Background Questionnaire) with previously collected cognitive data (the Shipley and flanker word/non-word performance tasks). The results showed that the context in which languages are used defines the degree of bilingualism, which, in turn, determines the degree to which cognitive consequences are found.

The need to consider language context for understanding the cognitive consequences of bilingualism was also supported by Pot et al.'s (2018) findings. The researchers compared the performance of a diverse group of older adults (65-to-95 years old) with varying levels of multilingualism on two cognitive tasks: one related to inhibition and attention (the flanker task) and one related to set-shifting (the Wisconsin Card Sorting Task). In line with their hypothesis, the regression analyses showed that it was not the number of languages or degree of proficiency that enhanced the participants' cognitive performance, but rather the intensities with which they used their languages in different contexts.

In the current study, we further investigated the possible role of bilingual experience in shaping the metalinguistic and cognitive performance of bilingual adults. In particular, we explored such dimensions as typological proximity/distance, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy in a linguistically diverse sample of bilingual adults from separated- and dual-language contexts.

5.3. Multiple Linear Regressions with Backward Elimination

The data obtained from the bilingual participants were used to determine the following: 1) which combinations (if any) of bilingual experience – typological proximity/distance, age of L2 acquisition, onset age of active bilingualism, language proficiency and/or language entropy – explain the highest percentage of variance in MAT and CST data; and 2) the extent to which each of the variables in the combinations affects metalinguistic and task-switching performance of bilinguals.

To examine the research questions, we took a data-driven (vs apriori) approach and ran multiple regressions with backward elimination (the leaps package in R) that excluded non-significant predictors using the regsubsets function. This technique was chosen because it provides an optimal simple model, which contains a combination of variables explaining the highest percentage of variance in the dependent variable without compromising the accuracy of the model (Larson-Hall, 2010; Lowie & Seton, 2013). The regressions were performed for each MAT task, for RTs on each trial and for both types of costs.

5.3.1. Predictors and dependent variables. As detailed in the Methodology Chapter, our sample consisted of 60 bilingual adults (20-40 years old) from non-English speaking backgrounds. On the basis of their self-reported data, we extracted demographic and language variables. Together with bilingual metalinguistic and cognitive data, they were added to dataframe 2.

The demographic variables were the same as in dataframe 1 (see Table 4.1 in Chapter 4). Given that they did not add significantly to the explanatory power of the base-line models in the previous round of analyses (see Chapter 4), they were not considered in this round. Among the language variables, we considered typological proximity/distance between two languages, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy.

As mentioned in Chapter 3, the bilingual participants were from very diverse L1 [non-English] backgrounds but had the same L2 [English]. The data on their L1 were converted into a dichotomous variable: languages that were typologically close to English (Germanic languages) vs languages that were typologically distant from English (non-Germanic languages). This variable was used as an indicator of *typological proximity/distance* between two languages (1 = *Germanic languages*, 0 = *non-Germanic languages*)[1].

The *age of L2 acquisition* variable was based on the self-reported age at which the bilinguals started learning English. To determine *onset age of active bilingualism*, we asked the bilinguals to indicate the age at which they began using their two languages actively on a daily basis (Luk et al., 2011). The reported age of L2 acquisition and onset age of active bilingualism in years were included as continuous variables.

Consistent with other studies of bilingual self-assessed proficiency (Anderson et al., 2017; Grosjean, 2004; Jia et al., 2002; Marian et al., 2007; Vaid & Menon, 2000), we elicited proficiency ratings in speaking, listening, reading and writing in both languages on a 10-point scale. On the basis of the data obtained along the different performance domains, the average proficiency score was calculated for each language. Using the calculation $(L1+L2) \times \sqrt{\frac{2 \times L1 \times L2}{L1^2 + L2^2}}$ suggested by Vaughn and Hernandez (2018), we created a score of bilingual proficiency. According to Vaughn and Hernandez, this

[1] We recognise that the categorisation between Germanic and non-Germanic languages is essentially genealogical in nature, but we have taken the view that genealogical differences are associated with (greater) typological distance. For instance, it seems uncontroversial to assume that the typological distance between English and Vietnamese is greater than the typological distance between English and German.

calculation gives equal weight to both languages, but also leads to higher scores for individuals who are more balanced, i.e. those who have high levels of proficiency in each language and do not appear to have one dominant language. The obtained score ranging from 0 to 20 (0 = *no proficiency in either language*, 20 = *high proficiency in both language*) was treated as a continuous *language proficiency* variable.

Language entropy was measured by computing Shannon Entropy (H), which provides a continuous measure of how often one or the two languages are used (for a similar approach, see Gullifer et al., 2018; Sulpizio et al., 2020). First, participants were asked to rate their language usage in different situations on a 5-point Likert scale (1 = *all English*; 3 = *half English, half the other language*; 5 = *only the other language*). Then these measures were used to quantify a proportion of L1 and L2 use for each participant by dividing the average percentage of use of a given language by the sum of the use of the two languages. Finally, Shannon Entropy (H) associated with proportional L1 and L2 use (language entropy) was computed using the following equation: $H = -\sum_{i=1}^{n} P_i log_2(P_i)$. Here, *n* represents the total possible languages (two in the present study) and P_i represents the proportion associated with the use of a given language. Language entropy provides a continuous measure of language usage on a 1-point scale (0 = *only one language is used*, 1 = *each language is used equally*).

The extracted language variables were used as predictors. Descriptive statistics are given in Table 5.1.

Table 5.1

Descriptive Statistics for Language Variables

Variable	*N*	Mean	*SD*
Typological proximity/distance	Germanic – 12 non-Germanic – 49		
Age of L2 acquisition	60	9.35	4.64
Onset age of active bilingualism	60	21.33	7.83
Language proficiency	60	18.55	1.07
Language entropy	60	.94	.05

Note. Typological proximity/distance: 1 = Germanic languages, 0 = non-Germanic languages. Age of L2 acquisition and onset age in years. Language proficiency on a 20-point scale (0 = no proficiency in each of the languages, 20 = high proficiency in both languages). Language entropy on a 1-point scale (0 = only one language is used, 1 = each language is used equally).

Besides language variables, dataframe 2 contained bilingual MAT and CST data, which were used as dependent variables. In line with dataframe 1, four sound-meaning and four grammaticality judgement task items were combined into sound-meaning task scores (out of 36) and grammaticality judgement task scores (out of 22.5), respectively. Descriptive statistics are given in Table 5.2.

Table 5.2

Descriptive Statistics for Metalinguistic Awareness Test Variables

Variable	*N*	Mean	*SD*
Sound-meaning task scores	60	32.28	3.07
Grammaticality judgement scores	60	9.98	3.15

Note. Sound-meaning task scores out of 36. Grammaticality judgement task scores out of 22.5.

Consistent with dataframe 1, bilingual CST data included the following: 1) RTs on blocked, repeat and switch trials and 2) mixing and switching costs, which were computed on the basis of RTs in each trial (see Chapter 3). Means and standard deviations are shown in Table 5.3.

Table 5.3
Descriptive Statistics for Colour-Shape Switching Task Variables

Variable	*N*	Mean	*SD*
Blocked RTs	60	569.67	151.40
Repeat RTs	60	796.14	187.04
Switch RTs	60	938.81	223.84
Mixing costs	60	226.47	127.25
Switching costs	60	142.66	106.76

Note. RTs, mixing and switching costs are given in ms.

An examination of correlations between the predictors revealed co-variations between language entropy and language proficiency (see Table 5.4). Also, there was a moderate correlation between age of L2 acquisition and onset age of active bilingualism, $p < .05$.

In all the analyses, the scatterplots of standardised predicted values versus standardised residuals showed that the data met the assumptions of homogeneity of variance. Furthermore, the expected and observed cumulative probabilities were fairly similar (see Figure 5.1). This suggests that the residuals were approximately normally distributed and the assumption of multivariate normality was not violated. What is more, there was a good linear relationship between each predictor and each dependent variable.

Table 5.4
Bivariate Correlations Between the Predictors

Variable	1	2	3	4	5
1. Typological proximity/distance	–				
2. Age of L2 acquisition	-.03	–			
3. Onset age of active bilingualism	.09	.40*	–		
4. Language proficiency	.11	.19	-.03	–	
5. Language entropy	-.23	.18	-.08	.50*	–

Note. Typological proximity/distance: 1 = Germanic languages, 0 = non-Germanic languages. Age of L2 acquisition and onset age in years. Language proficiency on a 20-point scale (0 = no proficiency in each of the languages, 20 = high proficiency in both languages). Language entropy on a 1-point scale (0 = only one language is used, 1 = each language is used equally). * $p < .05$.

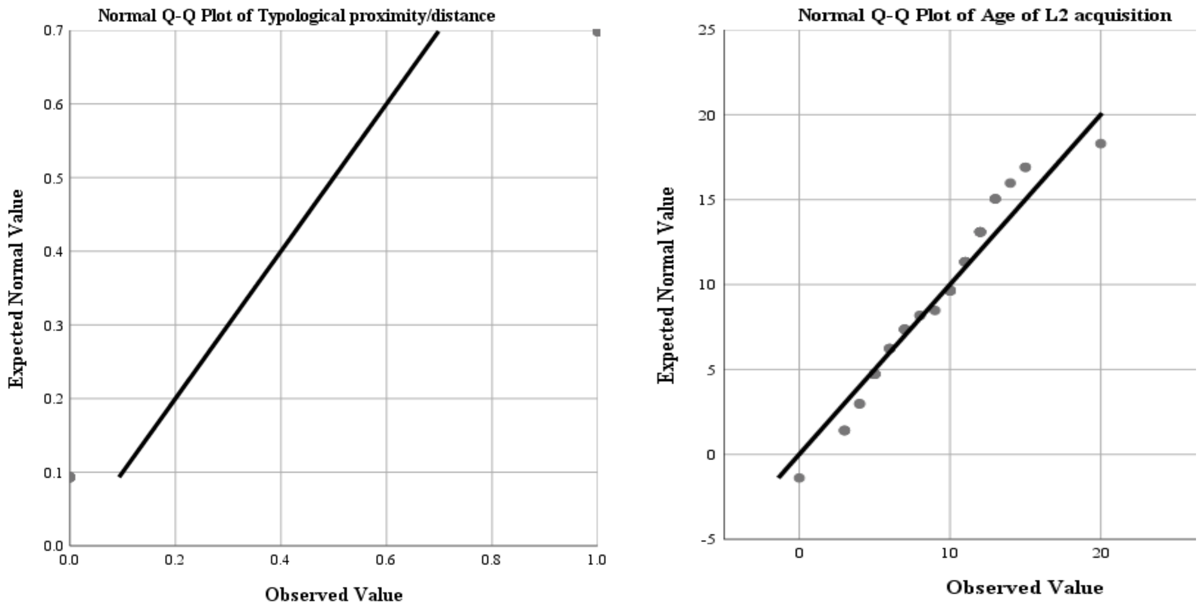


Figure 5.1. Normal Q-Q plots of the predictors.

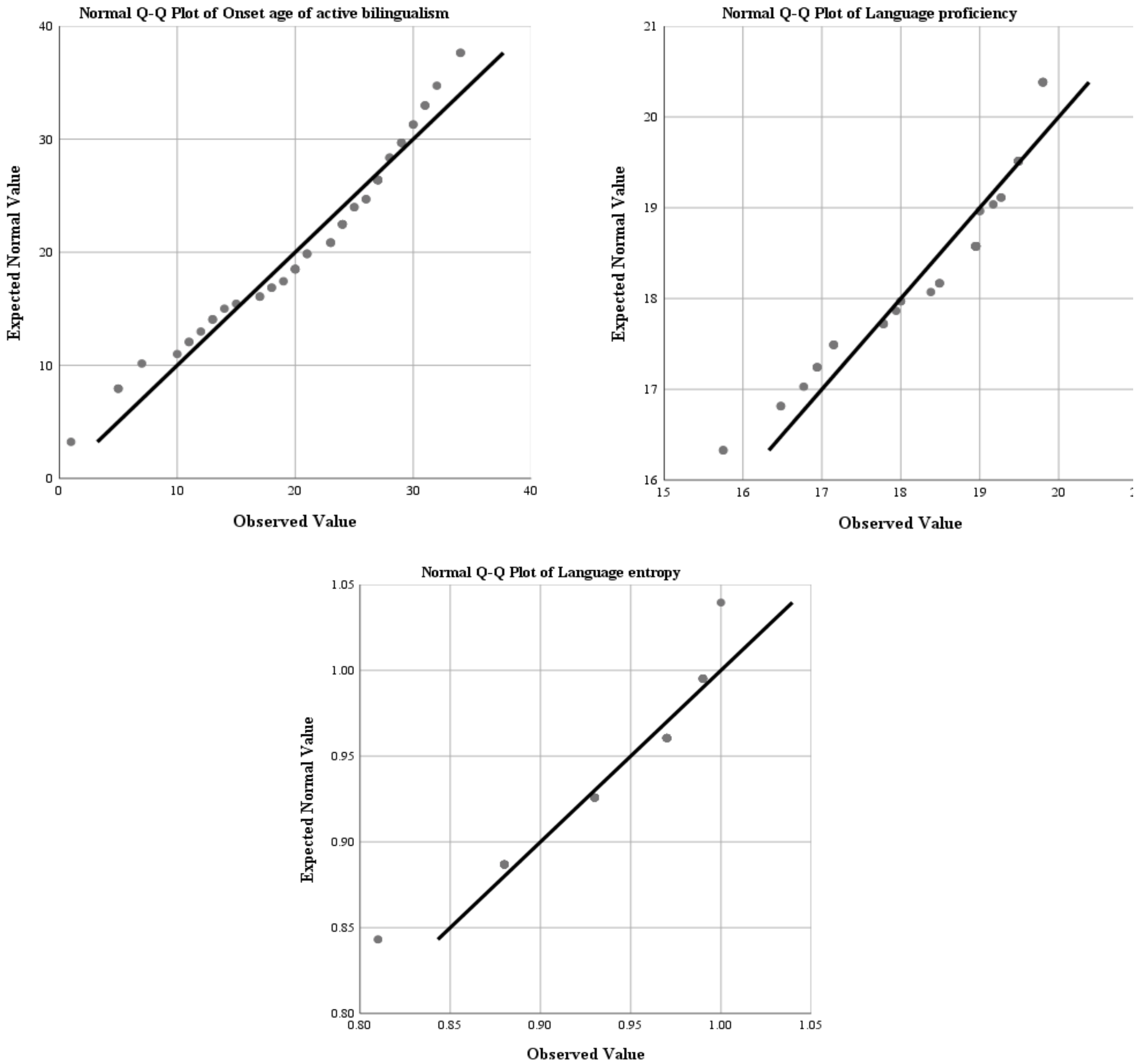


Figure 5.1 (continued). Normal Q-Q plots of the predictors.

5.3.2. Procedure. Given the co-variations between the language variables, we first performed preliminary regression analyses. As mentioned in the previous sub-section, there was a moderate correlation between age of L2 acquisition and onset age of active bilingualism, $p < .05$. To decide whether to keep both variables or to exclude one of them, we ran two preliminary multiple linear regressions with backward elimination for each dependent variable: one with *age of L2 acquisition* and the other with *onset age of active bilingualism* among the other language predictors. The results revealed that age of L2 acquisition was not part of the combination significantly predicting bilinguals' MAT or CST performance, *ps* > .05 (for the results, see Appendix F). On the other hand, onset age of active bilingualism was part of this combination, *ps* < .05 (for the results, see sub-sections 5.3.3.1 and 5.3.3.2). Thus, we kept onset age of active bilingualism and excluded age of L2 acquisition.

Also, there were statistically significant correlations between language entropy and language proficiency. Considering this, we ran two preliminary multiple linear regressions with backward elimination for each dependent variable. Both contained *typological proximity/distance* and *onset age of active bilingualism.* However, one had *language proficiency*, and the other included *language entropy.* The results showed that each of the two variables affected bilingual MAT and/or CST performance, *ps* < .05 (for the results, see sub-sections 5.3.3.1 and 5.3.3.2). Given this, we kept both language proficiency and language entropy but created two different base-line models for each dependent variable, as we did in the preliminary analyses.

Then using a stepwise backward approach, we built the best-fitting model (the one consisting of significant predictors only) for each of the dependent variables. In particular, we used the regsubsets function, which has the tuning parameter nvmax specifying the maximal number of predictors to incorporate in the model. It returned multiple models with different sizes up to nvmax. We then chose the best one on the basis of the prediction error, i.e. MAE, and predictive capacity, i.e. R^2, of each model: the lower the MAE and the higher the R^2, the better the model.

Following that, we inspected the best-fitting model(s) for each dependent variable, in particular we checked whether the assumptions of multiple linear regressions had been violated or not. After that, we reported the results of the best-fitting model(s), including the impact of each variable in the model on the metalinguistic and task-switching performance of the bilinguals.

5.3.3. Data analyses and results

5.3.3.1. Multiple linear regressions with Metalinguistic Awareness Test data as dependent variables. The four saturated base-line models for MAT data contained *typological proximity/distance* and *onset age of active bilingualism* as predictors. In addition, Model 1 had *language proficiency*, and Model 2 included *language entropy.* The two models were created for both sound-meaning task (SMT) and grammaticality judgement task (GJT) scores.

Then we performed multiple linear regressions with backward elimination using the regsubsets function. We specified the maximal number of predictors (nvmax) to incorporate in the models, i.e. three for both Model 1 and Model 2. Following that, we ran the analysis. The regsubsets function returned multiple models with different sizes up to nvmax. The results are given in Tables 5.5 and 5.6.

Table 5.5

Results of Multiple Linear Regression with Backward Elimination for the Sound-Meaning Task Scores

Nvmax	RMSE	R^2	MAE
Model 1			
1	1.74	0.66	1.42
2	1.82	0.67	1.46
3	1.90	0.65	1.55
Model 2			
1	2.75	0.15	2.10
2	2.65	0.19	2.02
3	2.80	0.16	2.11

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

Between the versions of Model 1 and Model 2, the best ones for the SMT and GJT scores were the versions of Model 1, i.e. the model with *language proficiency* among the predictors. They had the lowest prediction errors and the highest predictive capacity. In particular, the best model for the SMT scores was with *language proficiency* as the only predictor. For the GJT scores, it was the model with three predictors: *typological proximity/distance, onset age of active bilingualism* and *language proficiency.* In comparison with versions of Model 1, versions of Model 2, i.e. the model with *language entropy* among the predictors, had higher RMSEs and MAEs and lower predictive capacity. Among them, the model containing two predictors, *typological proximity/distance* and *onset age of active bilingualism,* was the best one for both SMT and GJT scores.

