Do bilingual and monolingual children differ?

Measuring and comparing attentional control skills in the verbal and non-verbal domains

Gloria Maria Pino Escobar

Bachelor of Arts (Interpreting-Translation) Western Sydney University

A thesis Submitted for the Degree of

Master of Philosophy

The MARCS Institute for Brain, Behaviour and Development
ARC Centre of Excellence for the Dynamics of Language
Western Sydney University

July, 2017
Principal Supervisor: A/Prof. Paola Escudero

Associate Supervisors: Dr. Marina Kalashnikova

A/Prof. Caroline Jones
The aim of the current master’s thesis was to investigate 1) whether bilingual and monolingual children display differences in behavioural measures of attentional control in the verbal and non-verbal domains and 2) whether attentional control performance in children correlates across domains. The present study therefore explored the impact of being bilingual from birth on the cognitive skills (specifically attentional control) and lexical retrieval proficiency of early-school-aged children in Greater Sydney, Australia. Participants included monolingual (N=17) and bilingual (N=17) Australian born children who were matched in age, sex and parental education. Bilingual participants were exposed to two languages from birth and were highly proficient in both their languages.

Chapter 1 introduces the thesis, including the literature review and general design of the study. Chapter 2 presents the study of the verbal domain in terms of children’s lexical performance. In this Chapter, performance in the letter and category verbal fluency task (VFT) (partially in Pino Escobar et al., 2016) are analysed and compared between language groups. Chapter 3 investigates the cognitive non-verbal domain under the Dimensional Card Change Sort (DCCS) and the Day-Night Stroop task (Day-Night). Afterwards, Chapter 4 investigates the relations between verbal and non-verbal tasks of attentional control in bilingual and monolingual children. Finally, Chapter 5 concludes the thesis with a General discussion.

Results indicated better bilingual performance on the letter and category VFT but comparable performance between monolingual and bilingual groups on the DCCS and the Day-Night task. It was also found that performance in the letter VFT correlated with the DCCS while no relation between category VFT and the Day-Night task was found.
Regression analyses, however, showed that while DCCS performance predicted only letter VFT; vocabulary proficiency (as measured by the Peabody Picture Vocabulary Test (PPVT)) predicted performance of both letter and category VFT. Results were explained in light of the characteristics of the participant samples. Firstly, bilingual and monolingual groups were strictly matched in age and gender, both groups exhibited similar parental education backgrounds and similar English receptive vocabulary proficiency. And secondly and more importantly, bilingual participants were highly proficient and productive in an additional language. It was therefore proposed that this last characteristic conferred bilinguals with additional attentional control to efficiently sort and retrieve words under different conditions. These results suggest that during complex lexical retrieval (i.e., letter VFT) seven to eight-year-old bilingual and monolingual children can recruit high order attentional control.

In sum, our findings show that both vocabulary proficiency and general attentional control skills account for monolingual and bilingual children’s performance on complex verbal fluency tasks. Additionally, controlling for vocabulary proficiency has a determining factor when comparing monolingual and bilingual performance: high vocabulary proficiency in both languages likely underlies the unprecedented bilingual advantage shown in the present study.
Acknowledgments

I would like to express my gratitude to my supervisory panel, Associate Professor Paola Escudero, Dr. Marina Kalashnikova and Associate Professor Caroline Jones for their guidance, support and advice throughout my candidature. I would like to give special thanks to my Principal Supervisor, Associate Professor Paola Escudero for being a great mentor and friend and for stimulating me academically throughout my studies. Thank you so much Paola, your love for research and dedication have been a source of example and admiration that kept me going throughout my candidature. I am also particularly grateful to Dr. Marina Kalashnikova for providing excellent guidance whenever I needed it, for all the training she has given me and her understanding and support. Marina, you are a truly gifted researcher and I have been so lucky to have you as my supervisor.

I would like to thank The MARCS Institute for Brain, Behaviour & Development for funding and covering every necessity during my research. I would like to acknowledge the ARC Centre of Excellence for the Dynamics of Language for awarding me financial support. I would like to give all my gratitude to every member of MARCS for showing me their friendship and support. Particularly, I would like to give a special thanks to Nicole Traynor and Aimee Oliveri for their technical assistance but most importantly for their highly appreciated friendship throughout my candidature. I am mostly grateful to each of the participants in this research and their parents for their time, effort and willingness to take part in this study; I definitely could not have done this study without their support.

Finally, I would like to dedicate this thesis to my family. I thank my children Gloria Andrea and Adrian for being the most significant engine behind my actions and decisions and to my husband Alejandro for being so supportive and understanding throughout my studies. I would like to acknowledge my parents’ love and guidance for inspiring me to dream, to trust
in myself and to undertake every challenge in my life with faith, optimism and hard work. I am also grateful to my mother in law Carmen and my sisters Sandra, Diana and Karla for believing in me and giving me their support.
Statement of Authentication

The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

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(Signature)
Author Contributions

Chapters 1 (Introduction), 2, 3 and 4: Parts of these chapters have been included in the following journal article which is currently under review:


GP posed the research question with valuable input from PE and MK. The experimental tasks were selected and adapted by GP with advice from PE and MK. The scripts to run the experiment were designed by GP with guidance from MK. GP recruited participants and run the experiment with the help of research assistants. Data analyses were conducted by GP with valuable input from MK. GP wrote the first version of the text and GP, MK and PE rewrote the text into its final version.

Chapter 2: Parts of this Chapter appeared in the following published Conference Proceedings:


GP posed the research question with valuable input from PE and MK. The experimental task was selected and adapted by GP with advice from PE and MK. The scripts to run the experiment were designed by GP with guidance from MK. GP recruited participants and run the experiment with the help of research assistants. Data analyses were conducted by
GP with valuable input from MK. GP wrote the first version of the text and GP, MK and PE rewrote the text into its final version.
Table of Contents

Table of Contents .................................................................................................................. i
List of Tables ............................................................................................................................. iv
List of Figures ........................................................................................................................... v

Chapter 1: Introduction ............................................................................................................. 1

1.1. General Introduction ........................................................................................................ 1
1.2. Executive function and attentional control ................................................................. 3
1.3. Attentional control and bilingualism ............................................................................. 6
1.4. Attentional control in children: results from non-verbal versus verbal tasks ............... 7
1.4.1. Non-verbal tasks ......................................................................................................... 8
1.4.2. Verbal tasks ............................................................................................................. 12
1.5. Contrasting positions regarding bilingual and monolingual children: The bilingual advantage controversy ................................................................. 18
1.6. Bilingual population in the present study and recruitment criteria ......................... 20
1.7. Research aims and questions ....................................................................................... 23
1.8. Chapter Summary and thesis outline .......................................................................... 25

Chapter 2: Bilingual children display attentional advantage in the verbal domain: Evidence from the Verbal Fluency Task ......................................................... 27

2.1. Introduction .................................................................................................................... 27
2.2. Method ........................................................................................................................... 33
2.2.1. Participants ............................................................................................................. 33
2.2.2. Tasks and procedure ............................................................................................... 37
2.3. Results .......................................................................................................................... 39
Chapter 3: Bilingual and monolingual children display similar performance in the non-verbal domain: Evidence from the Dimensional Card Change Sort Task and the Day-Night Stroop Task

3.1. Introduction ........................................................................................................... 45
3.2. Method .................................................................................................................... 50
  3.2.1. Participants ....................................................................................................... 50
  3.2.2. Tasks and procedure ....................................................................................... 50
3.3. Results .................................................................................................................... 54
3.4. Discussion .............................................................................................................. 56
3.5. Chapter Summary ................................................................................................. 58

Chapter 4: Relating performance in verbal and non-verbal tasks of attentional control in bilingual and monolingual children ........................................................................ 59

4.1. Introduction ........................................................................................................... 59
4.2. Analysis and results ............................................................................................. 62
4.3. Summary and discussion ...................................................................................... 64

Chapter 5: General Discussion .................................................................................... 67

5.1. Thesis summary .................................................................................................... 67
5.2. General discussion and future research ................................................................. 69
5.3. Limitations ............................................................................................................ 75
5.4. Implications .......................................................................................................... 75
5.5. Conclusion ............................................................................................................ 76
References........................................................................................................................................78

Appendix A: Child Language Background Questionnaire .................................................................92

Appendix B: Individual raw data of monolingual and bilingual participants’

performance in verbal tasks. ...........................................................................................................100

Appendix C: Individual raw data of monolingual and bilingual participants’

performance in non-verbal tasks. ...................................................................................................101
List of Tables

Table 1.1. Main components of the present masters thesis.........................................................25

Table 4.1. Correlations for monolingual and bilingual children’s scores on the non-verbal and verbal experimental tasks and PPVT scores .................................................................61

Table 4.2. Multiple regression analyses with factor scores for PPVT Standard Scores, DCCS Task, and Day-night Stroop task as the predictor variables and VFT-letter or VFT Category as the dependent variable.................................................................62
List of Figures

Figure 2.1. Monolingual and bilingual children’s scores (number of words retrieved in one minute) in the letter and category verbal fluency tasks (VFT) with PPVT as covariate (error bars represent SEM) ............................................................................................................ 39

Figure 3.1. Stimuli used in the Dimensional Card Change Sort (DCCS) – Advanced version ............................................................................................................................................................................................ 51

Figure 3.2. Stimuli used in the Day-Night Stroop Task (Day-Night) .................................................... 53

Figure 3.3. Monolingual and bilingual children’s scores for non-language processing tasks (DCCS and Day-Night) .......................................................................................................................................................... 54
Chapter 1: Introduction

1.1. General Introduction

The first studies that compared monolingual and bilingual children’s performance on tasks assessing intelligence and general cognitive abilities suggested that bilingualism causes mental confusion, low intelligence (Saer, 1923) and verbal disadvantages (Darcy, 1946; Goodenough, 1926). These observations were later challenged by a pioneer study proposing that bilinguals may in fact display greater mental flexibility and a larger range of mental abilities than monolinguals (Peal & Lambert, 1962). This seminal study conducted by Peal and Lambert’s (1962) contrasted their predecessors in design and results as in this case several variables such as age, socioeconomic status (SES) and degree of bilingualism were carefully controlled (Peal & Lambert, 1962). The study included ten-year-old balanced bilinguals with high proficiency in English and aged-matched monolinguals, recruited under a selection criteria that involved receptive and productive vocabulary tests and questionnaires. Results showed that bilingual children outperformed their monolingual counterparts in both verbal and non-verbal intelligence tests. The authors attributed these advantages to bilinguals’ need to detach words from meanings in order to label concepts in their two languages and to their continuous switching from one language to the other (Peal & Lambert, 1962).