Table 5.6

Results of Multiple Linear Regression with Backward Elimination for the Grammaticality Judgement Task Scores

Nvmax	RMSE	R^2	MAE
Model 1			
1	2.49	0.45	1.98
2	2.59	0.42	2.07
3	2.46	0.45	2.01
Model 2			
1	3.13	0.02	2.45
2	2.83	0.23	2.24
3	2.88	0.19	2.24

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

Next, we inspected the best-fitting model for each dependent variable: the model with *language proficiency* in the case of SMT and the model with *typological proximity/distance, onset age of active bilingualism* and *language proficiency* in the case of GJT. In both cases, the predictors met the assumptions of homogeneity of variance and multivariate normality (see Section 5.3.1). The assumption of multicollinearity was not violated either. There were no statistically significant correlations between the variables in the two best-fitting models, all $ps > .05$ The collinearity statistics were also within accepted limits ($VIF < 2$).

In addition, we checked for normality of residuals with normal P-P plots. The plots in Figure 5.2 demonstrate that the points generally follow the normal (diagonal) line with no strong deviations. This indicates that the residuals were normally distributed.

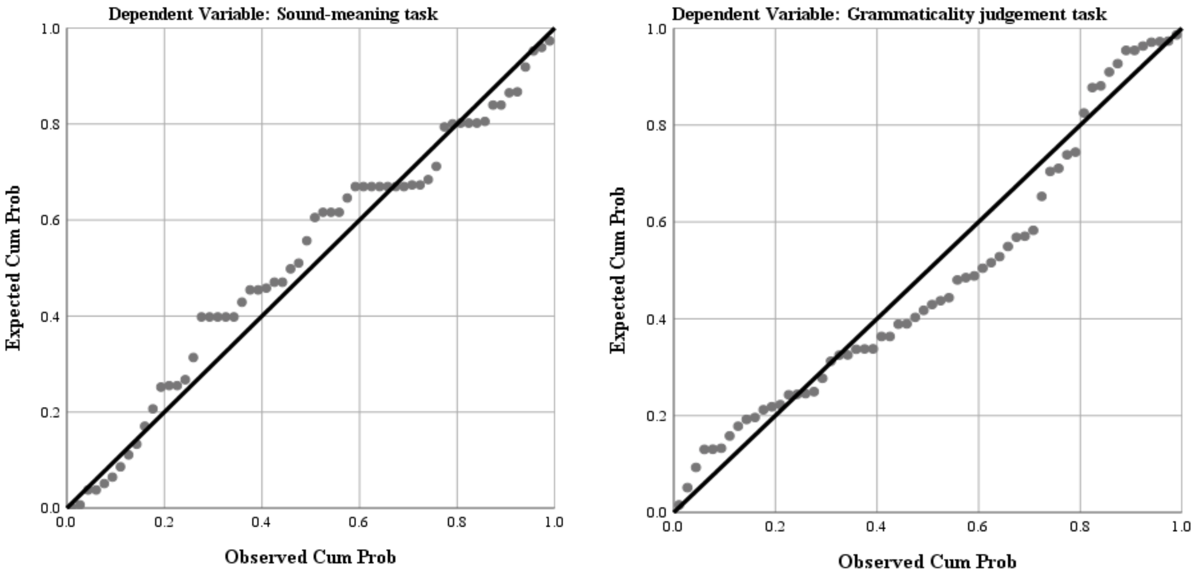
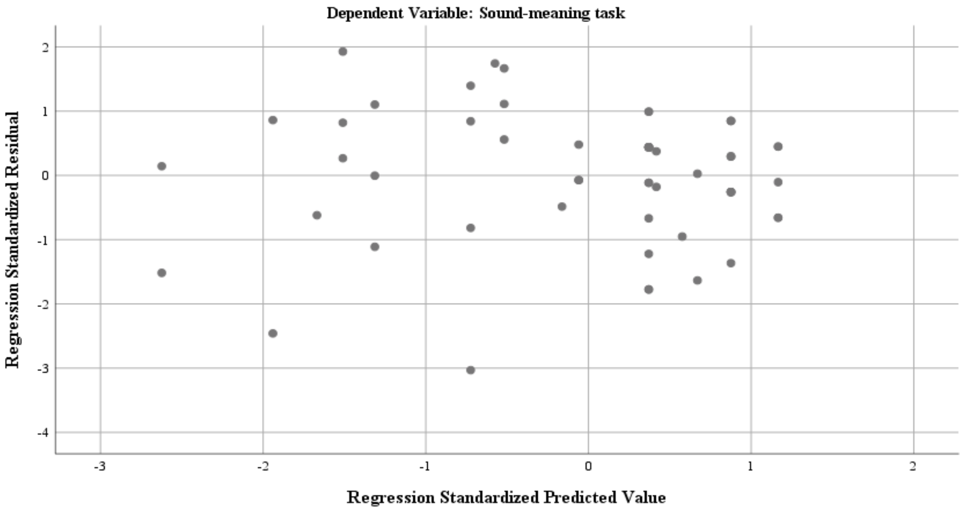


Figure 5.2. Normal P-P plots of regression standardized residuals.

Lastly, we tested the assumption of homoscedasticity. The plots of standardized residuals versus predicted values in Figure 5.3 show that data points are fairly randomly distributed across all values of the independent variables. This implies that the assumption of homoscedasticity was met.



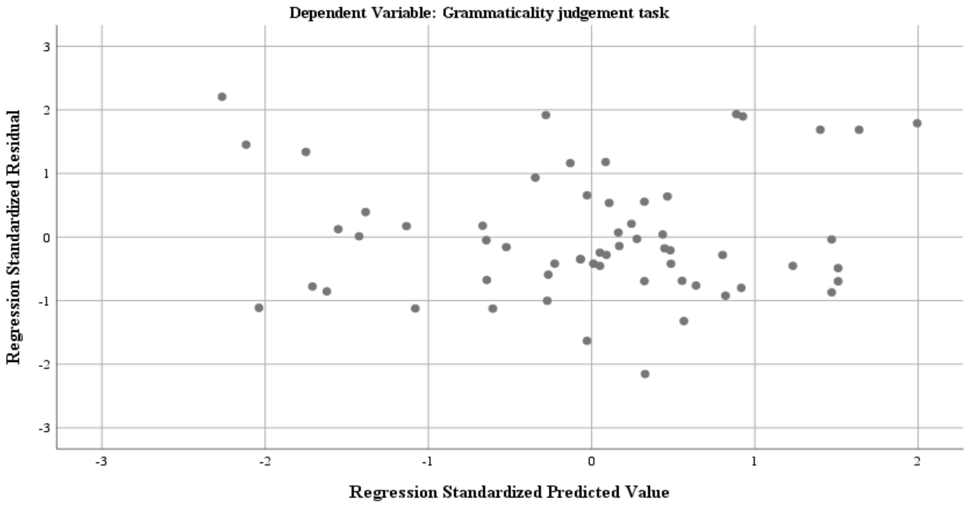


Figure 5.3. Scatterplots of standardized residuals versus predicted values.

The predictors in the best versions of Model 2, i.e. the ones with *typological proximity/distance* and *onset age of active bilingualism,* also met the assumptions of homogeneity of variance, multivariate normality and multicollinearity. Furthermore, the residuals were normally distributed (see Figure 5.4) and the assumption of homoscedasticity was met (see Figure 5.5).

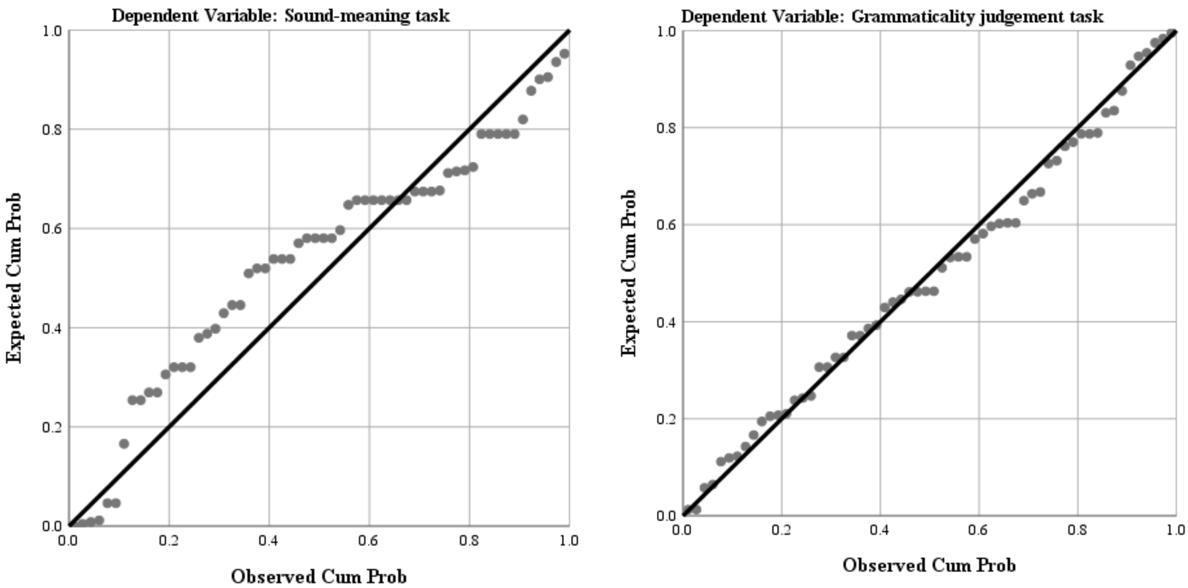


Figure 5.4. Normal P-P plots of regression standardized residuals.

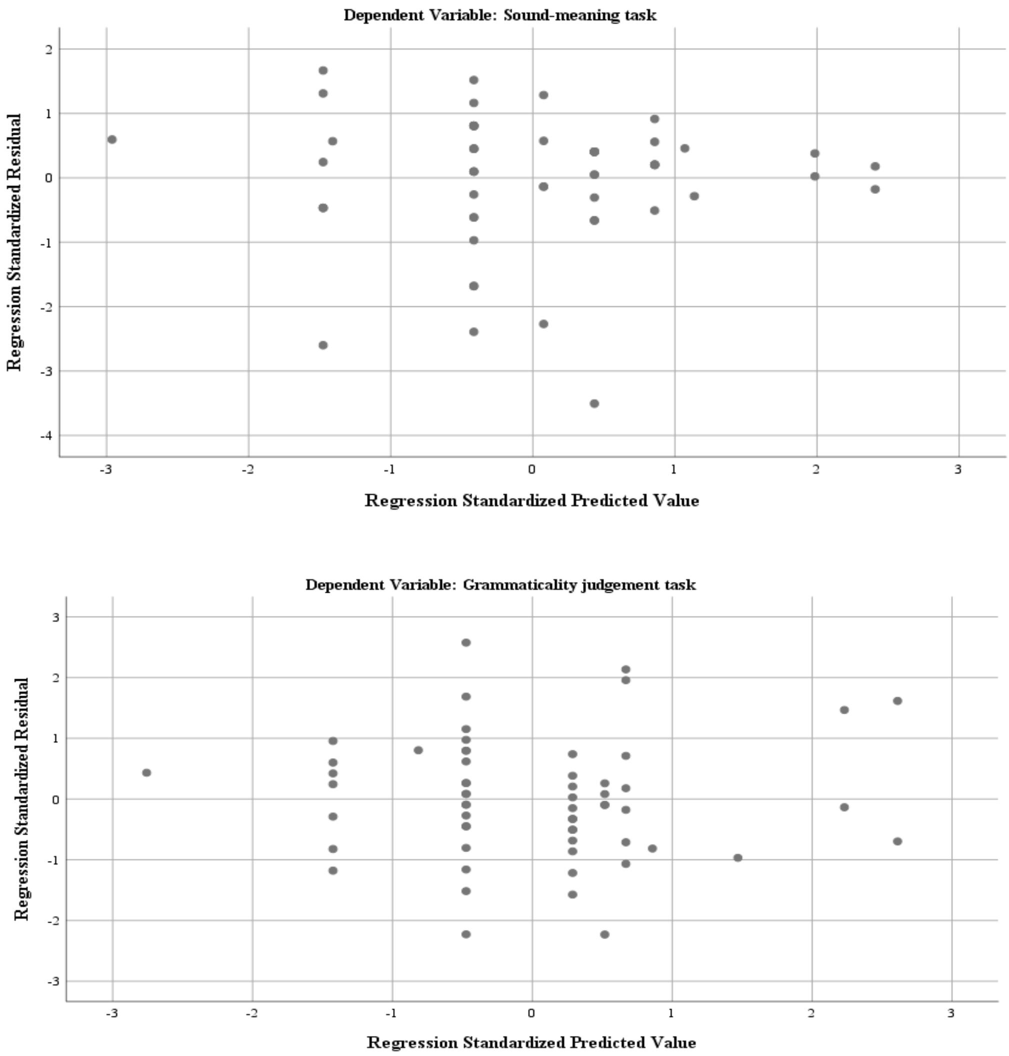


Figure 5.5. Scatterplots of standardized residuals versus predicted values.

Having performed model diagnostics, we computed linear regression models for the SMT and the GJT using only the selected predictors. As shown in Table 5.7, the best version of Model 1 for the SMT explained 66% of the variance in SMT scores, $p < .001$. It had only one predictor, i.e. *language proficiency,* which significantly predicted the dependent variable, $p < .001$. As the bilinguals' language proficiency increased by one point on a 10-point scale, their SMT scores increased by 2.33 points. As for the version of Model 2, it did not explain the variance in the sound-meaning task scores, $p > .05$.

Table 5.7
The Best-Fitting Models Showing the Capacity of the Variables to Predict Sound-Meaning Task Scores

Variable	*B*	SE *B*	*β*	*t*	Sig.
Model 1*: R^2 = 66%, p < .001 ***ΔR^2= 65.4%, p < .001***					
Language proficiency	2.33	.22	.81	10.60	.000
Model 2: R^2 = 2.9%, p > .05 ***ΔR^2= 0.5%, p > .05***					
Typological proximity/distance	1.34	1.03	.17	1.30	.199
Onset age of active bilingualism	-.01	.05	-.02	-.18	.857

Note. Model 1 provides the best-fitting version of the model with language proficiency among the predictors. Model 2 provides the best-fitting version of the model with language entropy among the predictors. * indicates the best-fitting model among all the models.

For the GJT, the best-fitting model accounted for 44.9% of the variance in the scores, $p < .001$ (see Table 5.8). As opposed to the SMT model, this model contained three predictors: *typological proximity/distance, onset age of active bilingualism* and *language proficiency*. All of them were revealed to significantly predict the performance of the bilinguals on the GJT. The participants whose L1 belonged to the Germanic language branch obtained higher scores ($B = 1.84$, $p < .05$). They also performed better as their language proficiency increased by one point on a 10-point scale ($B = 1.69$, $p < .001$) and their onset age of active bilingualism decreased by one year ($B = .08$, $p < .05$).

Among the versions of Model 2, the best one for the GJT explained 9.7% of the variance in the scores, $p < .05$. The model included *typological proximity/distance* and *onset age of active bilingualism* as predictors. However, only the first one significantly predicted the scores, $p < .05$. Once again, the participants whose L1 belonged to the Germanic language branch produced higher scores than those with non-Germanic language as their L1 ($B = 2.37$, $p < .05$). Taken together, the data suggest that higher language proficiency together with typological proximity between two languages and earlier onset of active bilingualism were predictive of higher levels of metalinguistic awareness.

Table 5.8

The Best-Fitting Models Showing the Capacity of the Variables to Predict the Grammaticality Judgement Task Scores

Variable	*B*	SE *B*	*β*	*T*	Sig.
Model 1*: R^2 = 44.9%, p < .001					
ΔR^2= 41.9%, p < .001					
Typological proximity/distance	1.84	.81	.23	2.27	.027
Onset age of active bilingualism	-.08	.04	-.21	-2.08	.042
Language proficiency	1.69	.30	.57	5.72	.000
Model 2: R^2 = 12.7%, p < .05					
ΔR^2=9.7%, p < .05					
Typological proximity/distance	2.37	1.00	.29	2.35	.022
Onset age of active bilingualism	-.09	.05	-.23	-1.87	.066

Note. Model 1 provides the best-fitting version of the model with language proficiency among the predictors. Model 2 provides the best-fitting version of the model with language entropy among the predictors. * indicates the best-fitting model among all the models.

5.3.3.2. Multiple linear regressions with Colour-Shape Switching Task data as dependent variables. For bilingual CST data analysis, we used the same basic analytical and reporting approach as described in the previous sub-section. We created two saturated base-line models for RTs on each trial and for both costs. Both of them contained *typological proximity/distance* and *onset age of active* *bilingualism* as predictors. In addition, Model 1 had *language proficiency*, and Model 2 included *language entropy.*

While performing multiple linear regressions with backward elimination, we indicated the maximal number of predictors to incorporate in the models, i.e. three for both Model 1 and Model 2. The regsubsets function returned multiple models with different size up to nvmax.

As opposed to MAT data, the best models for RTs on each CST trial varied. For blocked RTs (see Table 5.9), the version of both Model 1 and Model 2 with *onset age of active bilingualism* as the only predictor were the best ones: both had almost the same RMSE and MAE – the lowest RMSEs and MAEs among all versions.

Table 5.9
Results of Multiple Linear Regression with Backward Elimination for Blocked RTs

Nvmax	RMSE	R^2	MAE
Model 1			
1	143.1	0.04	109.1
2	148.4	0.16	114.4
3	152.4	0.16	118.7
Model 2			
1	143.3	0.04	108.6
2	146.0	0.08	111.1
3	151.3	0.12	116.1

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

The best model for repeat RTs (see Table 5.10) was the version of Model 1 with *language proficiency* as the only predictor. However, its MAE was just slightly lower and its R^2 was 0.1 higher than those of Model 2 containing two predictors, i.e. *typological proximity/distance* and *language entropy.*

Table 5.10
Results of Multiple Linear Regression with Backward Elimination for Repeat RTs

Nvmax	RMSE	R^2	MAE
Model 1			
1	178.8	0.07	142.7
2	182.6	0.07	145.0
3	186.0	0.02	147.3
Model 2			
1	182.9	0.01	151.4
2	178.8	0.06	146.7
3	184.0	0.02	147.1

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

On the other hand, versions of Model 1 and Model 2 varied significantly in relation to switch RTs (see Table 5.11): versions of the model with *language entropy* among the predictors had lower prediction errors and higher predictive capacity than versions of the model with *language proficiency*. In particular, the version of Model 2 containing *typological proximity/distance* and *language entropy* was the best one for switch RTs. Among the versions of Model 1, the one with *language proficiency* as the only predictor had the highest R^2 and lowest RMSE and MAE.

Table 5.11

Results of Multiple Linear Regression with Backward Elimination for Switch RTs

Nvmax	RMSE	R^2	MAE
Model 1			
1	206.9	0.08	175.1
2	218.5	0.01	186.6
3	223.8	0.01	188.8
Model 2			
1	206.2	0.14	166.8
2	201.7	0.16	165.3
3	206.2	0.09	168.8

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

Next, we inspected the best-fitting model(s) for each dependent variable, in particular, the model with *onset age of active bilingualism* for blocked RTs; the model with *language proficiency* and the model with *typological proximity/distance* and *language entropy* for repeat RTs; and the model with *typological proximity/distance* and *language entropy* for switch RTs. In addition, we examined the model with *language proficiency* for switch RTs.

In all cases, the predictors met the assumptions of homogeneity of variance and multivariate normality (see Section 5.3.1). Moreover, there were no statistically significant correlations between the variables, all *ps* > .05, and the collinearity statistics were all within accepted limits (*VIF* < 2).

The assumption of multivariate normality was not violated either. Normal P-P plots, given in Figure 5.6 and 5.7, demonstrate that the points generally follow the normal (diagonal) line with no strong deviations. This indicates that the residuals were normally distributed.

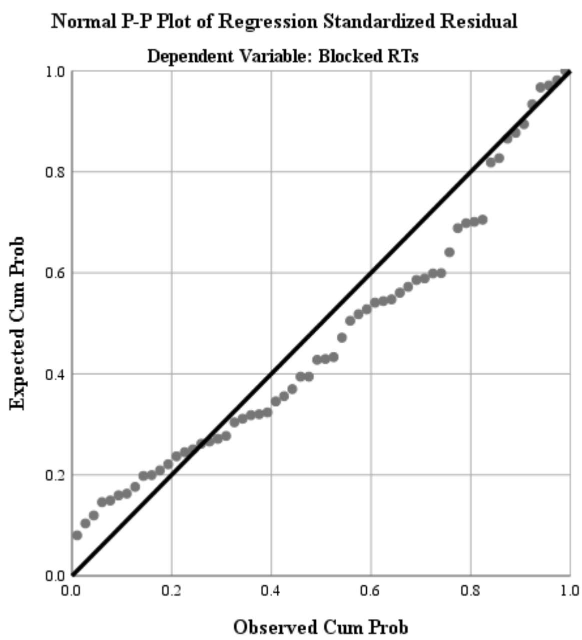


Figure 5.6. Normal P-P plots of regression standardized residuals.

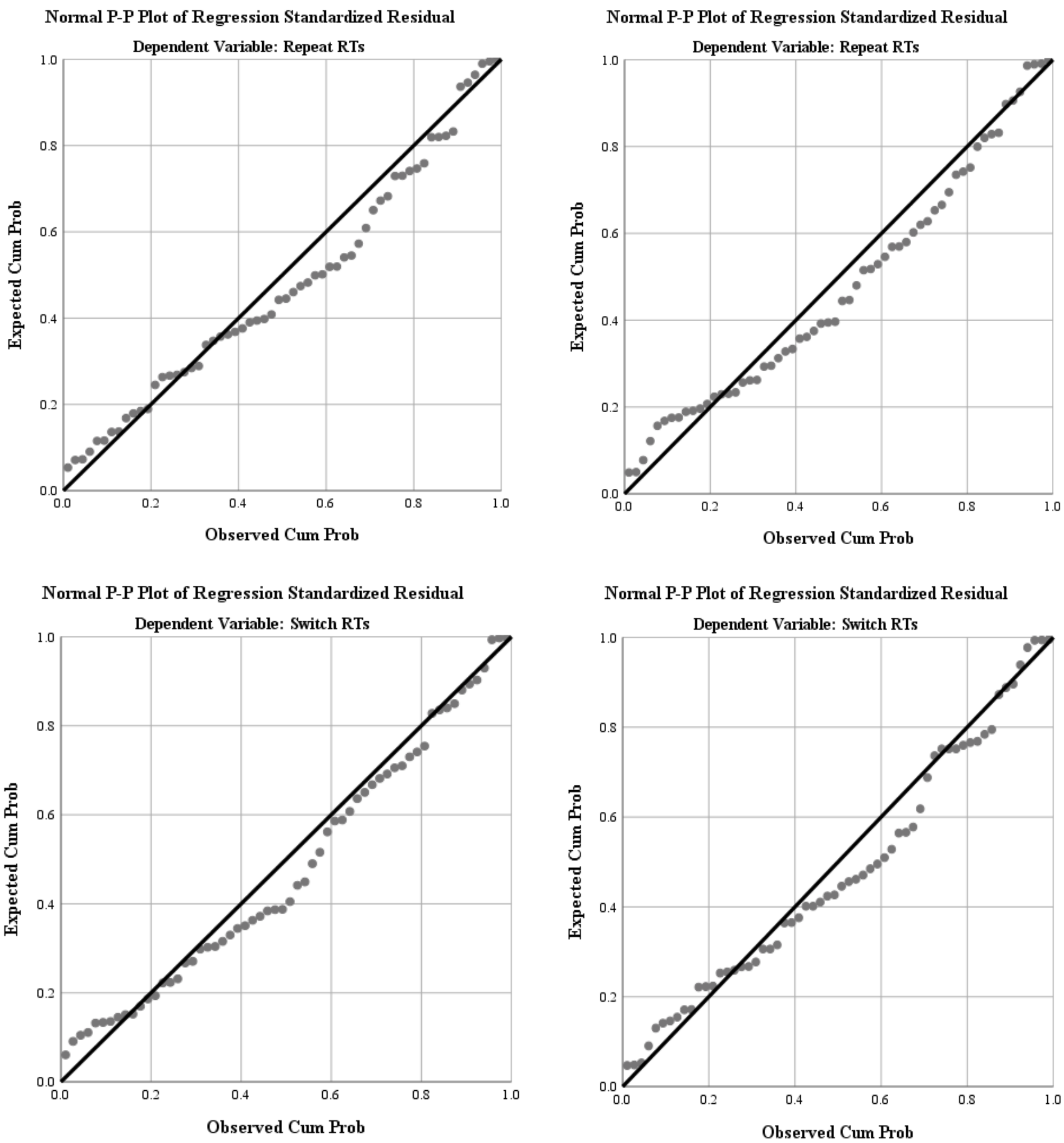


Figure 5.7. Normal P-P plots of regression standardized residuals. The models on the left have language proficiency as predictor; the models on the right contain typological proximity/distance and language entropy.

Finally, the plots of standardized residuals versus predicted values in Figures 5.8-5.10 show that data points are fairly randomly distributed across all values of the independent variables. This implies that the assumption of homoscedasticity was met.

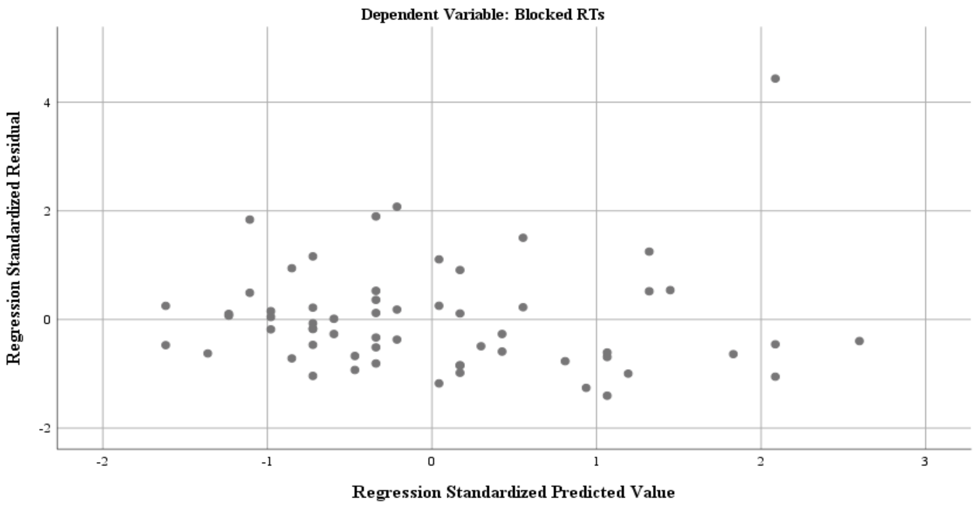


Figure 5.8. Scatterplots of standardized residuals versus predicted values.

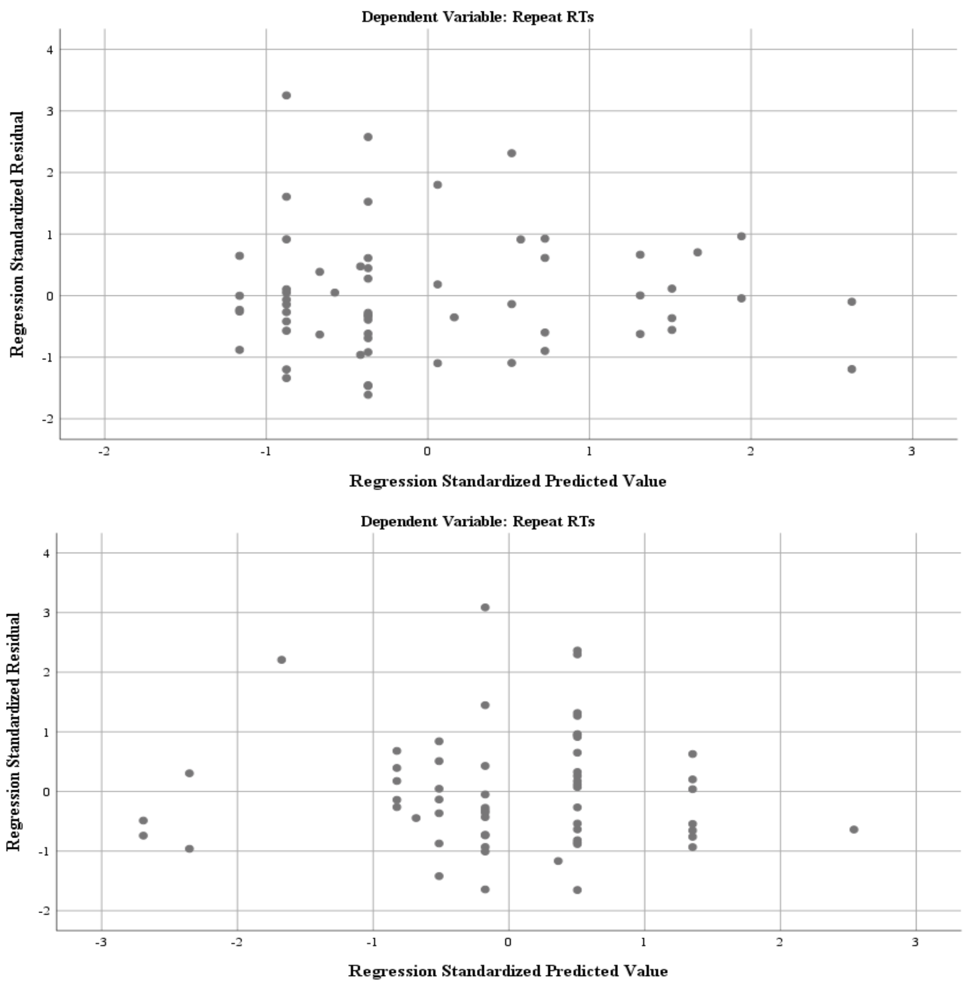


Figure 5.9. Scatterplots of standardized residuals versus predicted values. The model at the top has language proficiency as predictor; the model at the bottom contains typological proximity/distance and language entropy.

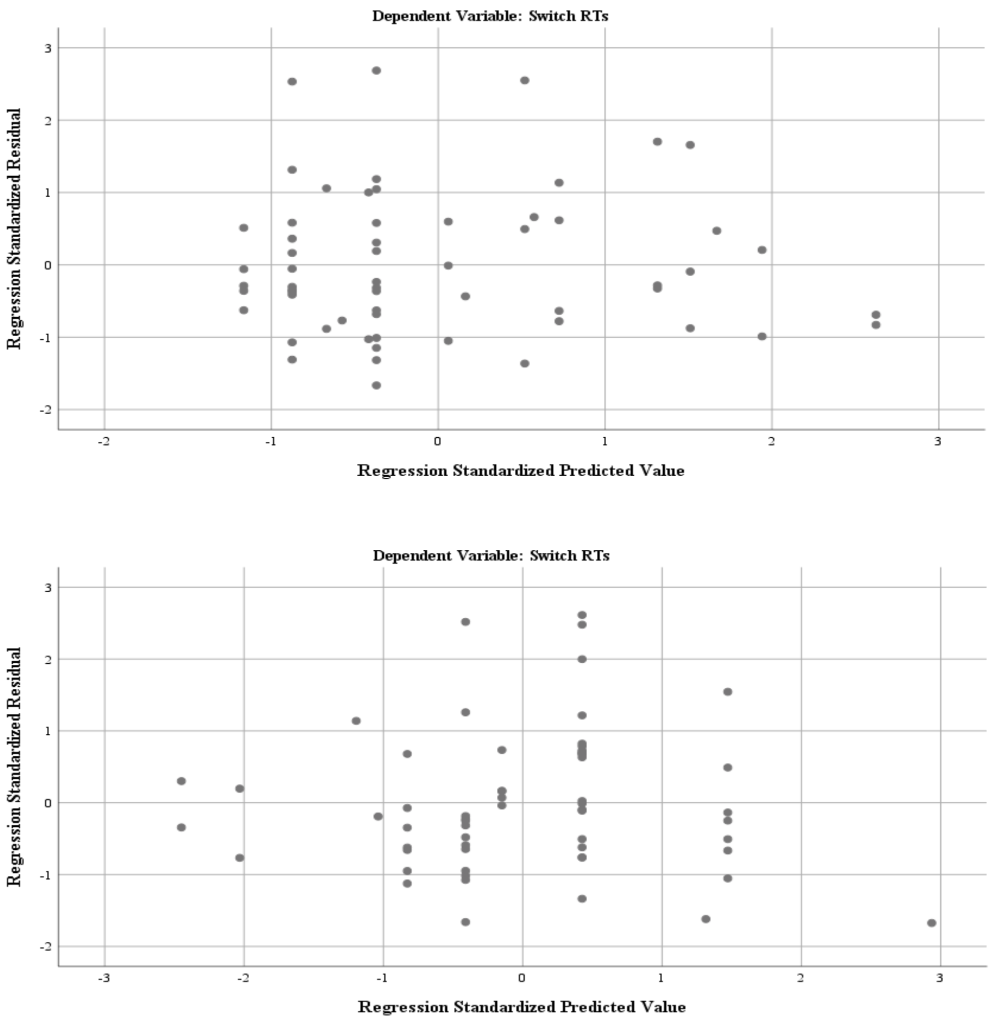


Figure 5.10. Scatterplots of standardized residuals versus predicted values. The model at the top has language proficiency as predictor; the model at the bottom contains typological proximity/distance and language entropy.

After inspecting the models, we ran multiple linear regressions for RTs on each trial using only the selected predictors. In the case of blocked RTs, the best-fitting model among all was the one with *onset age of active bilingualism* as the only predictor (see Table 5.12). However, it was not statistically significant, $p > .05$.

Table 5.12

The Best-Fitting Model Showing the Capacity of the Variables to Predict Blocked RTs

Variable	*B*	SE *B*	*Β*	*t*	Sig.
R^2 = 3.7%, p > .05					
ΔR^2= 2.1%, p > .05					
Onset age of active bilingualism	-3.73	2.49	-.19	-1.50	.140

The best-fitting model for repeat RTs was the version of the model with *language proficiency* as the only predictor (see Table 5.13). It explained 6.8% of the variance in the RTs, $p < .05$. As language proficiency increased by one point on a 10-point scale, the bilinguals' repeat RTs decreased by 38.28 ms, $p = .05$. As for the version of the model with *language entropy* among the predictors, it did not explain the variance in the RTs, $p > .05$.

Table 5.13

The Best-Fitting Models Showing the Capacity of the Variables to Predict Repeat RTs

Variable	*B*	SE *B*	*β*	*T*	Sig.
Model 1*: R^2 = 6.8%, p < .05					
ΔR^2= 5.1%, p < .05					
Language proficiency	-38.28	22.42	-.22	-1.71	.050
Model 2: R^2 = 5.6.%, p > .05					
ΔR^2= 2.3%, p > .05					
Typological proximity/distance	-96.60	63.40	-.20	-1.52	.133
Language entropy	-752.71	553.59	-.18	-1.36	.179

Note. Model 1 provides the best-fitting version of the model with language proficiency among the predictors. Model 2 provides the best-fitting version of the model with language entropy among the predictors. * indicates the best-fitting model among all the models.

As opposed to repeat RTs, the best model for switch RTs was the version of Model 2 with *typological proximity/distance* and *language entropy*. Both being statistically significant, the variables accounted for 15.5% of the variance in switch RTs, $p < .05$. As shown in Table 5.14, equal use of two languages was associated with lower switch RTs relative the use of only one of two languages (B = -1843.86, $p < .05$). Furthermore, the use of typologically close language pairs was also predicative of lower RTs (B = -142.94, p = .05). Among the versions of Model 1, the best one contained *language proficiency* as the only predictor. It explained only 8.4% of the variance in the RTs, $p < .05$. The bilinguals performed 60.54 ms faster on switch trials as their language proficiency increased by one point on a 10-point scale, $p < .05$.

Table 5.14
The Best-Fitting Models Showing the Capacity of the Variables to Predict Switch RTs

Variable	B	SE B	β	T	Sig.
Model 1: R^2 = 8.4%, p < .05					
ΔR^2= 6.8%, p < .05					
Language proficiency	-60.54	26.32	-.29	-2.30	.025
Model 2*: R^2 = 15.5.%, p < .05					
ΔR^2= 12.6%, p < .05					
Typological proximity/distance	-142.94	71.78	-.25	-1.99	.050
Language entropy	-1843.86	626.81	-.37	-2.94	.005

Note. Model 1 provides the best-fitting version of the model with language proficiency among the predictors. Model 2 provides the best-fitting version of the model with language entropy among the predictors. * indicates the best-fitting model among all the models.

The results of multiple models for the costs were in line with the RTs on the corresponding trials. Similarly to the situation with blocked and repeat RTs, the best model for mixing costs was the one with *language proficiency* among the predictors (see Table 5.15), in particular the version of Model 1 with *typological proximity/distance, onset age of active bilingualism* and *language proficiency.* The versions of the model with *language entropy* had higher RMSEs and MAEs and lower R^2s than the versions of the model with *language proficiency.* Among them, the best one for mixing costs was the version with *typological proximity/distance* and *onset age of active bilingualism.*

Table 5.15
Results of Multiple Linear Regression with Backward Elimination for Mixing Costs

Nvmax	RMSE	R^2	MAE
Model 1			
1	115.2	0.13	91.16
2	116.1	0.13	94.09
3	113.9	0.18	92.48
Model 2			
1	122.5	0.05	101.12
2	116.8	0.17	97.25
3	122.0	0.06	102.52

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

In the case of switching costs, the opposite was true (see Table 5.16), as it was for switch RTs. The best model was the version of Model 2 containing *language entropy* as the only predictor: it had the lowest prediction errors and one of the highest R^2s. Among the versions of Model 1, the best one was with *language proficiency* and *onset age of active bilingualism* as predictors.