After Peal and Lambert’s study, other studies have used intelligence tests to replicate and further examine the bilingual advantage (Cummins, 1976; Ianco-Worrall, 1972; Lambert & Anisfeld, 1969; Lambert & MacNamara, 1969; Lambert & Tucker, 1973; Tsushima & Hogan, 1975). However, different views pointed out that
higher intelligence as the source of the bilingual advantage may be tenuous (Bialystok, 1999). This is mainly due to the complexity of the intelligence concept, which is a broad construct that comprises many developmental skills such as self-awareness, metalinguistic abilities, comprehension, emotional knowledge, logic and problem solving, among others (Bialystok, 2001). Furthermore, intelligence is often connected to the use of Intelligence Quotient (IQ) tests, which are often not reliable in accounting for other aspects beyond the verbal sphere, or in showing whether or not enhanced intellectual capacities are ultimately related to bilingualism (Bialystok, 2001). In contrast to the extensive notion of intelligence, assessment of specific cognitive skills (i.e., executive function, described in Section 1.2) allows to focus on a smaller number of possible cognitive components impacted by bilingualism; therefore, offering a more direct approach for examining potential differences between bilinguals and monolinguals.

As a result many studies in this field focused on either non-language cognitive tasks (i.e., non-verbal tasks) or linguistic tasks (i.e., verbal tasks), rather than examining both areas in connection. Although recent research has focused on the cognitive bilingual experience in childhood during the primary school years, verbal and nonverbal domains are rarely explored together (Bialystok, Craik, Green, & Gollan, 2009; Bialystok, Craik, & Luk, 2012; Hernandez, Costa, Fuentes, Vivas, & Sebastian-Galles, 2010; Hernández, Martin, Sebastian-Galles, & Costa, 2013 for extensive reviews). The present thesis therefore investigated the impact of the bilingual experience in seven to eight-year-old children’s cognitive development, particularly their attentional control in comparison to that of monolingual age matched
children. More importantly, this study offers an integral view of two domains that are often studied in disconnection; this is the verbal cognitive domain (i.e., the linguistic or language processing domain) and the non-verbal cognitive domain (i.e., non-language processing domain, in which tasks without or with minimum verbal component were included).

1.2. Executive function and attentional control

Executive function (EF) is considered a key component of cognitive development (Carlson & Meltzoff, 2008; Diamond & Lee, 2011; Luo, Luk, & Bialystok, 2010) and is related to controlled attention, thought, and action (Posner & Rothbart, 2000). Specifically, it comprises a collection of control processes (e.g., sub functions) that facilitate a goal-directed behaviour (Hernández et al., 2013; Zelazo, Carter, Reznick, & Frye, 1997). These control processes include strategic planning, disablement of strategy in response to changes, attention, working memory, switching between mental sets, organised search, flexibility of action, suppression of impulsive responses, task monitoring and updating working memory (Costa & Sebastian-Galles, 2014; Hernández et al., 2013; Zelazo et al., 1997). However, inhibition (i.e., attentional control), shifting (i.e., flexibility) and updating (i.e., working memory) are known as the three core EF components (Miyake et al., 2000). It is suggested that these three EF components are overlapping, therefore more than one are used in conjunction when facing cognitive challenging tasks (Miyake & Friedman, 2012).

The development of EF begins early in life, but great advancements are experienced by children around their third year of age (Carlson, 2005; Korkman, Kemp & Kirk, 2001; Postner & Rothbart, 2000; Zelazo et al., 1997). Particularly, it
has been observed that during preschool years (i.e., from 3 to 6 years) children make the most dramatic gains in self-control, behaviours, and emotions (Carlson, 2005; Carlson & Meltzoff, 2008), and that this development is progressive and incremental with age (Best & Miller, 2010). Regarding children’s cognitive milestones, Korkman et al. (2001) observed the effects of age on neuropsychological assessment tasks in five to twelve-year-old children. The tasks assessed performance in five cognitive domains: EF (non-verbal), language (verbal), sensorimotor functions, visuospatial functions and memory and learning. Each domain contained more than one subtest. The subset for “auditory attention and response set” correlated with the verbal subset from the language domain, which indicates a potential relationship between performances in non-verbal and verbal tasks. This study also suggested that age effects in children’s EF development –as measured with a range of specific tasks, including the Verbal Fluency Task- are most sensitive to measurement within the 5-8 year window (Korkman et al., 2001). This is because the authors found more differences in children from 5-8 years of age that between children in the 9 to 12 year-old age group. As well, little variation was observed in the majority of the subtests administered to groups of 10-year-olds. (Korkman et al., 2001)

Typical development in executive functioning in children is related to positive progress in important social and cognitive skills such as social competence, moral conduct, school readiness and effective communication (Carlson & Meltzoff, 2008). In contrast, disruptions to children’s executive functioning are associated with disorders in attention and memory (Ostrosky-Solis et al., 2007), including Autism Spectrum Disorder, Attention Deficit/Hyperactivity Disorder (Carlson & Meltzoff,
Contributions to this area of research will help to understand cognitive processes that play important roles in children’s positive academic achievement, social integration, mental health and in general, wellbeing (Hernández et al., 2013). So far, there is evidence to suggest that executive function is enhanced in bilinguals. However, as mentioned above, it is also known that the executive function construct comprises many control processes with their own sub classifications. One of the challenges at this stage is to determine which process/processes are responsible for any cognitive advantage in bilinguals (Kroll, 2015; Kroll & Bialystok, 2013) and the way they relate to language processes.

Previous studies suggest that bilinguals’ executive function is enhanced by additional demands on their attentional control (also found in literature as cognitive control or inhibitory control) (Bialystok, 2015), which is the cognitive or inhibitory capacity that allows us to focus on relevant information in the presence of disruptive additional information (Bialystok, 1999; Bialystok et al., 2009). Studies have shown that strenuous demands are placed on attentional control (AC) during bilingual language acquisition (Bialystok, 2015; Kovács & Mehler, 2009). AC starts developing early in life and it is used to successfully sort a range of everyday challenges (Best & Miller, 2010; Diamond, 2002; Diamond & Lee, 2011). However, it is a complex concept that comprises response inhibition and interference suppression (or interference control) (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002; Martin-Rhee & Bialystok, 2008; Petersen & Posner, 2012; Sorge, Toplak, & Bialystok, 2016).
Response inhibition is induced by univalent tasks that create conflict between two simple options of the same stimulus feature. In this case a usual, correct option collides with an arbitrary unusual response (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016). Interference suppression meanwhile requires solving conflictive dimensions, avoiding distractions from salient but irrelevant cues (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016). In the following sections it is illustrated that bilinguals have mostly displayed enhanced attentional control compared to monolinguals under tasks that demand interference suppression but not under tasks that demand response inhibition (Bialystok et al., 2009; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016).

1.3. Attentional control and bilingualism

As mentioned above, research has shown that bilinguals have enhanced AC because of their daily use of two languages (Bialystok, 2015). This is because bilinguals’ two languages are simultaneously active during language processing (Guttentag, Haith, Goodman, & Hauch, 1984), which results in constant holding and retrieving of components of the language in use, while inhibiting unwanted intrusion from components of the other language (Hernández et al., 2013). That is, this complex process of attentively selecting the relevant linguistic information while filtering irrelevant lexical elements from the non-target language during communication with others, has been associated with bilinguals’ enhanced performance in tasks that require high control of attention (Bialystok, 2015; Carlson & Meltzoff, 2008; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Costa & Sebastian-Galles, 2014; Hernandez et al., 2010; Hilchey & Klein, 2011; Kalashnikova & Mattock,
The claim that bilinguals have enhanced AC is further supported by various studies that found that bilinguals outperform monolinguals in tasks that entail higher attentional control (i.e., interference suppression) in the non-verbal domain, for instance, in the Simon task (Bialystok, Martin, & Viswanathan, 2005; Martin-Rhee & Bialystok, 2008; Morales, Calvo, & Bialystok, 2013), the flanker task (de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012; Kapa & Colombo, 2013; Yoshida, Tran, Benitez, & Kuwabara, 2011), and the Dimensional Card Change Sort task (DCCS) and adaptations (Bialystok & Shapero, 2005; Carlson & Meltzoff, 2008; Iluz-Cohen & Armon-Lotem, 2013). Some tasks, however, have revealed similar performance in bilingual and monolingual samples. That is the case of tasks with lower conflict solving demands that mostly tap on the response inhibition component of attentional control, as it is the case of the Day-Night stroop task (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008).

1.4. Attentional control in children: results from non-verbal versus verbal tasks

As mentioned in the previous section, EF is a collection of cognitive processes and AC is one of its components. Recent studies suggest that complex attentional control is required and developed during simultaneous acquisition of two languages (Bialystok, 2015; Costa et al., 2009; Hernandez et al., 2010; Kovács & Mehler, 2009) and therefore attentional control abilities would be particularly enhanced by the bilingual experience (Bialystok, 2015; Hilchey & Klein, 2011; Kroll & Bialystok, 2013; Martin-Rhee & Bialystok, 2008; Struys et al., 2015). Below, relevant studies...
with bilingual children will be reviewed. First, I will discuss studies that used non-verbal tasks, followed by studies that used verbal tasks.