Table 5.16

Results of Multiple Linear Regression with Backward Elimination for Switching Costs

Nvmax	RMSE	R^2	MAE
Model 1			
1	107.6	0.05	84.20
2	104.7	0.08	83.72
3	104.9	0.08	83.84
Model 2			
1	92.63	0.18	73.40
2	98.96	0.02	80.57
3	98.47	0.10	80.15

Note. Model 1 contains typological proximity/distance, onset age of active bilingualism and language proficiency as predictors. Model 2 includes typological proximity/distance, onset age of active bilingualism and language entropy as predictors.

Next, we performed model diagnostics. We inspected the following models: in the case of mixing costs, the model with *typological proximity/distance, onset age of active bilingualism* and *language proficiency,* and in the case of switching costs, the model with *language entropy* and the model with *language proficiency* and *onset age of active bilingualism*.

In all cases, the predictors met the assumptions of homogeneity of variance and multivariate normality (see Section 5.3.1). Also, there were no statistically significant correlations between the variables, all *ps* > .05, and the collinearity statistics were all within accepted limits (*VIF* < 2). Furthermore, the residuals were normally distributed (see Figures 5.11 and 5.12) and the assumption of homoscedasticity was met (see Figures 5.13 and 5.14).

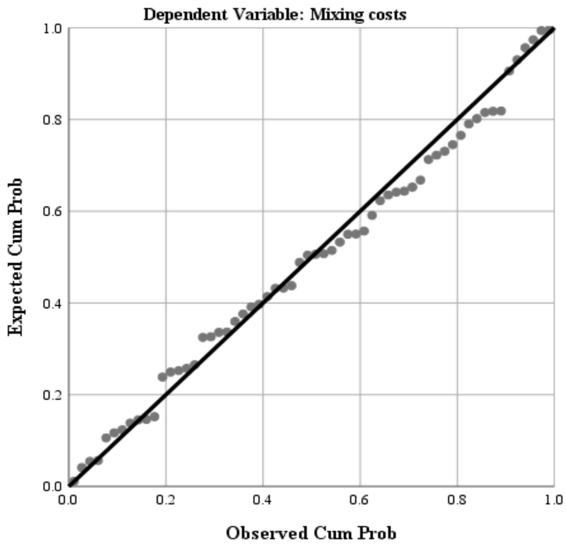


Figure 5.11. Normal P-P plots of regression standardized residuals.

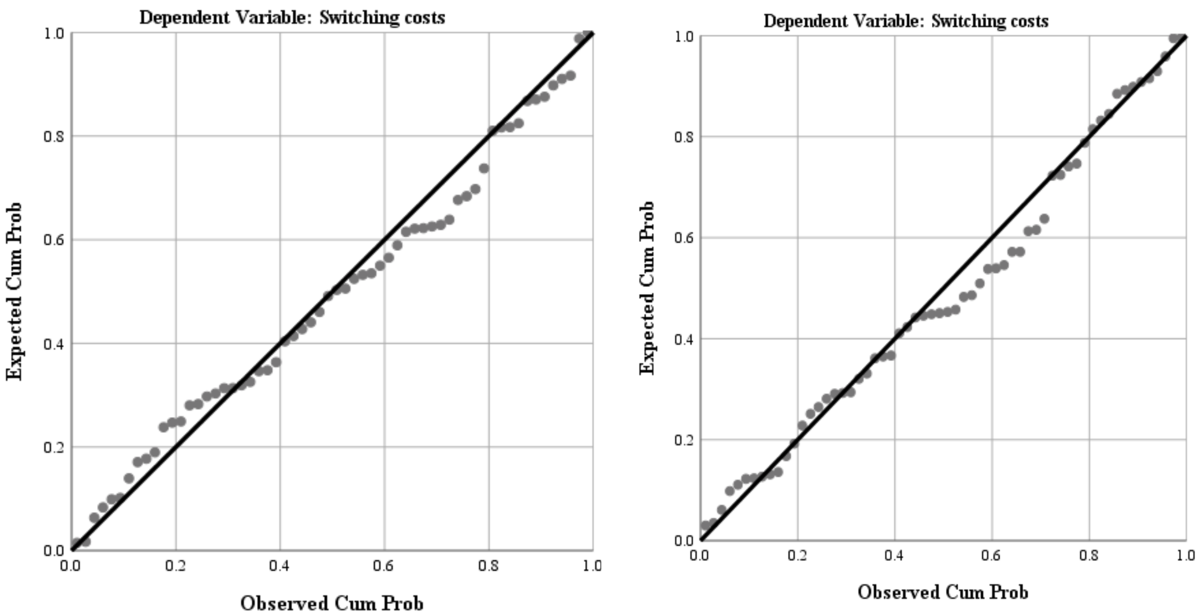


Figure 5.12. Normal P-P plots of regression standardized residuals. The model on the left has language entropy as predictor; the model on the right contains language proficiency and onset age of active bilingualism.

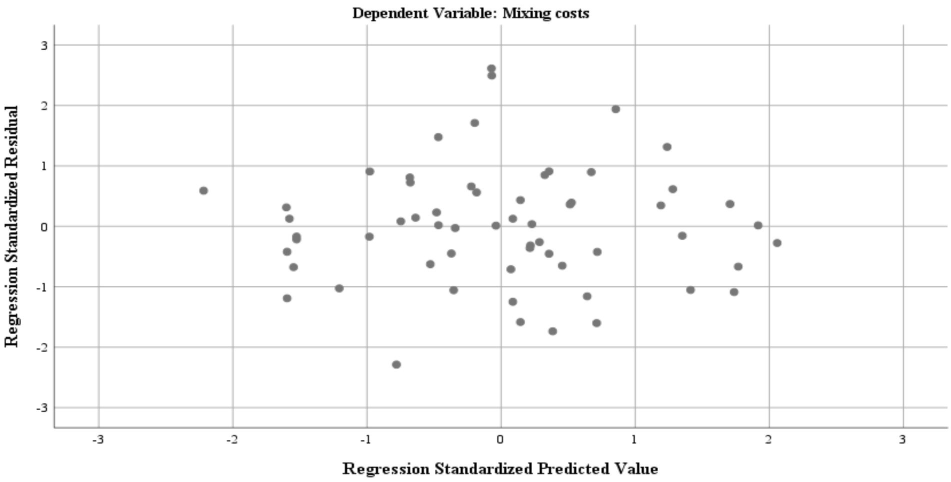
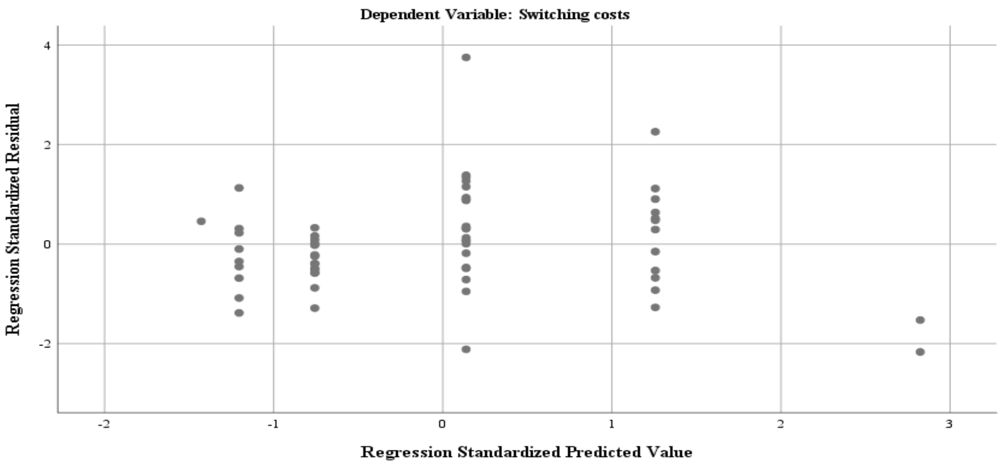


Figure 5.13. Scatterplots of standardized residuals versus predicted values.



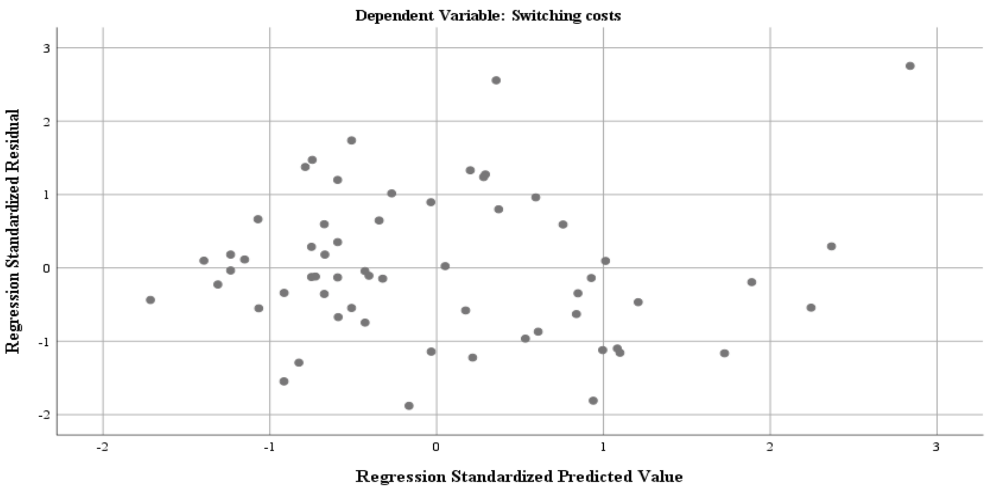


Figure 5.14. Scatterplots of standardized residuals versus predicted values. The model at the top has language entropy as predictor; the model at the bottom contains language proficiency and onset age of active bilingualism.

Having performed model diagnostics, we computed linear regression models for mixing and switching costs using the selected predictors. As shown in Table 5.17, the best-fitting model among all explained 13.1% of the variance in mixing costs, $p < .05$. The model had three predictors: *typological proximity/distance, onset age of active bilingualism* and *language proficiency.* However, only the last two were shown to significantly predict the dependent variable. As the bilinguals' language proficiency increased by one point on a 10-point scale, their mixing costs decreased by 33.66 ms ($p < .05$). Also, a decrease in onset age of active bilingualism led to a decrease in mixing costs ($B = -3.79$, $p < .05$).

Table 5.17

The Best-Fitting Model Showing the Capacity of the Variables to Predict Mixing Costs

Variable	*B*	SE *B*	*Β*	*T*	Sig.
R^2 = 17.6%, p < .05 ***$ΔR^2$= 13.1%, p < .05***					
Typological proximity/distance	-59.44	39.99	-.18	-1.49	.143
Onset age of active bilingualism	3.79	1.98	.23	1.91	.050
Language proficiency	-33.66	14.55	-.28	-2.31	.024

As opposed to mixing costs, the best model for switching costs was the version of Model 2 with *language entropy* as the only predictor. This model explained 17.8% of the variance in the dependent variable, $p < .05$. As shown in Table 5.18, an equal use of two languages was predicative of lower switching costs as compared to the use of only one of two languages (B = -997.60, $p < .001$). As for the version of the model with *language proficiency* among the predictors, it did not explain the variance in switching costs, $p > .05$. Hence, the results indicate that higher language proficiency together with typological proximity between two language and earlier onset of active bilingualism were predictive of lower mixing costs; whereas an equal use of two languages in the same context(s) were predictive of lower switching costs.

Table 5.18

The Best-Fitting Models Showing the Capacity of the Variables to Predict Switching Costs

Variable	*B*	SE *B*	*β*	*t*	Sig.
Model 1: R^2 = 8.2%, p > .05					
ΔR^2= 5.0%, p > .05					
Onset age of active bilingualism	-2.45	1.73	-.18	-1.41	.163
Language proficiency	-22.88	12.68	-.23	-1.80	.077
Model 2*: R^2 = 17.8.%, p < .001					
ΔR^2= 16.0%, p < .001					
Language entropy	-997.60	285.05	-.42	-3.50	.001

Note. Model 1 provides the best-fitting version of the model with language proficiency among the predictors. Model 2 provides the best-fitting version of the model with language entropy among the predictors. * indicates the best-fitting model among all the models.

5.4. Chapter Summary

In this chapter, we investigated which combinations (if any) of bilingual experience account for the highest percentage of variance in metalinguistic and task-switching performance in adults and, in addition, the predictive capacity of each variable in the combination(s). For this, we considered typological proximity/distance, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy.

To explore the research questions, we created two saturated base-line models for both MAT tasks, for RTs on each trial and for both costs. The two models contained *typological proximity/distance* and *onset age of active bilingualism* as predictors. In addition, Model 1 had *language proficiency* and Model 2 included *language entropy.* Then we built the best-fitting model(s) for each of the dependent variables using a stepwise backward approach.

Multiple regression analyses showed that variations in participants' metalinguistic and cognitive performance could be explained in terms of differences in language experience. In particular, *language proficiency* was predictive of MAT scores. In the case of SMT, it was the only predictor. However, in the case of GJT, it was not only *language proficiency* but also *typological proximity/distance* and *onset age of active bilingualism,* which accounted for the variance in the scores. In both tasks, the participants performed better if they had higher language proficiency. Also, higher GJT scores were linked to the bilinguals whose L1 belonged to the Germanic language branch and those with an earlier onset age of active bilingualism.

As for the CST data, the effects of the considered dimensions of bilingual experience varied. *Language proficiency* was predicative of blocked and repeat RTs: an increase in language proficiency resulted in significantly lower RTs. This was also the case with mixing costs, which were computed on the basis of blocked and repeat RTs. However, in addition to *language proficiency*, *typological proximity/distance* and *onset age of active bilingualism* played a role in explaining the maximum variance in mixing costs. In particular, lower mixing costs were associated with the bilinguals whose L1 belonged to the Germanic language branch and with an earlier onset age of active bilingualism.

On the other hand, *language entropy* accounted for the highest percentage of variance in switch RTs and switching costs. As language entropy increased, switching costs decreased significantly. Besides language entropy, *typological proximity/distance* significantly predicted switch RTs. Similar to mixing costs, lower RTs on switch trials were associated with the bilinguals speaking one of the Germanic languages as their L1. Taken together, the results show that metalinguistic awareness and proactive control processes were associated with language proficiency, typological proximity/distance and onset age of active bilingualism; whereas reactive control processes were associated with language entropy.

CHAPTER 6

DISCUSSION

6.1. Overview

This study tested the performance of adult bilinguals and a control group of adult English monolinguals on the Metalinguistic Awareness Test and the Colour-Shape Switching Task. This was done to explore the possible effects of language experience on metalinguistic awareness and non-verbal cognitive control, i.e. proactive and reactive control processes. In particular, we looked at bilinguals and monolinguals to investigate how (if at all) language context affects their metalinguistic and task-switching performance. To address this issue, we investigated: (1a) the bilingual dual-language context, (1b) the bilingual separated-language context and (1c) the monolingual language context. We also looked specifically at bilingual speakers to shed light on the dimensions (if any) of bilingual experience and the ways they affect bilinguals' levels of metalinguistic awareness and two indicators of cognitive performance, i.e. mixing costs and switching costs. In this case, we assessed: (1) typological proximity/distance, (2) age of L2 acquisition, (3) onset age of active bilingualism, (4) language proficiency and (5) language entropy in bilingual adults from separated- and dual-language contexts. The findings of the current study are discussed in detail in the following sections.

6.2. Language Experience as a Predictor of Metalinguistic Awareness and Cognitive Control in Bilingual and Monolingual Adults

The mental processing involved in language use is regarded as one of the most cognitively demanding experiences (Green & Abutalebi, 2013). Speakers, whether bilingual or monolingual, may need to select between different ways of conceptualising an event and/or between different ways of expressing this conceptualisation depending on their addressee. This language experience may be even more cognitively demanding when it comes to the two competing alternatives existing in two languages (in the case of bilingualism).

The fact that bilinguals, unlike monolinguals, need to select from different representational structures makes their language use fundamentally different (Anderson et al., 2018). Together with the repeated and sustained nature of the demands on the relevant executive functions in bilingual speakers, this further suggests that language management in bilinguals appears far more demanding than it does in monolinguals. If control processes adapt to such demands, then this argument provides a basis for expecting possible advantages in the cognitive control of bilingual speakers, including for non-verbal tasks (Green & Abutalebi, 2013).

Given the substantial inter-individual variability in language experience, the cognitive benefits are more likely to appear under specific conditions and/or for specific control processes (Pot et al., 2018). This fits well with recent theorising about the role of context in determining the nature of the bilingual effect (Green & Abutalebi, 2013). In light of this, we expected language context to affect metalinguistic awareness and the two indicators of cognitive performance – mixing and switching costs – in a different way. To test the hypothesis, we looked at three language contexts – the monolingual, bilingual separated and bilingual dual.

Further considering the multidimensional nature of bilingual language experience (de Bruin, 2019; Laine & Lehtonen, 2018; Sulpizio et al., 2020; Zirnstein et al., 2019), we hypothesised that there are some other language variables – those specific to bilingual experience – that may shape language-cognition interfaces and, therefore, lead to different (meta)linguistic and cognitive consequences (Green & Abutalebi, 2013; Gullifer et al., 2018; Hartanto & Yang, 2016; Pot, Keijzer, & de Bot, 2018). Given that some of the dimensions are not applicable to monolingual experience and that there is less variability in monolingual speakers, we used a within-group analysis of bilinguals.

Among the bilinguals, we considered such dimensions of language experience as typological proximity/distance of the two languages involved, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy. In line with our expectations, the effects of these dimensions on the metalinguistic and task-switching performance of bilingual adults manifested themselves in somewhat different ways.

6.2.1. The capacity of language experience to predict metalinguistic awareness in bilingual and monolingual adults. Given the previously reported effects of language proficiency on the level of metalinguistic awareness in children (e.g., Bialystok & Barac, 2012), we hypothesised that the model with *language proficiency* among the predictors would explain most of the variance in metalinguistic performance. In particular, we expected higher language proficiency to be predictive of higher scores on both MAT tasks. This would provide evidence that the level of metalinguistic awareness in adults is also sensitive to language proficiency. Further considering the role of language proficiency in shaping metalinguistic awareness and the co-variations between language proficiency and language use in our sample, we hypothesised that the language context(s) with higher levels of proficiency (in particular in English, i.e. the language of testing) would be associated with higher MAT scores.

In line with our hypothesis, the results showed that the minimal adequate model for both SMT and GJT was the one with *language proficiency* among the predictors. As expected, higher language proficiency was associated with higher scores.

In the case of SMT scores, language proficiency was the only predictor among the variables being tested. However, in the case of GJT scores, it was part of a statistically significant combination. Besides language proficiency, the best-fitting model for GJT contained *typological proximity/distance* and *onset* *age of active bilingualism* (as opposed to age of L2 acquisition) which were also statistically significant predictors. We found that higher GJT scores were linked to the bilinguals with typologically close languages (L1 and L2 belonged to the Germanic languages) and an earlier onset age of active bilingualism.

The findings on bilingual language experience may shed light on the effects of the language context variable. Taken together with the co-variations between language use (the variable used to extract language context) and language proficiency in our study, they suggest that the effects of the *language context* variable might have been mediated by language proficiency. As detailed in Chapter 3, Anglo-Australian monolinguals in the current study indicated higher levels of English proficiency than the bilinguals from both bilingual contexts. That might be why the monolingual language context was related to significantly higher SMT and GJT scores than both bilingual language contexts. These results might also be a reflection of the generally high educational level of the monolingual group. Therefore, different results could have emerged with substantially less educated participants.

Between two bilingual contexts, the dual-language context was predictive of significantly higher scores on both MAT tasks as compared to bilingual separated. This is what we expected given that the dual-context bilinguals reported higher levels of language proficiency than separated-context bilinguals.

Reconciling the current findings with the wider literature on the effects of language experience on metalinguistic awareness appears to be quite difficult.

One of the reasons for this is the inconsistency with which metalinguistic awareness has been conceptualised and measured. As detailed in Chapter 2, earlier studies approached it as a specific type of linguistic competence. They assessed phonological, word and/or sentence awareness (e.g., Ben-Zeev, 1977; Cummins, 1978; Ricciardelli, 1992; Smith & Tager-Flushberg, 1982; Yelland et al., 1993). On the other hand, later studies treated metalinguistic awareness as a form of language processing and targeted two skill components involved in language processing, i.e. the analysis of representation and control of attention (e.g., Bialystok, 1986; Bialystok & Barac, 2012; Cummins, 1993; Davidson et al., 2010; de Villiers & de Villiers, 1972; Galambos & Goldin-Meadow, 1990; Hakuta & Diaz, 1985). This resulted in differences in the conceptualisation and design of metalinguistic awareness tasks, both between the approaches and within each of them, with obvious implications for the interpretability and comparability of findings.

The second reason concerns inter-individual differences in participant samples and in how bilingualism has been approached and conceptualised in general. Most previous studies on bilingualism have not considered inter-individual variability in their participants' language experience. Instead, they conceived of bilingualism and monolingualism as dichotomous, rather than continuous, constructs and compared groups of people designated as bilingual or monolingual. Furthermore, they targeted mostly bilingual children – an age group whose performance on metalinguistic awareness provides more consistent findings. On the tasks demanding a high level of control of linguistic processing, bilingual children were shown to outperform monolinguals irrespective of their language proficiency (e.g., Bialystok, 1986, 1987, 1988). However, on the tasks requiring high levels of analysis, bilinguals produced better scores than monolinguals only if they had high levels of proficiency. These findings are supported by a number of subsequent studies on metalinguistic awareness (Cromdal, 1999; Cummins, 1993; Davidson et al., 2010; de Villiers & de Villiers, 1972; Foursha-Stevenson & Nicoladis, 2011; Hakuta & Diaz, 1985; Ricciardelli, 1992). Also, they align with the 'threshold hypothesis' proposed by Cummins (1976, 1977), according to which an overall bilingual superiority in terms of metalinguistic abilities would only manifest itself in bilinguals with high proficiency in both of their languages.

Our findings reinforce the role of language proficiency in shaping metalinguistic development. In line with previous studies, they suggest that high levels of language proficiency lead to enhanced metalinguistic awareness. However, our study goes further. It reveals that better metalinguistic performance is not only a matter of language proficiency, but also of typological proximity/distance between two languages and onset age of active bilingualism.

The differences in the effects of language variables between two metalinguistic tasks may stem from the differences in the extent to which the tasks place demands on each of the metalinguistic skills. Most of the sound-meaning task items required a high level of analysis of representation: participants had to know the meaning of the lexical items in order to choose the correct one (except for the cases where sound was a determining feature). On the other hand, the grammaticality judgement task placed more equal demands on the two skill components, i.e. analysis of representation and control of attention. That might be why the scores on this task were affected by language proficiency, typological proximity/distance and onset age of active bilingualism (for the effects of onset age of active bilingualism on control processes, see Bialystok & Barac, 2012; Luk et al., 2011). The present observations, therefore, suggest that high levels of language proficiency enhance analysis skills and, together with experience of using two typologically close languages over a sufficient period of time (earlier onset age), enhance control skills. The results of the current study thus reinforce the role of language experience in general and bilingual language experience in particular in shaping metalinguistic awareness (see Figure 6.1).

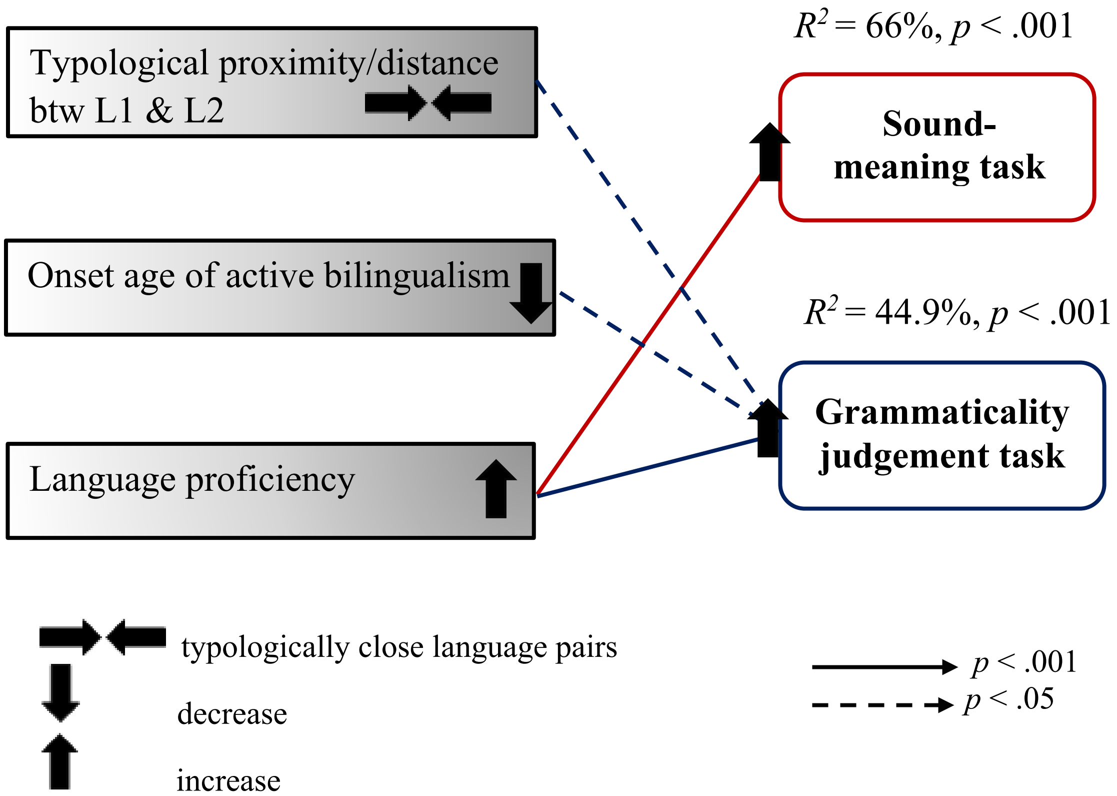


Figure 6.1. Dimensions of bilingual language experience predictive of metalinguistic performance.

6.2.2. The capacity of language experience to predict mixing and switching costs in bilingual and monolingual adults. As opposed to metalinguistic awareness, cognitive control in bilinguals appears to be sensitive to a variety of dimensions of bilingual experience, including typological proximity/distance, onset age of active bilingualism, language proficiency and language use, among others. Each of them has been suggested to contribute to bilingual cognitive performance, although in different ways, depending on the cognitive processes being targeted. In light of this and the dual mechanisms framework suggested by Braver and colleagues (2003), we expected mixing and switching costs to be affected by different combinations of bilingual experience.

Following the hypothesis of language proficiency being associated with an ability to control interference (Green & Abutalebi, 2013), we expected the version of the model with *language proficiency* among the predictors to be the best one for mixing costs. On the other hand, given the previously reported effects of language use on the task-switching performance (Bialystok & Barac, 2012; Hartanto & Yang, 2016), we hypothesised the version of the model with *language entropy* to explain most of the variance in switching costs.

Given that in the current study the three language contexts – the monolingual, bilingual separated and bilingual dual contexts – came with different levels of language proficiency in addition to different language use patterns, we expected the following scenarios for the *language context* variable. Between the two bilingual contexts, the dual-language context would be predictive of lower mixing and switching costs relative to the separated-language context. When compared with the monolingual language context, the bilingual dual-language context would be predictive of lower switching costs.

The results of our study supported our hypotheses. The best-fitting model for mixing costs was with *language proficiency* among the predictors. This was also the case with blocked and repeat RTs, on the basis of which the costs were computed. In all models, an increase in language proficiency resulted in significantly lower RTs. In addition to language proficiency, *typological proximity/distance* and *onset age of active bilingualism* were part of a combination significantly predicting mixing costs. In particular, the bilinguals whose L1 belonged to the Germanic language branch and those with an earlier onset age of active bilingualism produced lower mixing costs. These observations are similar to the findings on the effects of the language variables on metalinguistic awareness in our study.

On the other hand, the best model for switch RTs and switching costs was the one with *language entropy* among the predictors. In particular, an equal use of two languages was predicative of lower switching costs as compared to the use of only one of two languages. Besides language entropy, *typological proximity/distance* significantly predicted switch RTs. Similar to mixing costs, the bilinguals with one of the Germanic languages as their L1 produced lower RTs on switch trials.

These findings align with the effects of *language context* on bilinguals' and monolinguals' task-switching performance. As expected, there was a difference in the significance and impacts of language context 1 (1 = *monolingual*, 0 = *bilingual dual*) and language context 2 (1 = *bilingual separated*, 0 = *bilingual dual*) on the two costs. Specifically, language context 2 significantly predicted both costs: the bilingual dual-language context resulted in significantly lower mixing and switching costs than the bilingual separated context. On the other hand, language context 1 was a statistically significant predictor only in the case of switching costs: the bilingual dual-language context led to significantly lower switching costs than the monolingual language context.

As with metalinguistic awareness, it is quite difficult to relate the current findings to previous research targeting mixing and switching costs in bilinguals. One of the reasons for this is the inconsistency with which these component processes have been measured. For instance, the studies by Bialystok et al. (2006), Bialystok et al. (2004), Bialystok (2006), Bialystok and Viswanathan (2004) and Costa et al. (2008) revealed enhanced bilingual performance in experimental blocks with changing stimulus characteristics. These findings were interpreted as reflecting a bilingual advantage in ongoing monitoring, which would be expected to parallel mixing costs in the present research. However, in all these studies, the performance on the trials that were similar to mixed-task trials in the Colour-Shape Switching Task was not compared to an appropriately controlled single-task trials.

The studies which included single-task and mixed-task trials also differed in a number of ways: in the type of switches (predictable or unpredictable), in the time interval for preparing the task switch, in the type of stimuli used (bivalent or univalent), in the response mappings (bivalent or univalent) and/or in the response method (verbal or non-verbal; (Bialystok & Barac, 2012; Iluz-Cohen & Armon-Lotem, 2013; Hernández et al., 2013; Paap & Greenberg, 2013; Prior & Gollan, 2011; Prior & MacWhinney, 2010). For example, Prior and MacWhinney (2010) and Soveri, Rodriguez-Fornells and Laine (2011) reported bilingual non-verbal switching advantages when they used a task-switching test asking participants to give button press responses. On the other hand, Rosselli et al. (2016) did not find any switching advantages when they used verbal and non-verbal switching measures requiring oral responses. The specific implementations of these studies, therefore, might have contributed – at least, partially – to the differences in the findings.

Reconciling the current findings with previous studies is also difficult because of the lack of consistency in how bilingualism has been approached. Similar to studies on metalinguistic awareness, previous task-switching research compared the performance of bilinguals and monolinguals without considering the differences in their language experience and/or non-linguistic factors (e.g., demographics). In particular, two studies (Prior & Gollan, 2011; Prior & MacWhinney, 2010) recruited bilinguals who had similar proficiency in the two languages and had an early age of L2 acquisition and/or an early onset age of bilingualism. They found reduced switching costs for bilinguals as compared to monolinguals. However, using seemingly similar criteria, several other studies (e.g., Hernández et al., 2013; Paap & Greenberg, 2013) did not find a bilingual advantage, even after matching samples of monolinguals and bilinguals on key demographics. By looking at inter-individual variability in language experience and its effects on task-switching performance, we, therefore, extended previous research and shed light on the language-cognition interfaces in bilingual speakers.

In line with the Adaptive Control Hypothesis (Green & Abutalebi, 2013), the costs anchored in inhibition, i.e. mixing costs, were sensitive to language proficiency. As suggested by Green and Abutalebi (2013), an increase in language proficiency led to better control of interference, i.e. reduced mixing costs.

Besides language proficiency, onset age of active bilingualism and typological proximity/distance between two languages affected mixing costs. In line with previous studies, better cognitive performance, i.e. lower mixing costs, were related to the bilinguals with an earlier onset age (Luk et al., 2011; Tao et al., 2011) and language pairs that were relatively similar in terms of lexical items and grammatical structure (e.g., Catalan-Spanish bilinguals in Costa et al., 2008 and in Hernandez et al., 2010). The fact that age of L2 acquisition (as opposed to onset age of active bilingualism) in the present study did not affect the costs reinforces the idea that it is not earlier exposure to both languages but rather more prolonged experience managing two languages that may enhance cognitive performance (e.g., Bialystok et al., 2006; Luk et al., 2011).

In the current study, the bilinguals were on average late bilinguals and most of them spoke quite typologically distant languages. These may be the reasons for neither of the bilingual language contexts being associated with reduced mixing costs as compared to the monolingual language context. Similar observations were made by Prior and MacWhinney (2010): the mixing costs of fluent bilinguals with typologically distant languages were similar to those of English monolinguals. Also, the lack of mixing costs advantages aligns with Luk et al.'s (2011) results: late bilinguals in their study showed comparable flanker costs to monolinguals. Our findings on mixing costs, therefore, substantiate and extend previous research. They suggest that the use of two typologically close languages may require a greater degree of inhibition and updating. Hence, continuing experience of using such language pairs may lead to more efficient proactive control processes than the use of two typologically distant languages or the use of one language.

On the other hand, switching costs were not associated with language proficiency. Instead, they were related to language entropy. This observation aligns with the results obtained by Bialystok and Barac (2012) and Hartanto and Yang (2016): the task-switching performance of bilingual children and adults, respectively, in their studies was affected not by language proficiency but by the way and extent to which two languages were used. Similar findings were also presented by Gullifer et al. (2018), Ooi et al. (2018) and Pot et al. (2018), among others. Using other non-verbal cognitive control tasks (the flanker task, the Simon task, the Lateralized Attention Network Test, etc.), these researchers found the cognitive performance of bilinguals to be shaped by language use.

In our research, the use of two languages in the bilingual dual-language context resulted in lower switching costs than in the bilingual separated-language context. These results are in line with Hartanto and Yang's (2016) research, which showed smaller switching costs for dual-language bilinguals as compared to single-language bilinguals. Given that the bilingual dual-language context in our study was also predictive of lower switching costs than the monolingual language context, we suggest that the use of two languages in a dual-language context is likely to boost reactive control processes. Taken together, our empirical observations substantiate and extend previous findings by revealing that different combinations of language experience affect the components of non-verbal cognitive control (see Figure 6.2).

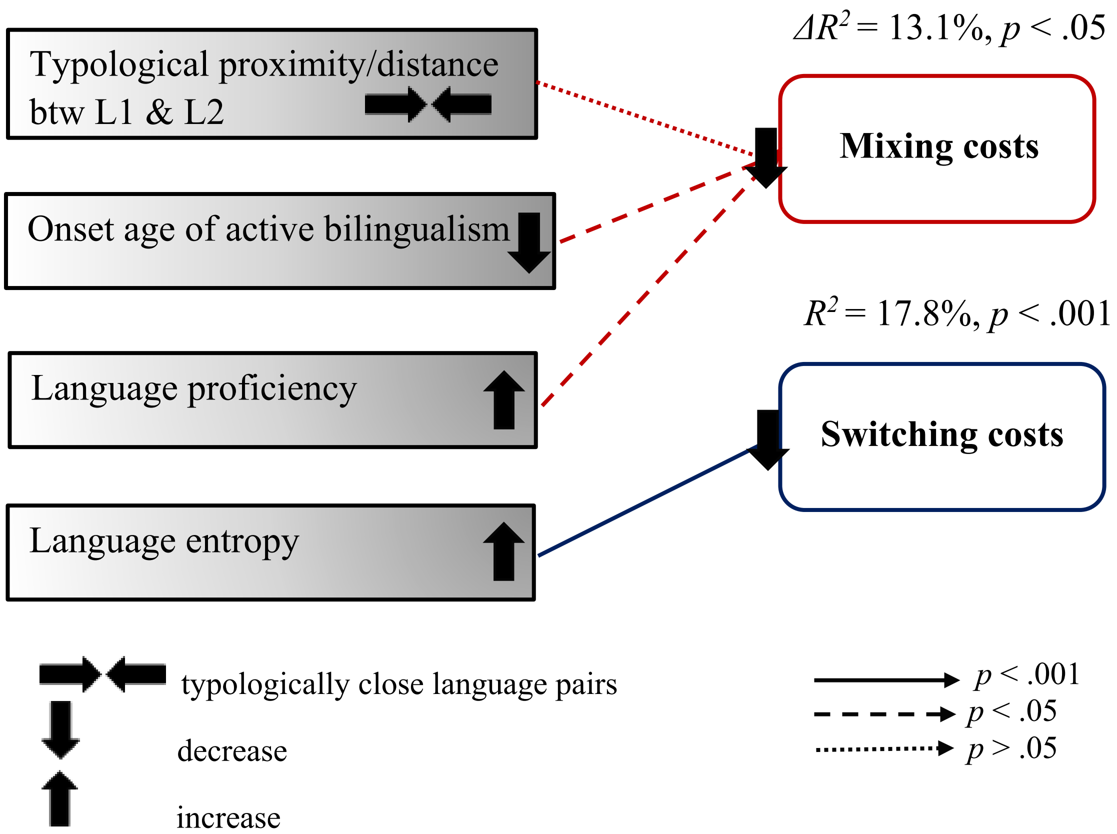


Figure 6.2. Dimensions of bilingual language experience predictive of mixing and switching costs.