1.4.1. Non-verbal tasks

From an early age bilingual and monolingual infants display different cognitive processing strategies when tested under diverse experimental paradigms. For instance, Kovács and Mehler (2009) looked at cognitive abilities in seven month old infants raised in bilingual families. They used a task that assessed eye movements in anticipation of finding a reward image after a sound cue. After infants learned to find the reward located on the right-hand side of the screen, the position of the reward was changed to the left-hand side. When this occurred, while monolingual children kept gazing to the right side even without the reward, bilingual babies moved their gaze to find the reward in the new position to the left (Kovács & Mehler, 2009) showing enhanced attentional skills. This experiment is evidence of some bilingual advantages prior to any verbal competence. Bialystok (2015) attributes these results to the increased attention that babies raised in bilingual families pay to their environments. Newborns in contact with two different languages learn to pay extra attention to two sets of sounds, gestures, prosodic properties and any other cues that help them distinguish and acquire the two linguistic systems. In other words, it is suggested that beyond inhibiting one of their languages, bilinguals pay constant attention to both their languages and constantly select the language in use. It is also proposed that these strategies used by bilinguals are later transferred to other cognitive processes (e.g. metalinguistic awareness as reviewed in Bialystok, 2001) and develop further during
the lifespan (Hernández et al., 2013; Sebastián-Gallés, Albareda-Castellot, Weikum, & Werker, 2012).

It remains unclear, however, which specific cognitive skills are enhanced as a result of bilinguals’ attentional strategies to avoid non-target language intrusion during communication. In order to find out the specific cognitive processes that are enhanced by the bilingual experience, studies comparing bilinguals and monolinguals at critical ages (e.g., 4 to 5 years) have revealed advantages in bilinguals only during non-verbal tasks that require a higher level of attentional control. For instance, in a study by Martin-Rhee and Bialystok (2008), inhibitory control was assessed in four to five-years-old bilingual and monolingual children using non-verbal tasks. The study used variations of the Simon task and the day-night Stroop task, along with a receptive vocabulary test to control for language proficiency. In the Simon task, a coloured shape appears either on the left or right of the display and the colour of the stimuli is mapped to a left or right key press. For example, if the colours of the stimuli to be displayed on the screen are blue and red, the red shape might be associated to the left key and the blue to the right key (e.g., red=left and blue=right). In a congruent trial a blue shape will appear on the right side of the screen (e.g., blue=right). In an incongruent trial, the blue shape will appear on the left side of the screen and the participant will need to inhibit a response to a non-relevant but more salient cue (e.g., left position in the screen) and attend to the less salient correct option or rule (e.g., blue=right key) and press the right key. In the day-night Stroop task children are asked to say the word “night” when they see a shiny sun picture and the word “day” when they see a picture of a moon with stars (Diamond, Kirkham, & Amso, 2002;
Martin-Rhee & Bialystok, 2008). Bilingual children outperformed their monolingual counterparts in the Simon task (e.g., bivalent task), particularly under limited time constrains, i.e., when the child was given a shorter response time (Martin-Rhee & Bialystok, 2008). Results under the day-night Stroop task, however, showed that bilingual and monolingual children performed similarly. The authors attributed this result to the fact that the Day-Night Stroop task demands response inhibition (i.e., univalent display or lower demands of attentional control), suggesting therefore that bilingual children display enhanced interference suppression abilities, which are revealed under high attentional demand conditions and not under lower attentional control demands. In sum, in this study bilingual children outperformed monolinguals only under tasks that required interference suppression skills (e.g., Simon task) but not when the task required response inhibition (e.g., day-night Stroop task) (Diamond, Kirkham, & Amso, 2002; Martin-Rhee & Bialystok, 2008).

In another study, Carlson and Meltzoff (2008) tested pre-school six-year-old children with a battery of non-verbal tests that measured executive functions. Children were classified in three language groups: a bilingual group from birth, a second language learners group that were exposed only to English from birth until enrolled in a preschool language immersion program, and a control group of monolingual English-speaking children. An advantage in the bilingual group was found in executive functions related to, i) attentional control that inhibited a conflicting response (e.g., interference suppression) and ii) working memory (Carlson & Meltzoff, 2008). This advantage was particularly found in the bilingual group during the advanced version of the Dimensional Change Card Sort (DCCS) task (Carlson &
Meltzoff, 2008). In the DCCS standard version, children are given a series of cards to sort by one dimension (e.g., shape) and then, when they have mastered this condition, children are asked to switch and sort the cards by a different dimension (e.g., colour). In the advanced version, children are first exposed to the basic version and after that, rules from the pre and post switch are mixed. Some cards marked with a star are presented to the children. Cards without stars have to be sorted by shape and cards marked with a star should be sorted by colour. Children performing this task need to hold two rules in mind and overcome a dominant salient cue (e.g., shape rule) to opt for the more relevant less salient cue (e.g., colour rule) (Carlson & Meltzoff, 2008).

In sum, in a number of studies bilingual young children performed better than monolinguals when tested with complex tasks that tap greatly into the interference suppression component of attentional control, particularly in the Simon task (Bialystok et al., 2005; Martin-Rhee & Bialystok, 2008; Morales et al., 2013), the flanker task (de Abreu et al., 2012; Kapa & Colombo, 2013; Yoshida et al., 2011), and the DCCS task and their adaptations (Bialystok & Shapero, 2005; Carlson & Meltzoff, 2008; Iluz-Cohen & Armon-Lotem, 2013; Kalashnikova & Mattock, 2014). In contrast, monolingual and bilingual children perform similarly under tasks that demand response inhibition as the Day-Nigh Stroop task (Martin-Rhee & Bialystok, 2008). The tasks used to assess the non-verbal domain may include a minimum verbal component however these are commonly used to measure general attentional control and not verbal proficiency. The reviewed tasks are only a small sample of the diverse range of tasks used in previous studies to investigate bilingual children’s executive function in the non-verbal domain. Whereas abundant research has focused on the
non-verbal domain, little research has been performed to investigate the cognitive impact of the bilingual experience in the verbal domain. In the next section a brief review of bilingual children’s linguistic performance and of the studies that explore bilinguals’ cognitive performance under a lexical retrieval task.

1.4.2. Verbal tasks

As considered in the previous section, bilingual children often outperform their monolingual counterparts in measures that tap into higher-order attentional control skills; however, contrasting results appear when comparisons are conducted using linguistic measures. In fact, disparities in lexical development between bilingual and monolingual children have been observed when using tests of receptive vocabulary (Bialystok et al., 2010). Specifically, bilingual speakers have been reported to have a smaller vocabulary size for each of their languages when compared to monolinguals (Bialystok, Luk, Peets, & Yang, 2010; Gollan, Montoya, & Werner, 2002; Jia, Chen, Kim, Chan, & Jeung, 2014; Sandoval, Gollan, Ferreira, & Salmon, 2010) from an early age (Poulin-Dubois, Bialystok, Blaye, Polonia, & Yott, 2013) and through adulthood (Bialystok & Luk, 2012). However, it is important to note that this situation does not imply a conceptual disadvantage because when bilinguals’ vocabulary size in both languages is measured, bilinguals’ vocabulary size is equivalent or sometimes larger than monolinguals’ vocabulary size (Pearson, Fernandez, & Oller, 1993).

In addition, bilingual adults show lower scores (accuracy) in picture naming tasks (Bialystok, Craik, & Luk, 2008; Ivanova & Costa, 2008) than their monolingual counterparts, undergo more tip-of-the-tong states (Gollan & Acenas, 2004), and
exhibit potential cross-linguistic interference during language production (Abutalebi & Green, 2008) and receptive language tasks (Friesen & Jared, 2012). In sum, bilinguals have been observed to incur additional costs during speech production tests in both their languages (Sadat, Martin, Magnuson, Alario, & Costa, 2015; Strijkers, Baus, Runnqvist, FitzPatrick, & Costa, 2013). These extra costs are found alongside bilingual advantages in the non-verbal domain. That is, non-target language intrusion occurs in bilinguals precisely because both their languages are activated constantly in the brain competing during the production process (Bialystok et al., 2008). However, it is important to remember that bilinguals’ language exposure and vocabulary differ from those of monolinguals. Specifically, bilinguals’ time of exposure is roughly divided between two languages and therefore each language’s input is often less than monolinguals’ exposure to only one language (Byers-Heinlein, 2012; Pearson et al., 1993). Since vocabulary size is the result of the time and frequency of exposure to a language (Byers-Heinlein, 2012; Byers-Heinlein & Fennell, 2014), bilinguals’ smaller vocabulary in each of their languages (when compared with monolinguals’ vocabulary) (Bialystok & Luk, 2012; Bialystok et al., 2010) may play a large role in the absence of enhanced attentional control skills in verbal tasks. (Byers-Heinlein, 2012; Byers-Heinlein & Fennell, 2014; Pearson et al., 1993). In fact, a smaller vocabulary in bilinguals may have potentially undermined bilinguals’ performance in language measures of attentional control. It is noteworthy that the above studies have included heterogeneous populations of bilinguals. Specifically, their bilingual participants are referred to as proficient or fluent bilinguals, but they vary in their proficiency and age of acquisition of the two languages. Thus, I believe there is a need
to study homogenous populations using stringent recruitment criteria for bilingual participants to achieve results that more closely represent the bilingual capacity.

The verbal fluency task (VFT) is a word retrieval task widely used to measure executive function and attentional control across the lifespan in bilingual and monolingual populations, and which demands high vocabulary proficiency (Korkman et al., 2001; Luo et al., 2010; Matute, Rosselli, Ardila, & Morales, 2004; Ostrosky-Solis et al., 2007). There are two versions within the VFT, category and letter, and both of them activate semantic memory and executive control but at different levels. Category (or semantic) VFT requires the participant to list words from a category, for example clothing items, animals, fruits, etc. The executive requirements of category VFT are similar to the ones for regular speech, and it is also an effective measure of vocabulary size. Letter (or phoneme) VFT requires the participant to list words beginning with a letter (e.g., m or p) often using restrictions as avoiding proper nouns and morphologically related words. Letter VFT is a more effective measure of higher demands of attentional control (i.e., interference suppression), along with other executive skills that affect capacity of organisation, monitoring and shifting but also poses demand on vocabulary proficiency (Friesen, Luo, Luk, & Bialystok, 2015).

The VFT was used along with several other tasks in the neuropsychological assessment of children in a study by Korkman and colleagues (Korkman et al., 2001). This study aimed to create standard levels and correlations between tasks of executive function and age in English speaking children. It was observed that the cognitive abilities measured by VFT do not reach ceiling at 12 years of age (Korkman et al., 2001; Matute et al., 2004). Studies have also shown that VFT measures continue to
demonstrate significant age-related increase in the older age groups. This suggests that VFT do not have an upper limit of performance, as reflected in the large variation at 12 years (Korkman et al., 2001). In particular, from this age on, although speed progressively decreases (Matute et al., 2004), retrieval of words by letter is not easily exhausted in 1 minute (Korkman et al., 2001).

Recent studies have used both versions of VTF to compare cognitive skills in bilingual and monolingual children yielding mixed results. Kormi-Nouri, Moradi, Moradi, Akbari-Zardkhaneh, and Zahedian (2012) tested 1600 monolingual and bilingual children with VTF in the Persian language. Children were classified by school year, from Grade 1 to Grade 4, and not strictly by age. Participants were recruited from three cities in Iran: Tabriz (Turkish–Persian bilinguals), Sanandaj (Kurdish–Persian bilinguals) and Tehran (Persian monolinguals), so that there were two groups of bilingual children and one group of monolinguals. Results showed only a slight bilingual advantage for the Turkish-Persian bilinguals and only in the letter version of the task. In the VTF category version monolinguals outperformed both bilingual groups (Kormi-Nouri et al., 2012). As bilingualism status or vocabulary proficiency assessments were not reported in this study, Friesen et al. (2015) suggests that possibly the Kurdish–Persian bilingual group was not as proficient in Persian as the Turkish-Persian group, so that a bilingual advantage could not be found in the former group. Indeed, the method adopted by Kormi-Nouri et al. (2012) and the large number of participants may have posed difficulties in terms of controlling variables such as age, socio-economic status (SES) and level of bilingualism (as suggested by Friesen et al., 2015). This is noteworthy because children continue developing
cognitive skills through childhood and important milestones can occur even in short periods of time, so that even at 12 years of age, cognitive processes required for some verbal tasks still may not be fully developed (Korkman et al., 2001; Matute et al., 2004).

In a later study, Friesen et al. (2015) tested bilinguals (of English and another language pair) and English monolinguals at four different ages: seven years, ten years, young adults and older adults, with a design that controlled for age and SES. This study found that seven-year-old bilingual and monolingual children, with similar language proficiency, performed similarly in both versions of the task (i.e., VTF letter and category), without finding any significant difference between language groups. In the ten-year-old group low vocabulary (LV) bilinguals were compared with age-matched monolinguals with higher vocabulary sizes. A bilingual advantage was not found in this age group. Although the ten-year-old LV bilinguals had a lower vocabulary than monolinguals, both groups performed similarly in VTF letter task. This suggests that LV bilinguals compensated for smaller vocabulary size with enhanced executive function that aided a more efficient lexical access. Bilinguals at ten years of age also showed effortless word retrieval in comparison with the 7 year old bilingual group (Friesen et al., 2015). Finally, in the young adult group that was composed of high vocabulary (HV) proficient bilinguals and monolinguals, bilinguals performed similarly to monolinguals in category VFT but bilinguals outperformed monolinguals’ in letter VFT. Bilinguals’ better performance in young adulthood was maintained through to the older adult group, decreasing only slightly with age. However, it is noteworthy that the letter VFT employed in the two younger groups
was different from the task used with the two adult groups included in the study. For instance, in the seven-year-old and the ten-year-old groups letter VFT restrictions of avoiding proper names and morphologically related words were not imposed, but it was imposed for the older groups. Finally, Friesen et al. (2015) suggested that while performance in category VTF is related to age and vocabulary knowledge, performance in letter VFT is closely related to the degree of bilingualism (e.g., high proficiency vs. low proficiency). This study suggests that the bilingual advantage emerges sometime after 7 years of age (where no differences between groups were found) and before young adulthood (i.e., around the early 20’s).

In conclusion, a bilingual advantage in childhood has so far been demonstrated mostly in studies that assess cognitive processes in the non-verbal domain, using tasks that demand higher processing of executive function but do not require language processing. Particularly, bilingual children perform better than monolinguals when facing tasks that involve solving conflictive displays that require interference suppression (e.g., DCCS), but a bilingual advantage has not been found when the task requires response inhibition (e.g., day-night Stroop task). A different view emerges from studies that have used verbal tasks to measure AC. Given the scarcity of studies with bilingual children using verbal tasks (e.g., letter and category VFTs), results in this field so far are mixed. Previous studies (Friesen et al., 2015; Kormi-Nouri et al., 2012; Luo et al., 2010) suggest that age, vocabulary proficiency and bilingualism level are crucial for participants’ VFT performance. Recall that Kormi-Nouri et al. classified children by school grade (overlooking age) and did not perform assessments for vocabulary proficiency or bilingualism level. Conversely, Friesen et al. did match
participants on age and assessed bilingualism and vocabulary proficiency, comparing monolingual and bilingual children at seven and at ten years of age. However in the latter study a simple version of the letter VFT was used, potentially failing to create enough difficulty in the task to capture group differences. Furthermore the ten-year-old monolingual and bilingual children were not similar in vocabulary proficiency. It is therefore valuable to observe whether a difference between bilingual and monolingual children could be captured before ten years of age if variables such as age, gender, task difficulty and vocabulary size are controlled. Furthermore, studies in bilinguals are often conducted using either non-verbal or verbal tasks separately. The present study integrates and relates both non-verbal and verbal tasks which could prove beneficial in assessing bilingual children’s attentional control in an integrated way.

1.5. Contrasting positions regarding bilingual and monolingual children: The bilingual advantage controversy

As reviewed previously, non-verbal processing measures are the main source of evidence of enhanced executive skills in bilingual children (Bialystok, 2015; Bialystok et al., 2009; Bialystok et al., 2012; Hernandez et al., 2010; Hernández et al., 2013 for reviews). However, there is also a number of studies that have not found support for enhanced attentional control in bilinguals, concluding that there is no difference between bilingual and monolingual performance (Antón et al., 2014; Duñabeitia et al., 2015; Kousaie & Phillips, 2012; Paap & Greenberg, 2013), and that the bilingual advantage is non-existent or at least evasive (Paap, Johnson, & Sawi, 2015). Furthermore, de Bruin, Treccani, and Della Sala (2015) have claimed that there
are many unknown studies that fail to find any bilingual advantage but that have not been published due to a publication bias. Their review takes into consideration papers presented at conferences from 1999 to 2012 which, although do not differ greatly in methods from similar published studies, do not support the hypothesis of a bilingual advantage (de Bruin et al., 2015).

Valian (2015), aiming to understand inconsistencies across existing research, performed a comprehensive review of studies that tested bilinguals and monolinguals and compared them in executive function performance at various stages of the lifespan (childhood, early adulthood, and older adulthood). The author concluded that overall, there is evidence that demonstrates advantages of bilingualism. However, contradictions and inconsistencies in results are due to different variables that enhance EF performance but have not been accounted for in previous studies (Valian, 2015). One potential variable may be socio-economic status (SES), as it has been shown to influence performance in a number of behavioural studies (Costa & Sebastian-Galles, 2014; Valian, 2015). The factors comprised in the SES construct, such as parental education, income or cultural status, significantly influence children’s cognitive experiences (Christensen, Schieve, Devine, & Drews-Botsch, 2014; Lee & Burkam, 2002) and their long term cognitive outcomes (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). In addition, asymmetrical gender balance across language groups could potentially impact in cognitive studies in childhood, as it has been proposed that around four to seven years of age girls display a better performance in many behavioural tests when compared with boys (Palejwala & Fine, 2015; Hyde, 2016).
A more important variable for this study however could be the characteristics of the tasks used across studies (See Hilchey & Klein, 2011 for a literature review). As a minor difference or adaptation can mean a change on the EF component tapped by the task (Qu, Low, Zhang, Li, & Zelazo, 2016). Accordingly, previous studies suggest that bilingual populations display better performance than monolinguals under high demanding tasks (Costa et al., 2009; Martin-Rhee & Bialystok, 2008). Particularly, attentional control levels demanded by tasks (high = interference suppression vs. low = response inhibition) may be one of the factors that determine finding or not differences between language groups (Luk, Anderson, Craik, Grady, & Bialystok, 2010; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016).

In conclusion, mixed results have been observed across studies in the topic of cognitive bilingualism, which has resulted in opposing views regarding the bilingual advantage. There is, however behavioural and electrophysiological evidence found over years of study points to a positive effect of bilingualism in EF (Barac, Moreno, & Bialystok, 2016; Bialystok, 2015; Kroll, 2015; Kroll & Bialystok, 2013). An approach in the right direction would acknowledge and account for a number of factors that at the individual level may impact the variation in results across studies and to establish common procedures in bilingualism studies in order to minimise contradicting findings.

1.6. Bilingual population in the present study and recruitment criteria

As described in the section above, several aspects can impact children’s performance in behavioural studies. This study therefore aimed to match bilingual and monolingual language groups in aspects such age and gender as well as including
measures of SES and vocabulary size during the assessments in order to account for variables that may influence EF performance. In addition, determining the type of bilingual participants is also crucial for obtaining the right sample in the bilingual group as pointed out in previous subsections.