6.3. Chapter Summary

This chapter discussed the current research findings in relation to the research questions/hypotheses posed at the beginning and in relation to previous metalinguistic and cognitive studies on bilingualism. In line with the research hypotheses, the version of the model with *language proficiency, typological proximity/distance between two languages* and *onset age of active bilingualism* explained the highest percentage of variance in metalinguistic performance. In particular, higher language proficiency, the use of typologically close language pairs and earlier onset of active bilingualism were associated with higher scores on the Metalinguistic Awareness Test. When considered together with monolingual data, the results suggest that high language proficiency together with experience in using two typologically close languages over a sufficient amount of time may help to obtain/maintain high levels of metalinguistic awareness.

The findings on cognitive data also supported our hypotheses. As expected, the version of the model with *language proficiency* among the predictors was the best one for mixing costs. Similarly to metalinguistic awareness, higher language proficiency, the use of typologically close languages and an earlier onset age of active bilingualism were related to lower mixing costs. These findings explain the effects of the *language context* variable, in particular why the bilingual dual-language context (higher language proficiency) led to lower mixing costs than the bilingual separated context (lower language proficiency). Together with the fact that the monolingual language context did not result in significantly lower costs than the bilingual dual-language context, the findings suggest that earlier and continuing experience of using two typologically close languages, together with high language proficiency, may lead to more efficient proactive control processes.

As opposed to mixing costs, variations in participants' switching costs were best explained in terms of differences in language use: the version of the model with *language entropy* accounted for the highest percentage of variance in switching costs. In line with our expectations, the use of two languages in the dual-language context (same context but different interlocutors) was predictive of reduced switching costs. Together with the effects of the *language context* variable, the results imply that an equal use of two languages across different contexts, i.e. the dual-language context, is likely to enhance reactive control processes. The current findings, therefore, reinforce the role of language experience in shaping metalinguistic awareness and non-verbal cognitive control (see Figure 6.3).

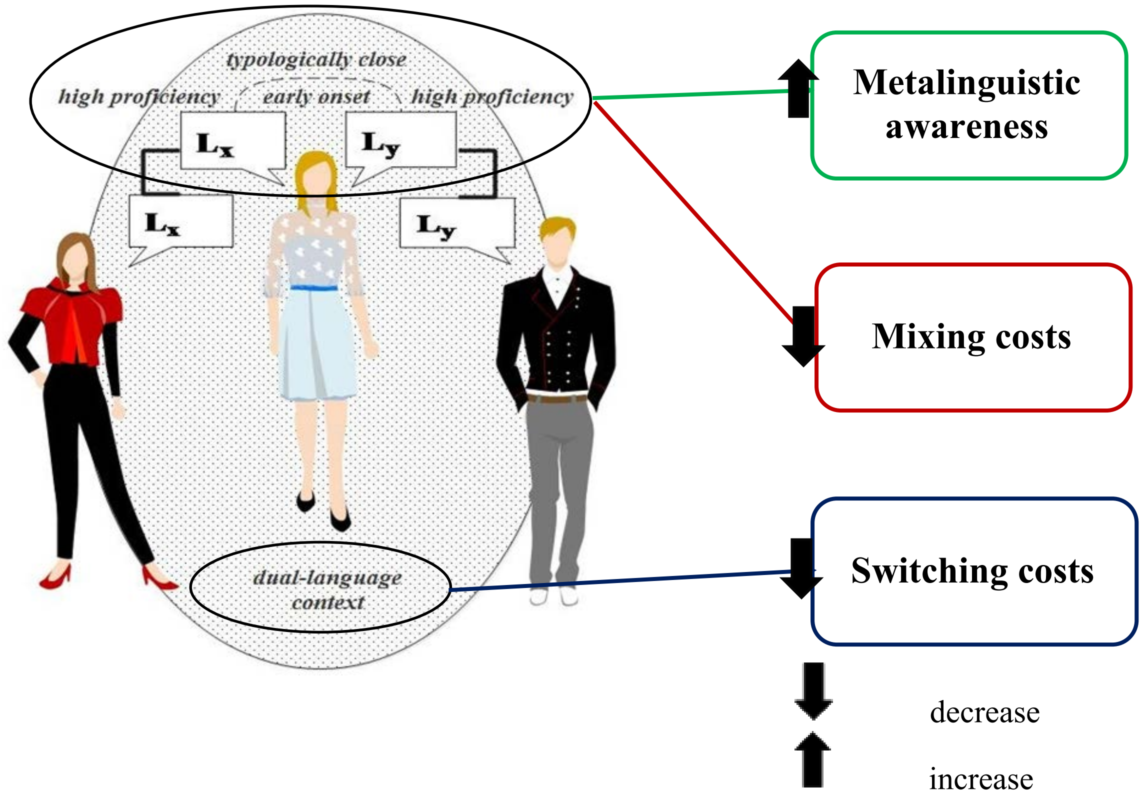


Figure 6.3. Bilingual language experience affecting metalinguistic awareness and two indicators of cognitive performance, i.e. mixing and switching costs.

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

7.1. Overview

Given the potential role of bi-/multilingualism in boosting metalinguistic skills and cognitive control processes, exploring language-cognition interfaces in bi-/multilinguals is an important research priority. This is especially true in Australia, where one in five people speaks a non-English language in addition to English (Australian Bureau of Statistics, 2016).

In the present study, we extended the previous metalinguistic and cognitive research on bilingualism by exploring the capacity of specific dimensions of language experience to predict metalinguistic and cognitive performance of bilinguals and monolinguals in the context of multicultural Australia. As indicators of language experience, we focused on language context, typological proximity/distance between two languages, age of L2 acquisition, onset age of active bilingualism, language proficiency and language use. As indicators of metalinguistic performance, we targeted analysis of representation and control of attention to capture metalinguistic awareness during the Metalinguistic Awareness Test. As indicators of cognitive performance, we measured mixing costs and switching costs to gage proactive and reactive control processes during the Colour-Shape Switching Task.

In the following sections, we highlight the main findings and contributions of the present study to metalinguistic and cognitive dimensions of bilingualism. We start by outlining the limitations of previous research and the way they were addressed in the current study. Then we move to a summary of the results. In particular, we underscore the way and extent to which language experience affected metalinguistic and task-switching performance. This is followed by a discussion of the theoretical and practical implications of our findings. The chapter finally outlines the limitations of the present study and offers recommendations for future research.

7.2. Some Limitations of Previous Research which the Current Study Was Specifically Designed to Address

Previous metalinguistic and task-switching studies had a few limitations, which may have led to (spurious) differences in findings. Most of them did not take into account the differences between the participants' language experience when interpreting their cognitive performance. The general approach was to compare groups of people designated as monolingual or bilingual to determine whether there were significant performance differences between those groups. However, it is now widely accepted that bilingualism is a multidimensional phenomenon and hence should be treated as such (de Bruin, 2019; Kroll & Bialystok, 2013; Laine & Lehtonen, 2018; Sulpizio et al., 2020; Zirnstein et al., 2019).

Those few studies that considered inter-individual variability in language experience targeted children – an age group whose performance on cognitive control tasks is known to be more consistent than that of bilingual adults (Barac & Bialystok, 2012). What is more, they had no monolingual control group. Thus, they were able to make conclusions only about whether or not variability in bilingual language experience affects metalinguistic and cognitive performance but not about the direction of the effect, i.e. whether it leads to metalinguistic and/or cognitive *advantages* in bilinguals.

In order to address the limitations of previous metalinguistic awareness and task-switching studies, we included three novel design features. First, we assessed bilingualism along a multidimensional continuum, simultaneously considering a number of linguistic and demographic factors characterising bilingual experience. This enabled us to explore the underlying dimensions of bilingual experience which potentially contribute to metalinguistic and cognitive advantages.

Secondly, we tested a linguistically diverse sample of bilingual participants. In particular, the bilinguals were heterogeneous in terms of L1 backgrounds (but had the same L2 – English). They also varied in the age at which they started learning the second language, in the age at which they began using two languages on a daily basis, in language proficiency and in the proportional L1 and L2 use. This provided an excellent opportunity to carefully investigate such language variables as typological proximity/distance between two languages, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy, and whether they are predictive of metalinguistic and task-switching performance of bilingual adults.

Thirdly, we included monolinguals in our sample too. However, instead of comparing participants as monolinguals vs bilinguals, we considered three language contexts: monolingual, bilingual separated and bilingual dual. Together with the data on the inter-individual variability in our bilingual sample, this provided a starting point for understanding what the underlying mechanisms of the cognitive advantages are and how bilingual experience may contribute to metalinguistic and cognitive performance.

Last but not least, our study is, to the best of our knowledge, the first research to examine the effects of bilingual experience on metalinguistic awareness and non-verbal cognitive control in adults in the context of multicultural Australia. All this enabled us to make a range of distinct theoretical and practical contributions to the field of bilingualism.

7.3. Summary of the Research Findings

The present study's principal goal was to test the capacity of inter-individual variability in language experience to explain the variance in metalinguistic and task-switching performance of bilingual adults. Consistent with our predictions, the results showed that variations in participants' metalinguistic scores, mixing costs and switching costs could be explained in terms of differences in language experience.

In line with the research hypotheses, language context was predictive of metalinguistic scores. The bilingual dual-language context was associated with lower scores relative to the monolingual language context and higher scores relative to the bilingual separated-language context. Language context also accounted for the variance in mixing and switching costs. The use of language(s) in the monolingual and bilingual dual-language contexts was associated with reduced mixing costs as compared to the bilingual separated-language context. On the other hand, switching cost advantages were found only among those who used two languages in the dual-language context.

The revealed effects of bilingual language variables were also in accord with our predictions. As expected, higher levels of language proficiency led to higher scores on the Metalinguistic Awareness Test. Besides language proficiency, typological proximity/distance between two languages and onset age of active bilingualism affected metalinguistic performance: the use of typologically close language pairs and an earlier onset age of active bilingualism were associated with higher scores.

As for the indicators of cognitive performance, they were also affected by the dimensions of bilingual experience. Similar to the MAT data, variations in mixing costs (proactive control processes) were best explained in terms of bilinguals' language proficiency, typological proximity/distance and onset age of active bilingualism (as opposed to age of L2 acquisition). Once again, higher language proficiency, use of typologically close languages and earlier onset age of active bilingualism were associated with better performance, i.e. lower mixing costs. On the other hand, variations in switching costs (reactive control processes) were best explained in terms of differences in language use, i.e. language entropy. As expected, an equal use of two languages in the same contexts but with different interlocutors was predictive of reduced switching costs. Taken together, the current results reveal that certain dimensions of bilingual language experience affect and potentially enhance metalinguistic and cognitive performance.

7.4. Implications of the Research Findings

The results of our study have a number of theoretical and practical implications. First of all, they reveal that the performance on metalinguistic awareness and non-verbal switching tasks is related to language experience. This underscores the important role of language in general and bilingualism in particular in shaping metalinguistic and cognitive abilities. Hence, this work contributes to the growing body of evidence for the language-executive functioning link (Anderson et al., 2018; Green & Abutalebi, 2013; Gullifer et al., 2018).

Secondly, our findings reinforce the emerging approach to bilingualism as a multidimensional dynamic phenomenon sensitive to a number of inter-individual language learning and use variables (de Bruin, 2019; Laine & Lehtonen, 2018; Sulpizio et al., 2020; Zirnstein et al., 2019). Moreover, the fact that differences in bilingual language experience (typological proximity/distance, onset age of active bilingualism, language proficiency, and language entropy) accounted for variations in bilinguals' metalinguistic awareness, mixing costs and switching costs suggests that some of the inconsistencies found in previous studies (e.g., Gold et al., 2013; Hernández et al., 2013; Paap & Greenberg, 2013; Paap & Sawi, 2014; Prior & MacWhinney, 2010) may have occurred because the differences between the participants' language experience were not taken into account analytically when interpreting their performance. This further reinforces the need to consider individual features and the dynamic nature of bilingual experience when modelling language-cognition interfaces and the effects of bilingual experience on (meta)linguistic development and domain-general cognitive control.

Thirdly, the results substantiate and extend previous findings showing that different dimensions of bilingual experience account for enhanced metalinguistic and cognitive performance (e.g., Bialystok & Barac, 2012; Green & Abutalebi, 2013; Gullifer et al., 2018; Hartanto & Yang, 2016; Ooi et al., 2018; Pot et al., 2018). In the present study, metalinguistic advantages were linked to high language proficiency, typologically close languages and earlier onset age of active bilingualism. In the same way, the three variables affected mixing costs. These results suggest that it is not so much the way and extent to which language(s) is/are used but rather language proficiency that affects metalinguistic awareness (Bialystok & Barac, 2012) and proactive control processes (Green & Abutalebi, 2013).

On the other hand, variations in switching costs were best explained in terms of language use. Specifically, a relatively equal use of two languages in the same contexts depending on the interlocutor was associated with switching cost advantages. This pattern of results indicates that simply knowing more than one language does not unequivocally lead to enhanced cognitive performance. Instead, it is the way and extent to which languages are used (i.e. a dynamic 'language usage' operationalisation of bilingualism; Pot et al., 2018) that might significantly affect certain components of cognitive control, e.g., reactive control processes.

Together with metalinguistic data, the results partially substantiate and reinforce the framework proposed by Bialystok (2001), which suggests that two different bilingual factors shape bilingual speakers' linguistic and cognitive development. In line with it, metalinguistic performance was affected mainly by language proficiency. However, non-verbal cognitive control was shaped not only by language use (see Bialystok & Barac, 2012), but also by language proficiency. The fact that proactive and reactive control processes were shown to be variably shaped as a function of different bilingual language experience aligns with the dual mechanisms framework described by Braver et al. (2003).

The findings, therefore, extend previous research and provide insight into the mechanisms of bilingual metalinguistic and cognitive advantages.

Furthermore, our findings reinforce the view that bilingual language experience does not impact cognitive control overall and uniformly; rather, it affects certain cognitive components and affects them in different ways (Gathercole et al., 2014; Paap et al., 2014; Scaltritti et al., 2017; Sun et al., 2019; Yow & Li, 2015). The use of two languages in the dual-language context led to advantages in switching costs, but not in mixing costs relative to the monolingual language context. Hence, the bilingual dual-language context contributed to enhanced reactive control, but not proactive control. These cost differences suggest that the impact of bilingualism on executive control is function-specific and not function-general (Yow & Li, 2015); in other words, the bilingual effect may not occur uniformly across all components of cognitive control.

The emergence of language context as an important dimension aligns with the Adaptive Control Hypothesis (Green & Abutalebi, 2013) and with recent empirical evidence indicating how different contexts of language use affect cognitive control ability (Gullifer et al., 2018; Hartanto & Yang, 2016; Pot et al., 2018). Specifically, our findings suggest that bilinguals who have mastered adaptive control in a dual-language context or across different interactional contexts are more likely to be better at background monitoring and inhibiting and faster at detecting a cue and making the required response (switching cost advantages) than bilinguals from a bilingual separated-language context and monolinguals.

Taken together with a high correlation between language use and language proficiency ($r = .50$, $p < .001$), the results also provide insights into the social, educational and cognitive factors involved in acquiring/using two languages that may lead to enhanced linguistic performance. In particular, they suggest that bilinguals who have mastered adaptive control in a dual-language context or across different interactional contexts are more likely to obtain/maintain high levels of proficiency in both languages. This implies the importance of executive functions for learning and maintaining two languages (see Vaughn & Hernandez, 2018).

Besides language context, typological proximity between L1 and L2 was predictive of the participants' cognitive performance, in particular of their mixing costs. In accord with recent neuroimaging research (Abutalebi et al., 2015), the current findings suggest that the use of two typologically close languages (vs two typologically distant ones) is likely to result in greater competition and place greater demands on inhibition, thus potentially enhancing the relevant proactive control process across cognitive domains.

In addition to these variables, onset age of active bilingualism affected mixing costs in the current bilingual sample who, on average, acquired and started to actively use their L2 later in life. The results of our study, therefore, add to the previous findings (Kapa & Colombo, 2013; Luk et al., 2011) suggesting that later acquisition and use of a second language after the consolidation of the first one may have a greater impact on proactive control processes, in particular on inhibition. However, the more experience bilinguals have later in life in managing their two languages, the faster they are likely to be at inhibiting.

The need for further research notwithstanding, the present study contributes clearly to our understanding that bilingual experience can offer additive, and not subtractive, cognitive effects. Further, these benefits can have a number of socially relevant consequences for educational attainment, future socioeconomic success and healthy cognitive ageing. In the multicultural Australian context, this underscores the importance of introducing suitably designed educational, social and political policies encouraging bi-/multilingualism and creating the best possible setting/environment for learning and maintaining two/multiple languages. Establishing language learning programmes and promoting social practices that maintain and further develop Indigenous and community languages seems particularly desirable. Along other bi-/multilingual practices, this may have serendipitous benefit of improving the social and cognitive health of multicultural Australia.

7.5. Limitations of the Current Study and Recommendations for Future Research

Interesting as these findings are, they probably only partially capture the way bilingual language experience interacts with metalinguistic awareness and non-verbal cognitive control. One of the limitations of the current study concerns the method used to collect data in relation to language proficiency and use. Being aware of the inherent shortcomings of self-reports, we used a detailed, reliable and valid tool that captures language proficiency and use in both languages and across different contexts in diverse communities. Moreover, to avoid misinterpretations and/or differential interpretations of the question items, the questionnaire was administered by a bilingual researcher in face-to-face sessions. That said, we recognise that comprehensive validity of self-reported data can only be established by comparing it with the scores on objective measurements.

Another limitation is related to our bilingual and monolingual sample. In the current study, the participants belonged to a particular type: the bilinguals were L2 speakers of English from diverse non-English speaking backgrounds, while the monolinguals were English-speaking Australians. All of them were living in a mostly English-oriented context, in which language use and proficiency were highly correlated. This limits the generalisation of results to people with similar language experience.

Given the peculiarities of our bilingual sample, we were able to simultaneously consider a number of inter-individual variables, in particular typological proximity/distance between L1 and L2, age of L2 acquisition, onset age of active bilingualism, language proficiency and language entropy, gender, SES and age. However, in addition to the socio-linguistic factors targeted in the current study, it would be interesting to consider other potential sources of inter-individual variability, such as language switching, level of education, immigration status and quality of life, among others (see Bak, 2016). This would allow for a more ecological conceptualisation of bilingualism (Sulpizio et al., 2020) and, as a result, for a more precise modelling of language-cognition interfaces and for a better understanding of the metalinguistic and cognitive effects of bilingual experience (Surrain & Luk, 2019).

Also, the specific distribution of L1 which we had in our sample allowed us only a coarse dichotomisation of the typological proximity/distance variable. However, given the fact that this variable significantly predicted metalinguistic and cognitive performance, future studies should operationalise it in a quantitative way.

Furthermore, the participants in the current study performed only one non-verbal task. However, using single indicators poses the problem of task-impurity (Miyake & Friedman, 2012) and makes it difficult to distinguish between task-specific and ability-general effects. It can also leave some of the cognitive effects undetected (Kroll & Bialystok, 2013). To ensure the convergent validity and reliability of the findings, therefore, future research should target more than one indicator of cognitive performance and use more than one cognitive measure targeting each indicator (see Paap & Greenberg, 2013).

It is also necessary to acknowledge that the current study was not designed to establish the causal direction of the link between language experience and executive control, hence its cross-sectional correlational design. Nevertheless, we interpreted our results in terms of language experience leading to variations in control processes. However, reactive and proactive control processes in particular and cognitive control in general can equally contribute to language performance. In line with the objectives of the present study, the participants performed only the non-verbal switching task capturing mixing and switching costs. Alternative designs might systematically vary practice on these tasks to observe differences in language performance.

Finally, our study was purely behavioural in nature, but, given the complexity of bilingual experience and cognitive control, better understanding of the relationship between language and cognitive processing in bilinguals would require more sensitive measures, such as those provided by brain imaging. As the findings of recent research suggest, brain-based measures are more accurate at detecting differences in cognitive processing than behavioural tools (Ansaldo, Ghazi-Saidi, & Adrover-Roig, 2015; Kousaie & Phillips, 2017).

7.6. Chapter Summary

This chapter provided a brief summary of the most significant research findings of the present study and identified its key theoretical and practical contributions to our understanding of the intricate ways in which bilingual experience interacts with, and perhaps even shapes, language-specific and domain-general cognitive systems. Consistent with recent studies and theories, our research suggests that particular dimensions of bilingual experience rather than bilingualism per se is linked to enhanced metalinguistic and cognitive performance (Green & Abutalebi, 2013; Gullifer et al., 2018; Hartanto & Yang, 2016; Laine & Lehtonen, 2018; Pot et al., 2018; Zirnstein et al., 2019). However, our study is unique in that it provides insight into dimensions of bilingual experience which may boost metalinguistic skills, proactive and reactive control processes. In particular, our findings suggest that the use of two languages in a dual-language context may lead to switching costs advantages (reactive control processes). When combined with typological proximity between two languages and an earlier onset of active bilingualism, such use of two languages is likely to enable bilinguals to obtain/maintain higher levels of language proficiency. This, in turn, may allow them to obtain/maintain higher levels of metalinguistic awareness and experience mixing costs benefits (proactive control processes).

To conclude, the current findings reinforce the argument that bilingual experience may contribute to enhanced metalinguistic and cognitive performance, but the strength of this contribution varies in different individuals and depends on the dimensions of their specific bilingual experience. An important way forward is, therefore, to focus more research attention on the individual features of bilingual experience and the ways in which they affect the performance of bilinguals on both linguistic and cognitive tasks. This adds strength to the idea of bilingualism as a research avenue for language learning mechanisms, language-cognition interfaces and brain plasticity in general.

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Appendix A

The research team

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Appendix B

Ethics-Related Documents

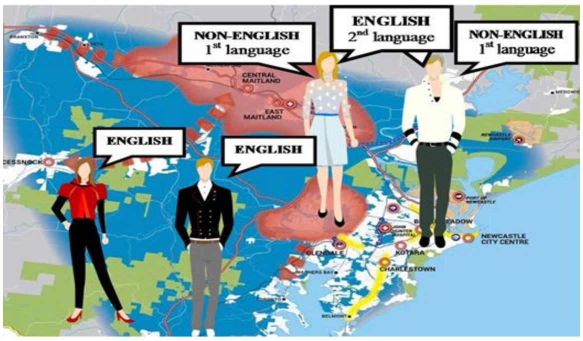
THE UNIVERSITY OF NEWCASTLE AUSTRALIA

RESEARCH STUDY

www.newcastle.edu.

BILINGUALS & MONOLINGUALS NEEDED

FOR THE RESEARCH PROJECT:
Inter-Individual Variability in Language Experience and Its Effects on Metalinguistic Awareness and Non-Verbal Cognitive Control in Bilingual and Monolingual Adults



✓ Are you a **BILINGUAL** or **MONOLINGUAL adult** (20-40 years old), currently living in the **Newcastle/Hunter area**, NSW, Australia?

If you are a **bilingual speaker**:
✓ Are you an **immigrant from non-English speaking background**?
✓ Is your **second language English**?

If you are a **monolingual speaker**:
✓ Are you an English-speaking Australian?

THEN WE WOULD REALLY LIKE TO HEAR FROM YOU :-).
If you choose to **participate**, you may go into the draw to win one of the **five $100 Westfield vouchers**.
INTERESTED? To get more information on the project, you are more than welcome to **contact**:

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This project has been approved by the University's Human Research Ethics Committee, Approval No. H-2017-0336.

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THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

Information Statement for the Research Project:

Inter-Individual Variability in Language Experience and Its Effects on Metalinguistic Awareness and Non-Verbal Cognitive Control in Bilingual and Monolingual Adults in the Context of Multicultural Australia

Dear Participant,

You are invited to participate in the research project identified above which is being conducted by Iryna Khodos, a student from the School of Humanities and Social Science at the University of Newcastle.

The research is part of Iryna's studies at the University of Newcastle, supervised by Dr. Christo Moskovsky and Dr. Alan Libert from the School of Humanities and Social Science.

Why is the research being done?

The research is expected to make a range of distinct theoretical and practical contributions to the field of bilingualism. Its results are likely to provide insights into metalinguistic and cognitive dimensions of bilingualism, which are currently not well understood. Also, the study's findings can potentially be used for the development of social and educational policies designed to support bi-/multilingual and multicultural practices.

Who can participate in the research?

You are invited to participate in the research if you are an educated bilingual or monolingual adult (20-40 years old), currently living in the Newcastle/Hunter area, NSW, Australia.

If you are a bilingual speaker, to be eligible for participation in the study you must be an immigrant from non-English speaking background, with English being your second language.

If you are a monolingual, you must be an English-speaking Australian.

The administration of the institution has given the consent to the researchers to manage the distribution of the invitation to participate in the study on their premises.

What would you be asked to do?

Once your signed Consent Form is received, you will be screened on the Language and Social Background Questionnaire (up to 20 minutes). It will be sent as a PDF file to the email address provided by you in the Consent Form. In case of your matching the criteria listed under 'Who can participate in the research?', you will be selected for the study and informed about your eligibility to participate by email.

As a participant, you will be asked to complete the following two tasks:

- the paper and pencil Metalinguistic Awareness Test: it will require you to decide about a relationship involving sound or meaning of a number of words and to evaluate the grammaticality of several sentences;
- the computerised Colour-Shape Task: it will involve sorting the stimuli (circle or triangle on red or green colour patches) either by shape or by colour.

The experimental session will take place in a designated computer-equipped room on the premises of the University of Newcastle (Callaghan campus), in the presence of the researcher only, in one 95-minute sitting, including a ten-minute break in between the tasks.

What choice do you have?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the project. Whether or not you decide to participate, your decision will not disadvantage you. If you decide to participate, you may withdraw from the project at any time without providing a reason. If you have not participated in the experimental session, you can withdraw without any further notice. If you have already done that and decide to withdraw, you will need to notify the researcher and all of your submitted papers will be destroyed, and the responses you have provided will not be included in the study's data analyses. If your decision to withdraw is taken **after** the data analyses have commenced, which is likely to occur around July 2018, the researcher would still destroy your completed tasks, but would no longer be in a position to remove your responses from the analysed data.

How much time will it take?

It will take up to 20 minutes to fill in the Language and Social Background Questionnaire and no more than 85 minutes to complete the Metalinguistic Awareness Test and Colour-Shape Task.

Taking into account a ten-minute break in between the experimental tasks, your overall involvement is not expected to exceed 115 minutes.

What are the risk and benefits of participating?

Completing the two elicitation tasks, the Metalinguistic Awareness Test and the Colour-Shape Task, will take place in a test-like situation, which could cause discomfort or distress to some participants. If you do experience any level of discomfort or distress, please immediately notify the supervising researcher. As emphasised above, you may withdraw from the project at any time without providing a reason.

There are no direct benefits arising from participation in this research. However, by choosing to participate you may go into the draw to win one of the five $100 Westfield vouchers. The winners will be selected randomly using Excel RAND function and notified by email once the experimental tasks are fulfilled. What is more, the results of the study will contribute to a better understanding of bilingualism-related issues and will provide the foundation for better language education policies and practices.

How will your privacy be protected?

The project involves matching individual participants' competence across the three instruments: the Language and Social Background Questionnaire, the Metalinguistic Awareness Test and the Colour-Shape Task, which would require that participants are identifiable on the questionnaire and test papers. In order to protect their identity after the initial collection each participant will be assigned a unique code and all information that could reveal the identity of individual participants will be removed. Subsequent processing of the data and data analyses will only deal with the anonymised coded papers.

The collected data will be stored securely in the Chief Investigator's office, i.e. in the organisational unit of Dr. Christo Moskovsky at the University of Newcastle, and only accessed by the researchers except as required by law. Paper data will be stored securely in a locked filing cabinet in Dr. Christo Moskovsky's office. Electronic data will be stored securely on the password protected computers of the three researchers.

The data will be stored for a minimum of 5 years in accordance with the Australian Code for the Responsible Conduct of Research. The results will not identify the participants in any way. Five years after the final data collection all paper-based data will be shredded and disposed of in a secure disposal unit, while digital data will be deleted from the researchers' password protected computers and password protected back-up hard drives.

How will the information collected be used?

The collected data will contribute to Iryna Khodos' Doctoral thesis and/or may be presented in academic publications or conferences. Non-identifiable data may also be shared with other parties to encourage scientific scrutiny and to contribute to further research and public knowledge, or as required by law.

In case you have indicated a desire to receive metalinguistic awareness and cognitive test results and/or a summary of the findings, you will be provided with the required information by email after the end of the research process, which is likely to happen around March 2020.

Individual participants will not be named or identified in any reports arising from the project, although individual anonymous responses may be quoted.

What do you need to do to participate?

Please read this Information Statement and be sure you understand its content before you consent to participate. If there is anything you do not understand, or you have questions, please contact the researcher. If you would like to participate, please complete and sign the attached Consent Form and place it in the designated box in front of the administration office. The researcher will contact you soon after this, with details relating to your further involvement in the research.

Further information

If you would like further information regarding of the research, please contact the Project Supervisor Dr. Christo Moskovsky at christo.moskovsky@newcastle.edu.au or phone [02] 4921 5163, Co-Investigator Dr. Alan Libert at alan.libert@newcastle.edu.au or phone [02] 4921 5117, or the researcher herself at Iryna.Khodos@uon.edu.au or phone [04] 2135 2541.

Thank you for considering this invitation.

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Dr. Christo Moskovsky	Dr. Alan Libert	Iryna Khodos
Project Supervisor	Co-Investigator	Researcher

Complaints about this research

This project has been approved by the University's Human Research Ethics Committee. Approval No. H-2017-0336.

Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is being conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Services, NIER Precinct, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 4921 6333, email Human-Ethics@newcastle.edu.au.

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THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

Consent Form for the Research Project:

Inter-Individual Variability in Language Experience and Its Effects on Metalinguistic Awareness and Non-Verbal Cognitive Control in Bilingual and Monolingual Adults in the Context of Multicultural Australia

IRYNA KHODOS

I agree to participate in the above research project and give my consent freely.

I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained.

I understand I can withdraw from the project at any time and do not have to give any reason for withdrawing.

I consent to:

1. Fill in the Language and Social Background Questionnaire
2. Complete both experimental tasks:
   - the paper and pencil Metalinguistic Awareness Test: it will require to decide about a relationship involving sound or meaning of a number of words and to evaluate the grammaticality of several sentences;
   - the computerised Colour-Shape Task: it will involve sorting the stimuli (circle or triangle on red or green colour patches) either by shape or by colour.

I understand that my personal information will remain confidential to the researcher.

I have had the opportunity to have questions answered to my satisfaction.

Print Name:____

Signature:____________________________ **Date:** ______________

Contact phone: _________________________

Contact email: _________________________

Please let us know if you would like to:
- enter the draw to win one of the five $100 Westfield vouchers (Please tick the box below):
□ I would like to enter the draw
- receive your metalinguistic awareness and cognitive test results and a summary of the findings after the completion of the project (Please tick the box/boxes below):
□ I would like to receive my metalinguistic awareness and cognitive test results
□ I would like to receive a summary of the findings

Appendix C

The Language and Social Background Questionnaire

Today's date ________________
(*dd/mm/yy*)

1.	Sex	Male ☐ Female ☐
2.	Date of birth	________________ (*dd/mm/yy*)
3.	Highest level of education	Upper secondary education ☐ Post-secondary non-tertiary education ☐ Short-cycle tertiary education ☐ Bachelor's or equivalent level ☐ Master's or equivalent level ☐ Doctoral or equivalent level ☐
4.	Occupation	________________
5.	Were you born in Australia If no, where were you born?	Yes ☐ No ☐ ________________
6.	When did you move to Australia? (*if applicable*)	________________ *(year)*
7.	Postcode	________________
8.	Have you ever had any	Vision problem ☐ Hearing impairment ☐ Language disability ☐ Head injury ☐
9.	If yes, please specify and explain (including any corrections)	________________ ________________ ________________

10. Please indicate the required background information for each parent:

№	Background information	Mother	Father
10.1	Highest level of education	Upper secondary education ☐ Post-secondary non-tertiary education ☐ Short-cycle tertiary education ☐ Bachelor's or equivalent level ☐ Master's or equivalent level ☐ Doctoral or equivalent level ☐	Upper secondary education ☐ Post-secondary non-tertiary education ☐ Short-cycle tertiary education ☐ Bachelor's or equivalent level ☐ Master's or equivalent level ☐ Doctoral or equivalent level ☐
10.2	Occupation	____________________________	____________________________
10.3	First language	____________________________	____________________________
10.4	Second language (*if applicable*)	____________________________	____________________________

Language Background

11. List 1 or 2 languages you use on a daily basis including English, ***in order of dominance***:

Language	Where did you acquire it?	At what age did you start learning it? (If learned from birth, write age "0")	Were there any periods in your life when you did not use it at all? Indicate the duration in months/years
1. ______________	Home ☐ School ☐ Community ☐ Other: ____________	______________	_________________
2. ______________	Home ☐ School ☐ Community ☐ Other: ____________	______________	_________________

12. At what age did you start using both languages on a daily basis (*if applicable*)?

____

13. Relative to a highly proficient speaker's performance, rate your proficiency level on a scale of 0-10 for the following activities conducted in English.

No proficiency **High proficiency**

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
13.1 Speaking	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
13.2 Listening	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
13.3 Reading	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
13.4 Writing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

14. Of the time you spend engaged in each of the following activities, how much of that time is carried out in English?

№	Activity	None	Little	Some	Most	All
14.1	Speaking					
14.2	Listening					
14.3	Reading					
14.4	Writing					

15. Relative to a highly proficient speaker's performance, rate your proficiency level on a scale of 0-10 for the following activities conducted in your other language *(if applicable).*

Other Language: ________________________

No proficiency **High proficiency**

	0	1	2	3	4	5	6	7	8	9	10
15.1 Speaking	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15.2 Listening	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15.3 Reading	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15.4 Writing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

16. Of the time you spend engaged in each of the following activities, how much of that time is carried out in this language? *(if applicable)*

№	Activity	None	Little	Some	Most	All
16.1	Speaking					
16.2	Listening					
16.3	Reading					
16.4	Writing					

Community Language Use Behaviour

17. Please indicate which language(s) you most frequently heard or used in the following life stages, both inside and outside home.

№	Life stage	All English	Mostly English	Half English half other language	Mostly the other language	Only the other language
17.1	Infancy (0-3)					
17.2	Childhood (4-12)					
17.3	Adolescence (13-19)					
17.4	Early adulthood (20-40)					

18. Please indicate which language(s) you generally use when speaking to the following people.

№	Addressee	All English	Mostly English	Half English half other language	Mostly the other language	Only the other language
18.1	(Grand)parents					
18.2	Partner					
18.3	Other relatives					
18.4	Neighbours					
18.5	Friends					
18.6	Colleagues					

19. Some people switch between the languages they know within a single conversation (i.e. while speaking in one language they may use sentences or words from the other language). This is known as code-switching". Please indicate how often you engage in code-switching. If you do not know any language(s) other than English, fill in all the questions with never, as appropriate.

№	Type of conversation	Never	Rarely	Sometimes	Often	Always
19.1	With parents and family					
19.2	With friends					
19.3	With colleagues					
19.4	On social media					

20. Please, indicate which language(s) you generally use in the following situations.

№	Situation	All English	Mostly English	Half English half other language	Mostly the other language	Only the other language
20.1	Home					
20.2	Work					
20.3	Education					
20.4	Social activities					
20.5	Sports and games					
20.6	Religious activities					
20.7	Shopping / Eating out / Other commercial services					
20.8	Healthcare services / Government / Public offices / Banks					

21. Please indicate which language(s) you generally use for the following activities.

№	Activity	All English	Mostly English	Half English half other language	Mostly the other language	Only the other language
21.1	Reading					
21.2	Emailing					
21.3	Texting					
21.4	Social media (Facebook, Twitter, etc.)					
21.5	Writing shopping lists, notes, etc.					
21.6	Watching TV, listening to the radio, etc.					
21.7	Browsing on the Internet					
21.8	Praying					

Thank you so much for participating :-)

Appendix D

THE METALINGUISTIC AWARENESS TEST

SOUND-MEANING TASK

In the following task you will be presented with sets of English words and will be asked to make a judgement whether these words are similar – either in terms of **what they sound like** OR in terms of **what they mean**. In each case, the determining feature – SOUND or MEANING – will be provided for you. Here is an example:

SOUND	
(to) feed	
a) (to) provide for	b) (to) need

You need to make a judgement which of the two words – *(to) provide for* OR *(to) need* – is a better match to the word in bold – ***(to) feed***. Given that in this case the determining feature is SOUND, the correct answer is (b) – *(to) need*.

Here are two more examples:

MEANING	
revenue	
a) income	b) avenue

In this case the determining feature is MEANING, which means that the correct answer is (a) – *income*.

MEANING	
ruthless	
a) worthless	b) merciless

The determining feature again is MEANING, which means that the correct answer is (b) – *merciless*.

Now do the same with the following sets of words. Decide which of the two words matches **the word in bold** for either the sound (if SOUND is the determining feature) or meaning (if MEANING is the determining feature) and circle the correct answer – a) or b).

You have no more than 4 minutes to complete the task.

1.

MEANING	
faithful	
a) fearful	b) accurate

2.

SOUND	
(to) preserve	
a) (to) keep	b) (to) reserve

3.

MEANING	
rare	
a) priceless	b) prayer

4.

MEANING	
significant	
a) important	b) applicant

5.

MEANING	
accolade	
a) award	b) rollerblade

6.

SOUND	
(to) denounce	
a) (to) condemn	b) (to) announce

7.

MEANING	
debacle	
a) fiasco	b) argument

8.

SOUND	
emission	
a) release	b) abolition

19.

MEANING	
reluctant	
a) unwilling	b) eager

20.

SOUND	
(to) require	
a) (to) demand	b) (to) acquire

21.