Particularly, in Section 1.3.2 it has been noted the importance of obtaining a sample of high proficient balanced bilinguals (Friesen et al., 2015). Bilingualism however, is not a fixed condition and it often differs in each individual (Bialystok, 2001). Degrees of bilingualism can vary depending on the exposure (i.e., input) and on opportunities for production in each language (Hakuta & Diaz, 1985). There are two main spheres of language input to be considered: the environment (home versus community) and the quality of the input (monolingual versus bilingual or mixed input) (Qi, 2011). The degree and variation of these elements will have an impact on the child’s language production. Additionally, types of bilingual children vary depending on age of acquisition, type of language exposure and parental language strategy used at home (Romaine, 1995). However, identical bilingual proficiency is not ensured among the children that share the same characteristics under these criteria of bilinguals’ classification, as individual psychological aspects also play a crucial role (Romaine, 1995, 1999). Definitions therefore are insufficient to procure a homogenous bilingual sample. Thus, in order to enable recruitment of participants with similar bilingual proficiency, operational criteria were implemented for the purposes of the present study. These criteria included:
1. Australian born bilingual children of Australian English (AusE) and any language other than English (LOTE) and exposure to both their languages from birth;

2. To have at least one parent who speaks their heritage LOTE at home on a daily basis;

3. To use receptively and productively both their languages on a daily basis. Specifically, children who receive at least 20% of weekly exposure to their LOTE were selected for this study;

The first criterion was established in order to attain a homogenous sample of simultaneous-bilingual participants. It was particularly aimed to minimise variations in the age of bilingual acquisition and bilingualism level, as these factors potentially contribute to different cognitive outcomes in bilinguals (Valian, 2015). Regarding the second criterion, in order to avoid any specific-culture interference in bilinguals’ data (Paap et al., 2015) recruitment was opened to bilingual participants who speak English and any other minority language spoken in Australia. Children from 7.5 to 8.5 years of age were included aiming for a mean age of eight years because around this age bilingual children can potentially reach similar English proficiency norms to monolinguals (Jia et al., 2014), which is particularly crucial for the verbal tasks as mentioned previously in §1.3.2. The percentage in the third criterion of at least 20% of LOTE exposure was included because children in school age spend at least six hours a day (out of 12-14 hours awake in average) at school speaking English and many children spend an extra three hours a day in an after school care facility.
Therefore the chosen percentage of LOTE exposure in the selection criteria aimed to be realistic to the Australian reality without compromising high bilingual proficiency.

1.7. Research aims and questions

The above subsections have introduced the relevant literature pertaining to attentional control studies in bilingual children involving the non-verbal domain, followed by a review of literature pertaining to studies in the verbal domain that include lexical access tasks (i.e., VFT). They also introduced the importance of accounting for different variables in the participants sample as a method to ensure reliable results.

The present masters thesis compares monolingual and bilingual children’s performance in verbal and non-verbal attentional control measures to assess the role of bilingualism in children’s cognitive processes. Particularly, the experiments that will be reported aimed to assess eight-year-old monolingual and bilingual children in the verbal (with language based tasks) and non-verbal (with non-language processing tasks) domains and to relate performances across tasks and across domains. Consequently, the following questions were formulated:

1. Do bilingual and monolingual children display differences in behavioural measures of attentional control? And if so;
   1. A. Is there a difference in the verbal domain?
   1. B. Is there a difference in the non-verbal domain?

2. Does attentional control performance in children correlate across domains?
To address these questions the present thesis was divided in three experimental Chapters for each of the three parts of the research questions. Specifically, Chapter 2 addressed the question 1.A, Chapter 3 the question 1.B and Chapter 4 the question 2, as explained below. For each Chapter two tasks were selected, one with high and one with low levels of attentional control demands.

Chapter 2 addressed question 1.A by measuring whether bilingual and monolingual children display attentional control differences under verbal tasks. For the verbal domain two versions of the VFT were selected, namely, letter VFT (phonemic) for high demands of attentional control and category VFT (semantic) for lower levels of attentional control (Friesen et al., 2015; Korkman et al., 2001; Luo et al., 2010). A receptive vocabulary test to measure English language proficiency was also included to account for participants’ language proficiency.

Chapter 3 addressed question 1.B by measuring whether bilingual and monolingual children display attentional control differences under non-verbal tasks. The DCCS advanced version (Carlson & Meltzoff, 2008; Zelazo, Frye, & Rapus, 1996) that requires higher demands of attentional control (i.e., interference suppression) and the day-night Stroop task (Diamond et al., 2002; Martin-Rhee & Bialystok, 2008) that requires lower demands of attentional control (i.e., response inhibition) were selected.

Chapter 4 presents an assessment of the relations between verbal and non-verbal attentional control. In this Chapter the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4) as a measure of receptive vocabulary was entered as a covariant dependent variable in correlations, and as a predictor of performance in
regressions to control for vocabulary proficiency. This last Chapter was decisive in evaluating the cognitive components underlying children’s performance in the verbal tasks.

Table 1.1.

*Main components of the present masters thesis*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Tasks</th>
<th>Demands of Attentional control (AC)</th>
<th>Two levels IV Correlations and regressions across domains (Chapter 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Domain (Chapter 2)</td>
<td>Letter VFT / number of accurate words in 1 minute</td>
<td>High</td>
<td>High demands</td>
</tr>
<tr>
<td></td>
<td>Category VFT / number of accurate words in 1 minute</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Non-Verbal Domain (Chapter 3)</td>
<td>DCCS / successful sorting (0-4)</td>
<td>High</td>
<td>Low demands</td>
</tr>
<tr>
<td></td>
<td>Day-Night / accurate opposite naming (0-12)</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

Predictions for the research questions are comprehensively addressed in each Chapter. In general, it was expected to find score differences between groups, where bilinguals would have higher performance scores than monolinguals in both domains (non-verbal and verbal domains) only under high levels of attentional control (i.e., DCCS task and VTF-letter). Contrastingly, considering that monolinguals and bilinguals perform similarly when the attentional control demands are low, it was not expected to find score differences between groups in the day-night Stroop task and in the VTF category task. Finally, I predicted a relation across domains after conducting
a correlation analysis. Particularly, a positive relation was expected in performance under high levels of attentional control demands in the verbal domain and high levels of attentional control demands in the non-verbal domain.

1.8. Chapter Summary and thesis outline

Chapter 1 introduced the overall aim of the thesis which is to investigate how the bilingual experience could impact children’s attentional skills in the verbal and non-verbal domains and their subsequent interrelation. After introducing a review of relevant studies that investigate bilingual children’s attentional control in both domains: verbal and the non-verbal; it has pointed out the unique attributes of this thesis. In particular, this thesis includes the same participants across three studies using a very strict and controlled method. The method includes matching bilingual and monolingual children by age, gender and SES as well as comparing both groups in English vocabulary proficiency. The fact that the same participants and stimuli are used in all tasks allows for an appropriate examination of the correlation between tasks and across domains.

As described above, Chapters 2 to 4 constitute the experimental Chapters of this thesis. Chapters 2 and 3 present the results of experiments that measured bilingual and monolingual performance in the verbal and non-verbal domains to answer research question 1.A and 1.B respectively. Chapter 4 assessed the relations between verbal and non-verbal attentional control and evaluated the cognitive components underlying children’s performance in the verbal tasks. Chapter 5 concludes with a general discussion of the key findings and observations as well as suggestions for future research.
Chapter 2: Bilingual children display attentional advantage in the verbal domain: Evidence from the Verbal Fluency Task

The present Chapter addresses research question 1.A, Do bilingual and monolingual children differ in behavioural measures of attentional control in the verbal domain? To address this question, bilingual and monolingual children’s attentional control was assessed and compared using the verbal fluency task (VFT). Two versions of the VFT, namely letter VFT and category VFT were used to measure children’s attentional control at two levels of cognitive demand. The letter VFT was used to measure high demand in attentional control and the category VFT to measure lower demand in attentional control. Results are presented and discussed in light of previous studies.

2.1. Introduction

Previous studies argue that bilingual speakers possess enhanced executive functioning skills when compared to monolinguals throughout the lifespan (Bialystok, 1999; Bialystok, 2007; Bialystok, 2015; Bialystok et al., 2012; Hernandez et al., 2010; Hernández et al., 2013; Kroll, 2015; Kroll & Bialystok, 2013). Attentional control has been proposed to be the component of executive functioning responsible for this

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1 A version of this Chapter appeared as Conference Proceedings of the 16th Australasian Speech Science and Technology Conference (SST2016) http://www.assta.org/sst/2016/SST2016_Proceedings.pdf. For a full citation please see (Pino Escobar, Kalashnikova, & Escudero, 2016) in the References Section. The present Chapter however includes a larger number of participants and a more detailed Introduction and Participant Sections.
cognitive advantage in bilinguals, suggesting that bilinguals’ constant selection and use of lexical forms from only one of their languages while inhibiting lexical forms of the other, enhances their capacity to process competing responses (Bialystok, 1999, 2015; Friesen et al., 2015; Hernandez et al., 2010; Sorge et al., 2016). This bilingual advantage has been mostly observed using non-language processing tasks, which demand executive functioning in the non-verbal domain (Bialystok et al., 2005; Bialystok & Senman, 2004; Bialystok & Shapero, 2005; Carlson, 2005; Martin-Rhee & Bialystok, 2008). In contrast, a bilingual disadvantage has been observed under language processing tasks (Bialystok et al., 2008; Sandoval et al., 2010).

However, limited research has been carried out to compare children in the verbal domain, where performance relies not only on participants’ lexical competence and retrieval skills but also on their attentional control skills and where monolingual and bilingual groups are matched in age and gender. Therefore, the present study investigated whether bilingual children exhibit an enhanced attentional control under lexical processing demands using Verbal Fluency Tasks (VFTs) in two different versions, category (or semantic) and letter (or phonemic) (Friesen et al., 2015; Korkman et al., 2001; Luo et al., 2010).

VFTs have been widely used in studies with children (Filippetti & Allegri, 2011; Korkman et al., 2001; Matute et al., 2004; Ostrosky-Solis et al., 2007) and adults (Gollan et al., 2002; Luo et al., 2010; Sandoval et al., 2010) to measure attention and executive functions that involve lexical processing and retrieval (Filippetti & Allegri, 2011; Korkman et al., 2001), but they have been used scarcely in studies that compare monolingual and bilingual children (Friesen et al., 2015; Kormi-
Nouri et al., 2012). VFT’s two modalities (or versions) activate lexical knowledge, semantic memory, and executive control at different levels (Friesen et al., 2015; Luo et al., 2010). The first modality, category (or semantic) VFT, requires the participant to list words from a semantic category (e.g., clothing items, animals, fruits) in a set period of time (e.g., 1 minute). The executive requirements of category VFT are similar to the ones for regular speech, and this VFT version is also an effective measure of productive vocabulary size (Friesen et al., 2015; Luo et al., 2010). The second modality, letter (or phonemic) VFT, requires the participant to list words beginning with a letter (e.g., f, m, or p) often imposing restrictions on acceptable responses (e.g., to avoid people and places’ names and morphologically related words). The letter VFT is more effective than the category version for measuring higher demands of attentional control, along with other executive skills that affect capacity of organisation, monitoring and shifting (Friesen et al., 2015; Luo et al., 2010). Using VFT therefore offers an interesting approach to bilingualism studies because each modality allows to measure two levels of attentional control (low with category VFT and high with letter VFT) as well as lexical access.

Studies with adults have shown a bilingual advantage for letter VFT only (Friesen et al., 2015; Luo et al., 2010, as reviewed in Chapter 1); however, studies with children have yielded mixed results (Friesen et al., 2015; Kormi-Nouri et al., 2012). For instance, Kormi-Nouri et al. (2012) tested 1600 monolingual and bilingual children in Persian language with VTF. Children were recruited from school grades 1 through 4 and were divided in three groups: Turkish–Persian bilinguals, Kurdish–Persian bilinguals, and Persian monolinguals. Results showed a slight bilingual
advantage for the Turkish-Persian bilinguals in letter VFT only. However, the letter VFT used in this study did not include restrictions on potential answers. In the category version, monolinguals outperformed both bilingual groups (Kormi-Nouri et al., 2012). It is noteworthy that this study did not report language proficiency assessments in the target language across groups or bilingualism level assessments in the bilingual groups. It has been therefore suggested that the Kurdish–Persian bilingual group may not have been as proficient in Persian as the Turkish-Persian group, which may have influenced in different results between groups (Friesen et al., 2015). Thus, the recruitment method adopted and the large number of participants in this study may have led to difficulties in controlling for variables such as age, socio-economic status (SES), level of bilingualism (Friesen et al., 2015), and language proficiency in the language being tested. Careful control of these variables in experimental designs is essential, as children develop their language and cognitive skills at different rates. Furthermore, important milestones can occur even in short periods of time. For instance, even at 12 years of age, cognitive processes required for language processing tasks have not yet reached adult performance (Korkman et al., 2001; Matute et al., 2004).

Regarding the effect of age, Friesen et al. (2015) tested bilinguals of English and another language) and English-speaking monolinguals with the VFT at four different age-groups: seven-year-olds, ten-year-olds, young adults, and older adults finding a main effect of age. Again, in this study the letter VFT did not include restrictions for the two younger age groups. It was found that seven-year-old bilingual and monolingual children, with similar English proficiency, performed similarly in
both versions of the task (i.e., letter and category). In the ten-year-old group, the authors matched low vocabulary (LV) bilinguals with high vocabulary monolinguals. Although the ten-year-old LV bilinguals had a lower vocabulary than monolinguals, both groups performed similarly in the letter VTF; however monolinguals outperformed bilinguals in the category VFT (Friesen et al., 2015). This suggests that LV bilinguals compensated for their smaller vocabulary size with an enhanced executive function that aided a more efficient lexical access (Friesen et al., 2015). Ten-year-old bilinguals also showed effortless word retrieval in comparison with the seven-year-old bilingual group (Friesen et al., 2015).

In the young adult group that comprised high vocabulary (HV) proficient bilinguals and monolinguals, bilinguals outperformed monolinguals in the letter VFT but performed similarly to monolinguals in category VFT. Bilinguals’ higher performance was held through to the older adult group, decreasing only slightly with age. Their findings also suggest a possible developmental trajectory for the bilingual advantage in the verbal domain, emerging sometime before young adulthood.

VFTs may yield mixed results in children due to differences in English language proficiency between monolinguals and bilinguals (Friesen et al., 2015). Indeed, as mentioned in Chapter 1, bilingual children’s receptive vocabulary in their dominant language is often smaller when compared to monolingual children’s vocabulary (Bialystok et al., 2010; Gollan et al., 2002; Jia et al., 2014; Sandoval et al., 2010), which poses a challenge for this line of research. However, by the age of eight years, English receptive vocabulary in bilingual children has been reported to reach a similar level as the vocabulary of same-age monolingual peers (Jia et al., 2014).
Therefore, the present study included nearly eight-year-old children to ensure that differences in performance were not due to differences in English proficiency. Language groups were also matched in age and gender and assessed in receptive vocabulary proficiency in order to account for target language differences.

The aim of the present experiment was to investigate whether bilingual and monolingual children differ in behavioural measures of attentional control in the verbal domain thus addressing the Research Question 1.A. of this thesis. For this matter, letter and category versions of VFT were used to measure attentional control under lexical processing demands. Two possible outcomes were predicted. The first possible outcome was that eight-year-old bilingual children would present high vocabulary proficiency (HV), similar to monolinguals’ vocabulary. Then it was expected that HV bilingual children would outperform their monolingual counterparts in letter VFT since this version requires higher demands on executive functions, which have been observed previously in bilinguals (Luo et al., 2010). Contrastingly, in this case HV bilinguals were expected to perform similarly to monolingual children under category VFT because this version requires lower levels of executive functioning, which resemble ordinary speech demands (Friesen et al., 2015; Luo et al., 2010). Alternatively, bilingual children could present significantly lower vocabulary proficiency (LV) than their monolingual matched counterparts. In this case LV bilingual children were expected to perform similarly to monolingual children under letter VFT as it occurred with ten-years-old low vocabulary bilinguals (Friesen et al., 2015). As well, in this case, LV bilinguals were expected to underperform
monolinguals in the category VFT as it also occurred with ten-year-old low vocabulary bilinguals (Friesen et al., 2015).

2.2. Method

2.2.1. Participants

Thirty-four Australian-born children participated in the present study. Seventeen Australian-English (AusE) monolingual children (\(M\) age = 7 years 10 months, \(SD = 3.6\) months; 10 female) and 17 children bilingual in AusE and another language (\(M\) age = 7 years 10 months, \(SD = 3.5\) months; 10 female). Children were recruited from the Western Sydney University MARCS BabyLab database of parents who have volunteered to participate in child language research, as well as through flyers and word of mouth.

The groups of monolingual and bilingual children were carefully matched by age and gender. The bilingual children were proficient in AusE and one of the following languages other than English (LOTE): Arabic (4), Spanish (4), Cantonese (2), Mandarin (1), Malay (1), Russian (1), Hindi (1), Indonesian (1), Italian (1) and German (1). All parents signed an informed consent form in accordance with the Western Sydney University Human Research Ethics Committee. One bilingual participant and his monolingual age-matched counterpart were tested but excluded from the final sample because the bilingual participant did not comply with the minimum language exposure criteria (described in Section 1.6 of this thesis). Particularly, the mother of this one bilingual participant changed the information provided during the initial telephonic survey. She initially informed that the child used their LOTE with high frequency of around 40 to 50%, however in the language
background questionnaire she reported only 10% of LOTE exposure and mostly English production during communication. Additionally it was reported that the child was born overseas and arrived in Australia before turning 1 year old. Therefore the child did not fulfill the present study’s strict language selection criteria.

Parents were contacted by telephone and/or email before being invited to take part in the study. At this stage, parents were asked about their children’s language exposure and eligibility criteria (detailed in Section 1.4) was checked. A crucial question for prospective bilingual participants’ selection was if children were receptive and highly productive bilinguals, capable to understand but more importantly to produce meaningful sentences in their additional language during communicative interactions. Children were not included in the study if their parents specified that their children were only able to understand but not produce utterances in their LOTE.

After eligibility criteria were checked, selected participants were invited to attend the MARCS’ BabyLab to participate in the study. Only bilingual children who were reported to use their two languages on a regular basis (with at least one of their LOTE native speaker parents) were invited. Monolingual participants were invited only if they were not exposed to a LOTE for more than two hours per week and if both their parents were native English speakers.

Additionally, parents completed a language and family background questionnaire to obtain more detailed information related to participants’ language exposure and domains of exposure (See appendix 1: Language background questionnaire). Parents of all bilingual participants were fluent in English and did not
require language assistance to fill the questionnaire. They reported that their children were exposed to their additional language on average for 34.12% of the time (SD = 11.35%). All bilingual children were reported to have been exposed to their two languages from birth. Parents also indicated that children’s LOTE exposure was higher during early childhood, decreasing when children started formal schooling (at around five to six years of age). All of the participant children were attending mainstream schools in English only, with exception of one bilingual child who was home-schooled in English only and spoken in German the rest of the time. Parents of bilingual children reported using English with their children during school-homework coaching and during activities related to school and extracurricular activities, leaving LOTE usage for recreational activities and home-family time. Seven of the bilingual children were reported to be reinforcing their LOTE proficiency by attending formal language classes (at community language schools N=5 or at mainstream school N = 2) for 2.5 hours per week. Six of the bilingual children were reported to have travelled overseas in the last 4 years, displaying a high command of their LOTE. Three of the children reported to attend church offered in their LOTE. Seven children were reported to communicate with their families from overseas in a regular basis using their LOTE.

Parents of bilingual participants also rated their children’s comprehension and production skills in the additional language on a scale from 0 to 5 where 5 was native-like, 4 near-native, 3 advanced, 2 intermediate, 1 low and 0 was very low ability. The median LOTE proficiency was 3 indicating an advanced proficiency in both comprehension and production. Particularly, in comprehension three children were
reported as native-like, two as near-native, eight were reported as advanced, and four of them as intermediate ability. In production three children were reported as native-like, two as near-native, five were reported as advanced, six as intermediate and one of them as low ability.

Parental education was collected and used as a proxy of SES and type of school attended by the children (i.e., private or public) was also considered. Parental higher education achieved was rated on a scale from 1 to 3 where 1 was school education, 2 was technological college (i.e., TAFE) and/or incomplete university education, and 3 was complete university education. The median parental education level was complete university education and there were no differences between monolingual and bilingual groups (Kolmogorov Smirnov Z = .514, p = .954). Most children attended public school and the proportion was similar in the monolingual (12 children attended public and 5 attended private school) and the bilingual (10 attended public, 6 attended private school and 1 child was home-schooled) language groups.