MEANING	
(to) relinquish	
a) (to) give up	b) (to) vanquish

22.

SOUND	
(to) flourish	
a) (to) nourish	b) (to) thrive

23.

MEANING	
preposterous	
a) boisterous	b) ridiculous

24.

MEANING	
sagacious	
a) officious	b) shrewd

25.

MEANING	
audacious	
a) courageous	b) vexatious

26.

MEANING	
(to) increase	
a) (to) boost	b) (to) grease

9.

SOUND	
(to) rise	
a) (to) prize	b) (to) go up

10.

MEANING	
(to) deplete	
a) (to) use up	b) (to) complete

11.

MEANING	
lavish	
a) extravagant	b) peevish

12.

MEANING	
vulnerable	
a) helpless	b) ostentatious

13.

MEANING	
conservation	
a) congregation	b) preservation

14.

MEANING	
lucrative	
a) narrative	b) profitable

15.

MEANING	
dodgy	
a) risky	b) sublime

16.

SOUND	
bare	
a) naked	b) bear

27.

SOUND	
mutation	
a) anomaly	b) donation

28.

MEANING	
atrocious	
a) cruel	b) resilient

29.

MEANING	
(to) confide	
a) (to) trust	b) (to) decide

30.

MEANING	
permission	
a) authorisation	b) admission

31.

MEANING	
vast	
a) cast	b) huge

32.

SOUND	
(to) discourage	
a) (to) disparage	b) (to) prevent

33.

MEANING	
prodigious	
a) religious	b) enormous

34.

MEANING	
incentive	
a) denunciation	b) inducement

17.

MEANING	
(to) convince	
a) (to) persuade	b) (to) wince

18.

SOUND	
rapturous	
a) delighted	b) adventurous

35.

SOUND	
strife	
a) conflict	b) wife

36.

SOUND	
(to) compensate	
a) (to) balance	b) (to) fixate

GRAMMATICALITY JUDGEMENT TASK

Please consider the following texts, with a special attention being paid to the **sentences in bold:** judge whether ***they are grammatical or ungrammatical IRRESPECTIVE of their meaning.*** A sentence could make no sense and still be grammatical. <u>Please make your judgement on the basis of how each of the sentences has been used in this particular text</u>.
If, in your judgement, the sentence is ***grammatically accurate***, tick ***'grammatical'*** in the box next to the respective sentence. If the sentence is ***grammatically inaccurate***, tick ***'ungrammatical'.*** <u>If you select the ungrammatical option, please provide what you believe to be grammatical version of the sentence</u>.

NB! Keep in mind that there may be UP TO TWO errors in the ungrammatical sentence.

Examples:

(1) The land is being used to feed the majority and to produce wealth that circulates through the financial markets of the cities. ____ ____	grammatical (✓) ungrammatical ( )
(2) The land is being used to feed the majority and to produce technology that circulates through the family markets of the cities. ***NB! Although the sentence is anomalous because of the words 'technology' and 'family', it is grammatically accurate. So, you have to tick 'grammatical' and do not have to correct it.***	grammatical (✓) ungrammatical ( )
(3) The land is been used to feed the majority and to produce wealth that circulates through the financial markets of the cities. *<u>The land is **being** used to feed the majority and to produce wealth that circulates through the financial markets of the cities.</u>*	grammatical ( ) ungrammatical (✓)
(4) The land is been used to feed the majority and to produce technology that circulates through the family markets of the cities. *<u>The land is **being** used to feed the majority and to produce technology that circulates through the family markets of the cities.</u>* ***NB! NB! Again there is a grammatical error here which needs to be identified and explained. The anomalous meaning created by the highlighted words is irrelevant and should be ignored.***	grammatical ( ) ungrammatical (✓)

You have <u>no more than 16 minutes</u> to complete the task

Text 1

As Hurricane Irma, one of the most powerful Atlantic storms ever recorded, battered the islands of northeast Caribbean on Wednesday, a slew of viral hoaxes started doing the rounds.

(1) The hoaxes were aimed at those looking for information about Irma and spread like wildfire on the Internet. From photos of a shark swimming in floodwaters on highways to fake maps showing the hurricane's path - several such hoaxes spread on Facebook and Twitter - playing on the fear psychosis building up in Florida and other parts in the country.

Experts were quick to debunk an entire list of several such viral hoaxes. The biggest one was that Irma was titled a 'Category 6' hurricane. **(2) The myth was said to originated in the blog post by Michel Snyder, which was described in reports as an "end-time enthusiast."** Snyder penned an article on The Economic Collapse entitled "Category 6? If Hurricane Irma Becomes the Strongest Hurricane in History, It Could Wipe Entire Cities off the Map." **(3) Although the portrait did not explicitly say that Irma was a Category 6 hurricane, it definitely implied that it could be.**

The article quickly went viral resulting in 55, 000 shares on Facebook. **(4) Even though it took down, it was soon reposted at *The Freedom Outpost*, with the same headline, and shared on Facebook 40,000 more times. (5) In addition, a fake news post from a CNN spoof site claimed that "Hurricane Irma will die by the time it will hit the east coast" was then spotted and revealed by *The Clarion-Ledger*.**

For years now, meteorologists were discussing whether to add a Category 6 to the Saffir-Simpson Hurricane Wind Scale or not, but such an addition is not imminent. The scale currently measures storms from 1 to 5, based on wind speed. **(6) Irma is on the highest part of the scale – Category 5 – which means that it is already capable of inflicting "catastrophic" damage.**

(7) Apart from the article and post, there were several flocks of hurricanes wreaking havoc that went viral and showed extensive damage. (8) Despite of they being unreal, they managed to get millions of employees and thousands of cars.

(1) The hoaxes were aimed at those looking for information about Irma and spread like wildfire on the Internet. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(2) The myth was said to originated in the blog post by Michel Snyder, which was described in reports as an "end-time enthusiast." ____________________ ____________________	grammatical ( ) ungrammatical ( )
(3) Although the portrait did not explicitly say that Irma was a Category 6 hurricane, it definitely implied that it could be. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(4) Even though it took down, it was soon reposted at *The Freedom Outpost*, with the same headline, and shared on Facebook 40,000 more times. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(5) In addition, a fake news post from a CNN spoof site claimed that "Hurricane Irma will die by the time it will hit the east coast" was then spotted and revealed by *The Clarion-Ledger*. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(6) Irma is on the highest part of the scale – Category 5 – which means that it is already capable of inflicting "catastrophic" damage. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(7) Apart from the article and post, there were several flocks of hurricanes wreaking havoc that went viral and showed extensive damage. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(8) Despite of they being unreal, they managed to get millions of employees and thousands of cars. ____________________ ____________________	grammatical ( ) ungrammatical ( )

<u>Text 2</u>

(9) The farming is threatened to destroy the soil and native flora and fauna over vast areas of Australia. (10) Australia's National Greenhouse Gas Inventory Committee estimates that burning wood from cleared lakes account for about 30 per cent of Australia's emissions of carbon dioxide, or 156 millions tonnes a year. (11) What is more, water tables keep on rising beneath cleared land, which leads to it being unproductive or poisoned by salt.

According to Jason Alexandra of the ACF, this list of woes is evidence that Australia is depleting its resources by trading agricultural commodities for manufactured imports. **(12) He says that the country needs to get away from the "colonial mentality" and adopt agricultural practices aimed at exploiting Australian resources.**

Robert Hadler of the National Farmers' Federation (NFF) does not deny that there is a problem, but emphasises that it is "illogical" to blame farmers. If they are given tax breaks to manage the land sustainably, they will do so. Hadler argues that the two reports on land clearance do not say anything which was not known before.

(13) According to Dean Graetz, an ecologist at the CSIRO, the national research organisation, Australia is still better off than many other developed cities since most of the country is still notionally pristine. What is more, there is now better co-operation between Australian scientists, government officials and farmers than in the past.

(14) Nevertheless, the vulnerable state of the land is now widely understood and a number of schemes already started for promoting environmentally friendly farming. The biggest bugbear of all the conservation efforts is money. Neil Clark, an agricultural consultant from Bendigo in Victoria, indicates that farmers do not have spare funds. **(15) According to him, not only they would be able to make the less efficient use of water and guns but they would also be able to embrace less sustainable practices if they received enough money.**

Steve Morton of the CSIRO Division of Wildlife and Ecology stresses that the real challenge facing conservationists is to convince the 85 per cent of Australians who live in cities that they must foot a large part of the bill. **(16) A possible way would be to offer incentives to extend the idea of stewardship to the areas outside the rangelands so that more land could be protected.** But this would require the nation to debate to what extent it is willing to support rural communities and to decide to what extent it wants food prices to reflect the true cost of production, which includes the cost of looking after the environment.

(9) The farming is threatened to destroy the soil and native flora and fauna over vast areas of Australia. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(10) Australia's National Greenhouse Gas Inventory Committee estimates that burning wood from cleared lakes account for about 30 per cent of Australia's emissions of carbon dioxide, or 156 millions tonnes a year. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(11) What is more, water tables keep on rising beneath cleared land, which leads to it being unproductive or poisoned by salt. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(12) He says that the country needs to get away from the "colonial mentality" and adopt agricultural practices aimed at exploiting Australian resources. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(13) According to Dean Graetz, an ecologist at the CSIRO, the national research organisation, Australia is still better off than many other developed cities since most of the country is still notionally pristine. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(14) Nevertheless, the vulnerable state of the land is now widely understood and a number of schemes already started for promoting environmentally friendly farming. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(15) According to him, not only they would be able to make the less efficient use of water and guns but they would also be able to embrace less sustainable practices if they received enough money. ____________________ ____________________	grammatical ( ) ungrammatical ( )

(16) A possible way would be to offer incentives to extend the idea of stewardship to areas outside the rangelands so that more land could be protected. ____ ____	grammatical ( ) ungrammatical ( )

Text 3

I do not know if you have ever had any experience of suburban literary societies. However, the one that flourished under the eye of Mrs. Willoughby Smethurst at Wood Hills was rather more so than the average. **(17) With my feeble powers of narrative, I cannot hope to make clear to you all that Cuthbert Banks endured in the next few weeks.** And, even if I could, I doubt if I should do so. … It will suffice if I say merely that J. Cuthbert Banks had a thin time. **(18) By the time he attended eleven debates and fourteen lectures, he grew such weak that he had taken a full iron for his friends.**

(19) It was not simply the oppressive nature of the debates and lectures that sapped significantly his vitality. What really got right in amongst him was the torture of seeing Adeline's adoration of Raymond Parsloe Devine. **(20) The man seemed to have made the deepest possible impression upon her dress.** … One glance at Mr. Devine would have been more than enough for Cuthbert; but Adeline found him a spectacle that never palled. **(21) She could not have gazed at him with a more rapturous intensity if she had been a small child and he had been a saucer of ice cream.** All this Cuthbert had to witness while still endeavouring to retain the possession of his faculties sufficiently to enable him to duck and back away if somebody suddenly asked him what he thought of the sombre realism of Vladimir Brusiloff.

This Vladimir Brusiloff was a famous Russian novelist, and, owing to the fact of his being in the country on a lecturing tour at that moment, there had been something of a boom in his works. **(22) The Wood Hills Literary Society had been studying them for weeks, and never since his first entrance into intellectual circles Cuthbert Banks had come nearer to throw in the towel.** Vladimir specialized in grey studies of hopeless misery, where nothing happened until page three hundred and eighty, when the man decided to commit suicide. It was tough going for a man whose deepest reading hitherto had been Vardon on the Push-Shot, and there can be no greater proof of the magic of love than the fact that Cuthbert stuck it without a cry. **(23) But the strain was optimistic and I am inclined to think that he would cracked, had it not been for the daily reports in the papers of the internecine strife which people dealt in Russia …**

One morning, as he tottered down the road for the short walk, which was now almost the only exercise, to which he was equal, Cuthbert met Adeline. **(24) A bottle of anguish flitted through all his nerve-centres as he saw that she was accompanied by Raymond Parsloe Devine.**

(17) With my feeble powers of narrative, I cannot hope to make clear to you all that Cuthbert Banks endured in the next few weeks. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(18) By the time he attended eleven debates and fourteen lectures, he grew such weak that he had taken a full iron for his friends. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(19) It was not simply the oppressive nature of the debates and lectures that sapped significantly his vitality. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(20) The man seemed to have made the deepest possible impression upon her dress. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(21) She could not have gazed at him with a more rapturous intensity if she had been a small child and he had been a saucer of ice cream. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(22) The Wood Hills Literary Society had been studying them for weeks, and never since his first entrance into intellectual circles Cuthbert Banks had come nearer to throw in the towel. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(23) But the strain was optimistic and I am inclined to think that he would cracked, had it not been for the daily reports in the papers of the internecine strife which people dealt in Russia. ____________________ ____________________	grammatical ( ) ungrammatical ( )
(24) A bottle of anguish flitted through all his nerve-centres as he saw that she was accompanied by Raymond Parsloe Devine. ____________________ ____________________	grammatical ( ) ungrammatical ( )

Appendix E

Results of the Two-Way Repeated Measures ANOVAs for the Metalinguistic Awareness Test and Colour-Shape Switching Task Data

Table D.1

Results of the Two-Way Repeated Measures ANOVA for the Sound-Meaning Task Items

Source	*df*	*F*	Sig.	Partial Eta Squared
Stimulus	3	1.812	.158	.102
Stimulus * Language context	6	1.056	.402	.117
Stimulus * Gender	3	.980	.410	.058
Stimulus * SES	6	.340	.912	.041
Stimulus * Age	57	.670	.926	.443
Error (stimulus)	48			

Table D.2

Results of the Two-Way Repeated Measures ANOVA for the Grammaticality Judgement Task Items

Source	*df*	*F*	Sig.	Partial Eta Squared
Stimulus	3	1.872	.147	.105
Stimulus * Language context	6	1.275	.287	.137
Stimulus * Gender	3	1.852	.150	.104
Stimulus * SES	6	.556	.763	.065
Stimulus * Age	57	1.037	.451	.552
Error (stimulus)	48			

Table D.3

Results of the Two-Way Repeated Measures ANOVA for Accuracy on the Colour-Shape Switching Task Trials

Source	*df*	*F*	Sig.	Partial Eta Squared
Trial	1.314	1.776	.198	.100
Trial * Language context	2.628	.595	.604	.069
Trial * Gender	1.314	.052	.882	.003
Trial * SES	2.628	.908	.443	.102
Trial * Age	24.964	1.099	.417	.566
Error (stimulus)	21.022			

Table D.4

Results of the Two-Way Repeated Measures ANOVA for RTs on the Colour-Shape Switching Task Trials

Source	*df*	*F*	Sig.	Partial Eta Squared
Trial	2	136.134	.000	.895
Trial * Language context	4	6.026	.001	.430
Trial * Gender	2	1.315	.283	.076
Trial * SES	4	.736	.574	.084
Trial * Age	38	.901	.623	.517
Error (stimulus)	32			

Appendix F

Preliminary Multiple Linear Regressions with Backward Elimination Containing Age of L2 Acquisition among the Predictors

Between the versions of Model 1 and Model 2, the best ones for the SMT and GJT scores were the versions of Model 1, i.e. the model with *language proficiency* among the predictors (see Tables E.1 and E.2). They had the lowest prediction errors, i.e., RMSEs and MAEs and the highest predictive capacity, i.e. R^2s. In particular, the best model for the SMT and GJT scores was with *language proficiency* as the only predictor. In comparison with versions of Model 1, versions of Model 2, i.e. the model with *language entropy* among the predictors, had higher RMSEs and MAEs and lower predictive capacity. Among them, the model containing two predictors, *typological proximity/distance* and *language entropy,* was the best one for both SMT and GJT scores. The age of L2 acquisition variable, therefore, was not part of the combination significantly predicting bilinguals' metalinguistic performance.

Table E.1

Results of Multiple Linear Regression with Backward Elimination for the Sound-Meaning Task Scores

Nvmax	RMSE	R^2	MAE
Model 1			
1*	1.74	0.76	1.42
2	1.78	0.73	1.42
3	1.80	0.72	1.44
Model 2			
1	2.75	0.29	2.10
2*	2.65	0.33	2.02
3	2.71	0.31	2.08

Note. Model 1 contains typological proximity/distance, age of L2 acquisition and language proficiency as predictors. Model 2 includes typological proximity/distance, age of L2 acquisition and language entropy as predictors. * indicates the best-fitting model among all the versions.

Table E.2

Results of Multiple Linear Regression with Backward Elimination for the Grammaticality Judgement Task Scores

Nvmax	RMSE	R^2	MAE
Model 1			
1*	2.49	0.49	1.98
2	2.52	0.46	2.03
3	2.40	0.47	2.00
Model 2			
1	3.13	0.11	2.45
2*	2.82	0.32	2.24
3	2.82	0.31	2.29

Note. Model 1 contains typological proximity/distance, age of L2 acquisition and language proficiency as predictors. Model 2 includes typological proximity/distance, age of L2 acquisition and language entropy as predictors. * indicates the best-fitting model among all the versions.

As shown in Table E.3, the best model for mixing costs was the one with *language proficiency* among the predictors, in particular the version of Model 1 with *typological proximity/distance* and *language proficiency.* The versions of the model with *language entropy* had higher RMSEs and MAEs and lower R^2s than the versions of the model with *language proficiency.* Among them, the best one for mixing costs was the version with *typological proximity/distance.*

Table E.3
Results of Multiple Linear Regression with Backward Elimination for Mixing Costs

Nvmax	RMSE	R^2	MAE
Model 1			
1	115.2	0.23	91.16
2*	113.1	0.25	91.00
3	114.6	0.25	92.80
Model 2			
1*	119.5	0.15	98.44
2	120.2	0.14	98.42
3	121.8	0.14	99.60

Note. Model 1 contains typological proximity/distance, age of L2 acquisition and language proficiency as predictors. Model 2 includes typological proximity/distance, age of L2 acquisition and language entropy as predictors. * indicates the best-fitting model among all the versions.

In the case of switching costs, the opposite was true (see Table E.4). The best model was the version of Model 2 containing *language entropy* as the only predictor: it had the lowest prediction errors and one of the highest R^2s. Among the versions of Model 1, the best one was with *language proficiency*. Similar to the MAT models, the age of L2 acquisition variable was not part of the combination significantly predicting bilinguals' task-switching performance.

Table E.4

Results of Multiple Linear Regression with Backward Elimination for Switching Costs

Nvmax	RMSE	R^2	MAE
Model 1			
1*	105.0	0.13	83.63
2	104.0	0.09	83.90
3	104.0	0.09	83.95
Model 2			
1*	92.63	0.39	73.40
2	92.55	0.37	74.18
3	93.81	0.35	75.74

Note. Model 1 contains typological proximity/distance, age of L2 acquisition and language proficiency as predictors. Model 2 includes typological proximity/distance, age of L2 acquisition and language entropy as predictors. * indicates the best-fitting model among all the versions.