To assess monolingual and bilingual children’s English receptive vocabulary proficiency, the standardised Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4) was administered (Dunn & Dunn, 2007). In this test, each child was shown an easel that displays four pictures on a page and then asked to point or say the number of the image that corresponded to the word spoken by the examiner. The test is administered in sets of 12 items, and it is terminated when the child has reached eight errors in a set. This test took between 15 and 25 minutes to complete and it was the last in every testing session. Standard scores were calculated and bilingual (M = 106.824, SD = 15.757) and monolingual children’s (M = 109.235, SD = 14.307)
English receptive vocabulary scores were not significantly different, \( t(32) = .467, p = .644, d = .165 \).

**2.2.2. Tasks and procedure**

All children completed the letter and category VFTs (Korkman et al., 2001). Letter VFT assessed high-order demands of attentional control and category VFT assessed low-order demands of attentional control and lexical access. The order of administration of the tasks was counterbalanced within and across the two language groups (bilinguals: letter VFT first \( n = 8 \), Category VFT first \( n = 9 \); monolinguals: letter VFT first \( n = 9 \), Category VFT first \( n = 8 \)). All testing sessions were conducted in a child-friendly laboratory room. All participants were tested in English by a female Australian English native speaker in order to avoid non-target language intrusion. The experimenter was not involved in the design of the present study or in participant recruitment, and was therefore unaware of the aims of the study and of participants’ language background.

In the category (or semantic) VFT, participants were asked to name all different animals they could think of in one minute. The number of items that the child mentioned in the one minute time frame was counted for the data analysis. Wrong (e.g., words that do not represent an animal) or repetitive answers were excluded from the total score. During the letter (or phonemic) VFT, participants were asked to name any word they could think of starting with the letter “f”. In addition, they were asked to omit names for people and places, and morphologically related words (e.g., fast, faster, fastest). During the task, the child sat at a table facing the experimenter in a child-friendly laboratory room. A timer was placed in front of the
child. The experimenter, a female native speaker of Australian English, started the task by saying “now we are going to play the letter game”, “I am going to say a letter of the alphabet to you, and I want you to tell me as many words as you can think of that begin with that letter. However, none of the words can be names of people or places. For example, if I give you the letter M you can say mother, monkey and money but you cannot say Mary because that’s a person’s name and you can’t say Melbourne, since that is a place. Also, you can’t say the same word with different endings. For example, if you say mail you can’t say mailing or mailed. Finally, if you notice that you said a repeated word, don’t worry about it and just keep on telling me other words you can think of for the rest of your time. Does that all make sense?
Okay! The letter that we are going to use is the letter F. I want you to tell me as many words as you can think of that begin with the letter F, until I tell you to stop. Ready? Okay go!”

The number of items that the child mentioned in the one minute time frame was counted for the data analysis. The task was conducted in English only as children had different additional languages. Conducting the task bilingually would have required various research assistants with knowledge of different languages, which poses a practical difficulty for the study. As well, it would have implied choosing different letters and categories for the task for each language because of the different frequencies of phoneme usage across languages. When children were introduced to the research assistant at the beginning of the study they were told that she could speak only English. Then, no other instruction about the language in use was given during the study. All children naturally refrained from speaking in their other language at all
times and there was not verbal intervention in a language other than English at any stage.

2.3. Results

To compare monolingual and bilingual children’s performance in the letter and category VFTs, a one-way Analyses of Variance with language group as the independent variable were conducted for each VFT task. The ANOVA for the VFT – letter task showed a significant effect of language group, $F(1, 31) = 7.168$, $p = .012$. There was also significant effect of language group for the VFT – category task, $F(1, 31) = 9.054$, $p = .005$. I also conducted a 2 (VFT: letter, category) x 2 (language group: monolingual, bilingual) Analysis of Variance to examine the combined effect of language and task. Results showed a main effect of task, $F(1, 32) = 143.451$, $p < .001$, $\eta^2 = .818$, and group, $F(1, 32) = 11.618$, $p = .002$, $\eta^2 = .266$. The interaction task * group was not significant, $F(1, 32) = 3.274$, $p = .080$, $\eta^2 = .093$. These analyses indicated that overall, bilingual children retrieved more words than monolingual children, and children in both groups retrieved more words in the category than in the letter condition (Figure 2.1).

Additionally, to compare monolingual and bilingual children’s performance in the letter and category VFTs while accounting for their English vocabulary size, a 2 (VFT: letter, category) x 2 (language group: monolingual, bilingual) x 2 (task order: letter first, category first) a repeated-measures ANCOVA was conducted. PPVT scores were used as the covariate to account for individual English proficiency. Results showed main effects of language group, $F(1, 29) = 21.726$, $p < .001$, $\eta^2 = .428$, and of PPVT, $F(1, 29) = 20.500$, $p < .001$, $\eta^2 = .414$, indicating that bilingual
children retrieved more words than monolingual children, and children with larger English vocabularies retrieved more words in both tasks (Figure 2.1). There were no significant main effects of VFT version, \( F<1 \) or task order \( F<1 \).

The main effect of language group was qualified by a significant VFT version by language group interaction, \( F(1, 29) = 4.251, p = .048, \eta^2 = .128 \), indicating that bilingual children outperformed monolinguals in the two tasks but the difference was more pronounced in the category VFT. All other interactions were not significant: VFT version by PPVT, \( F(1, 29) = 3.051, p = .091, \eta^2 = .095 \), VFT version by task order, \( F(1, 29) = 1.792, p = .191, \eta^2 = .058 \), language group by task order, \( F<1, \) VFT version by language group by task order \( F<1 \).

![Figure 2.1](image.png)

*Figure 2.1* Monolingual and bilingual children’s scores (number of words retrieved in one minute) in the letter and category verbal fluency tasks (VFT) with PPVT as covariate (error bars represent SEM).
2.4. Discussion

The present study assessed whether bilingual children exhibit an enhanced attentional control under lexical processing demands, specifically in the letter VFT and category VFT. Findings showed that bilingual children who were comparable to monolingual children in age, gender, parental education and English receptive vocabulary performed better in the two versions of the VFT. VFT is a lexical retrieval task that strongly depends on vocabulary proficiency but also requires attentional control at different levels (Friesen et al., 2015; Luo et al., 2010). While the attentional demands of letter VFT are higher than those for category VFT, both VFT’s tap other Executive Function processes, including working memory and monitoring at different levels (Friesen et al., 2015; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003).

In this study monolingual and bilingual groups had similar receptive vocabulary proficiency in English as assessed by the PPVT. The PPVT scores were then considered as covariate in the analysis of VFT scores to control for individual vocabulary proficiency. Results revealed significant differences between language groups in both, the higher (letter VFT) and the lower level (category VFT) attentional control conditions. Even though monolingual and bilingual language groups had similar English vocabulary knowledge, bilinguals were able to retrieve more words in both letter and category VFTs. This suggested that bilinguals were more efficient than their monolingual counterparts in accessing their lexical repertoire and retrieving the required words under both conditions. Previous studies suggested that vocabulary knowledge is more important for category than letter VFT (Friesen et al., 2015; Luo et al., 2010). However, the present results suggest that the impact of vocabulary
proficiency is similarly crucial for both versions of VFT (letter and category). At the end of this Thesis, Appendix B shows the individual scores of monolingual and bilingual participants in each of the tasks. In this table it is observable that similar pattern of results apply to most of the bilingual-monolingual aged matched pairs.

Our findings of a better bilingual performance in the letter VFT were expected although they do not fully coincide with previous studies (Friesen et al., 2015; Kormi-Nouri et al., 2012). For instance Friesen et al. (2015) results did not find performance differences between bilinguals and monolinguals in letter VFT in the sample of seven or ten-year-old participants. Likewise, Kormi-Nouri et al. (2012) only found slight differences in one of their samples. The letter VFT used in the present study, unlike these studies, included restrictions such as requiring children to avoid proper nouns and morphologically related words, which made it a more demanding task. Thus, it is possible that this challenging version of the task was more effective on exposing performance differences between the two language groups.

This is, however, the first study to report a bilingual advantage in the category VFT in this age group, differing in this aspect with previous studies (Friesen et al., 2015; Kormi-Nouri et al., 2012). It has been previously observed that category VFT poses demands predominantly on lexical knowledge rather than on executive functions and that, still its attentional control demands are low, comparable to the ones required by regular speech (Luo et al., 2010). This study suggests that accounting for English language proficiency and other potentially interfering variables (i.e., age, gender and parental education) helped to capture the cognitive demands of the task. It is plausible as well that attentional control demands in the category VFT
are higher for the bilingual group than for the monolingual group. This is justified by the fact that bilingual minds need to recall, sort, and retrieve words from two language systems during communication, overcoming cross-language activation contrarily to monolinguals that recall, sort and retrieve words from only one language system. Bilinguals therefore, face a double challenge, having to do the same exercise required by monolinguals but overcoming cross-language activation from two language systems (Friesen & Jared, 2012; Sandoval et al., 2010).

2.5. Chapter Summary

In this Chapter, an investigation of the bilingual advantage in children in the verbal domain (Pino Escobar et al., 2016) was presented. The VFT was used to measure monolingual and bilingual children’s attentional control performance under high (letter VFT) and low levels (category VFT) of attentional demands. Results indicated a higher performance under both versions. These findings confirmed our prediction that bilingual children would outperform their monolingual counterparts in the letter VFT. Indeed, in line with previous studies (Friesen et al., 2015; Kormi-Nouri et al., 2012; Luo et al., 2010) it was hypothesized that bilingual children would display enhanced attentional control skills under high demanding cognitive tasks, which occurred during the letter VFT.

Surprisingly, predictions were not borne out as bilingual children also outperformed their monolingual counterparts in the category VFT. This finding contrasts with previous studies that used the category VFT task, which did not find performance differences in children (Friesen et al., 2015) and in adults (Luo et al.,
2010), with some parts of studies even finding a slight bilingual disadvantage (Kormi-Nouri et al., 2012).

The overall bilingual advantage in the present study was attributed to two characteristics of our participant sample. Firstly, bilingual participants had a very high command of both their languages and were highly productive in their LOTE. And secondly, bilingual and monolingual groups were strictly matched in age and gender; both groups exhibited similar parental education background and more importantly; exhibited closely similar receptive vocabulary proficiency in the language used for testing (i.e., English). Our findings therefore suggest a bilingual cognitive advantage in the verbal domain, but more importantly suggest that this advantage is more likely to be observed in bilingual participants that are strictly matched to monolingual peers in age and target language proficiency.

The present chapter thus has given a positive answer to research question 1.A, Do bilingual and monolingual children display differences in behavioural measures of attentional control in the verbal domain? Other two parts of the research question yet remain to be addressed. Next, Chapter 3 investigates bilingual children’s attentional control under non-language processing tasks and later in Chapter 4 the last part of the research question is addressed (i.e., Does attentional control performance in children correlate across domains?), relating VFT tasks of this Chapter and the non-verbal tasks of Chapter 3 with correlations and regressions analyses. Finally in Chapter 5 a discussion and conclusion integrating all chapters is offered.
Chapter 3: Bilingual and monolingual children display similar performance in the non-verbal domain: Evidence from the Dimensional Card Change Sort Task and the Day-Night Stroop Task

The previous Chapter revealed a performance difference between bilingual children and their monolingual aged matched counterparts under word retrieval tasks (i.e., letter and category VFT), indicating a bilingual advantage in the verbal domain. In the present Chapter it is tested whether a performance difference in monolingual versus bilingual children is also found in the non-verbal domain using standard tasks reported in previous literature.

3.1. Introduction

There is evidence pointing out that the bilingual experience impacts on one’s cognitive abilities (Bialystok, 1999; Bialystok, 2007; Bialystok, 2015; Bialystok et al., 2009; Bialystok et al., 2012; Costa & Sebastian-Galles, 2014; Hernandez et al., 2010; Hernández et al., 2013; Kroll & Bialystok, 2013; Peal & Lambert, 1962) and shapes mind and brain (Barac et al., 2016; Bialystok et al., 2012; Costa & Sebastian-Galles, 2014). These studies have associated the bilingual experience with enhanced components of the executive function (EF). At present, however it is not clearly understood which are the EF components that are precisely involved and improved as a result of being bilingual (Costa & Sebastian-Galles, 2014). However, as noted in Section 1.2.1 of the Introduction, it is proposed that an enhanced attentional control

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2 Parts of this Chapter have been included in a paper under review in Bilingualism, Language and Cognition (Pino Escobar, Kalashnikova, & Escudero, under review)
may be the attribute that aids bilinguals’ higher performance under cognitive tasks (Bialystok, 2015; Sorge et al., 2016).

While numerous studies have observed bilinguals’ higher cognitive performance than monolinguals (for a review see Bialystok, 2015; Kroll & Bialystok 2013), another group of studies consider that the findings are contradictory (Anton et al. 2014; Paap, Jhonson & Sawi, 2014; Paap & Greenberg 2013). They argue therefore that there are not strong indicators to attribute higher bilinguals’ higher cognitive performance when compared to monolinguals (as discussed in Section 1.4. of the introduction). However, it is suggested that a potential reason of discrepancies among studies may lie in the characteristics of the tasks used (See Hilchey & Klein, 2011 for a literature review). This idea posits that only high demanding tasks are appropriate to reveal a bilingual advantage (Costa et al., 2009; Martin-Rhee & Bialystok, 2008). Particularly, as noted in Sections 1.2 to 1.3 of the introduction, levels of attentional control demanded by tasks (high = interference suppression vs. low = response inhibition) have been pointed out as one of the factors that determine finding or not differences between language groups (Luk et al., 2010; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016).

Indeed, bilingual children have displayed greater performance than their monolingual counterparts when exposed to interference suppression tasks. This is particularly noteworthy because interference suppression poses high attentional control demands and requires solving conflictive dimensions, avoiding distractions from salient but irrelevant cues (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016). Contrariwise, bilingual and monolingual children have performed
similarly under response inhibition tasks (Bialystok et al., 2009; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016), which is less cognitive demanding than interference suppression. Response inhibition tasks are univalent and require solving conflict between two options of the same stimulus feature, where the correct option collides with an arbitrary unusual alternative (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016). It is suggested therefore that bilinguals’ attentional control performance is sensitive to the degree of conflict posed by the tasks. Hence, it has been observed in previous studies that bilinguals particularly outperform monolinguals under tasks that require a higher degree of conflict solving (Bialystok et al., 2009; Bialystok et al., 2012; Martin-Rhee & Bialystok, 2008; Sorge et al., 2016). It is proposed therefore that incorporating highly conflicting attentional tasks would contribute to capturing cognitive differences between bilinguals and monolinguals more efficiently than low demanding attentional tasks.

Demands on attentional control, however, would not only depend on the tasks’ specific characteristics but also on the child’s age. Hence, it has been proposed that interference suppression and response inhibition have different developmental trajectories (Bunge et al., 2002) and that both develop at different rates and are tapped by different tasks and measures at different childhood stages (Best & Miller, 2010; Iluz-Cohen & Armon-Lotem, 2013; Lehto et al., 2003; Nigg, 2000). For instance, the Dimensional Card Change Sort (DCCS) task (Zelazo, 2006; Zelazo et al., 1997; Zelazo, Craik, & Booth, 2004) poses different levels in conflict. There is a standard or basic version of the task where children are expected to first sort a set of cards by one dimension (i.e., shape) and after that, children are expected to sort the same set of
cards by other dimension (i.e., by color). When performing the basic version of the DCCS, most three-years-old children, despite understanding the rules and knowing that they are expected to change sorting dimension from shape to color, keep on sorting by the previous dimension and fail at the post switch (Zelazo, 2006; Zelazo et al., 1996). Bialystok (1999) observed that four-year-old bilinguals performed similarly than five-year-old monolinguals in a variation of the DCCS task, attributing a bilingual developmental advantage of one year in this task. Four to five-year-old bilingual children outperformed monolingual children in a subsequent study using the task (Bialystok & Martin, 2004). After five years of age, most children succeed in the DCCS standard version (Zelazo, 2006). There is, however, an advanced version of the task that adds an extra level of conflict which incurs in interference suppression and it is used with older children (Carlson & Meltzoff, 2008; Zelazo, 2006). In this case a distinctive visual feature that could be a border (Zelazo, 2006) or a star (Carlson & Meltzoff, 2008) is added in some of the basic cards of the set, and children are expected to sort the basic cards by one dimension (i.e., by shape), and to sort the cards with the distinctive feature (starred or bordered) by the other dimension (i.e., by color) during one uninterrupted trial. Bilingual six-year-old children showed superiority over monolingual age-matched counterparts when tested with DCCS advanced version (Carlson & Meltzoff, 2008). In order to be successful at this task, children needed to hold two rules in mind and overcome a dominant salient cue (e.g., shape rule) to opt for the more relevant but less salient cue (e.g., colour rule) (Carlson & Meltzoff, 2008) during one testing trial. Still, it is not yet clear if the conflict demands in this task would reveal performance differences among seven to eight-year-old bilingual
and monolingual children. In adults however, computerised adaptations of the DCCS have been used, finding bilinguals more skilled in suppressing conflicting responses during the adaption of the task that required high cognitive demands for response suppression (Qu et al., 2016).

In contrast with the high attentional control requirements of the DCCS, the day-night Stroop task (Diamond et al., 2002; Gerstadt, Hong, & Diamond, 1994; Martin-Rhee & Bialystok, 2008) poses a lower demand of attentional control that incurs in response inhibition. In the day-night Stroop task, children are expected to say “night” when shown a figure depicting a bright shining sun and to say “day” when shown a figure depicting a dark moon figure. In this task response inhibition is required as children are expected to utter the option that collides with a usual response and to inhibit the correct response (See Section 1.3.1. of the introduction for a complete summary of the tasks). Children younger than five-years-old find it difficult to succeed at this task, whereas six to seven-years-old children find this task achievable (Diamond et al., 2002). Four to five-year-old monolingual and bilingual children performed similarly at the day-night Stroop task (Martin-Rhee & Bialystok, 2008). In the same previous study bilingual outperformed monolingual children in an interference suppression task (i.e., Simon task), confirming a bilingual advantage in interference suppression tasks but not in response inhibition tasks (Martin-Rhee & Bialystok, 2008). Little is known whether seven to eight-year-old bilingual and monolingual children would display the same performance patterns in this task. Two tasks that assess monolingual and bilingual children’s performance under high (DCCS) and low levels (Day-Night Stroop task) of attentional control demands were
selected. A bilingual advantage in the DCCS task was predicted because it requires higher demands on attentional control, which have been observed previously in bilinguals (Carlson & Meltzoff, 2008). Conversely, similar performance in bilinguals and monolinguals was predicted in the Day-Night Stroop task it requires response inhibition which is a low attentional demands task that has not revealed language group differences in previous studies (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008).

3.2. Method

3.2.1. Participants

Participants were the same as those described in Chapter 2 (Section 2.2.1) of the present thesis.

3.2.2. Tasks and procedure

All children completed the DCCS task advanced version and the day-night Stroop task. The DCCS was chosen to test high-order demands of attentional control (i.e., interference suppression) and the day-night to assess the low-order demands of attentional control (i.e., response inhibition). The order of administration of all tasks was counterbalanced across and within language groups. Approximately half of the monolingual ($n = 9$) and bilingual children ($n = 8$) completed the non-verbal tasks first and half completed the verbal tasks first. Similarly, half of the monolingual ($n = 8$) and half of the bilingual children ($n = 9$) were presented with the DCCS first and the other half with the Day-Night first.
Dimensional Card Change Sort (DCCS) – Advanced version (Carlson & Meltzoff, 2008; Zelazo, 2006; Zelazo et al., 1997): The stimuli for this task included 66 cards (13 x 10 cm) and two card sorters. Thirty-three cards (13 for training and 20 for testing) were used in each of two conditions counterbalanced across participants to ensure that the images chosen for the tasks did not affect children’s performance (Figure 3.1).

The two card sorters consisted on two translucent containers with one card attached to each on display. The first condition used a blue boat and a red rabbit attached to the sorters and the second condition used a red boat and a blue rabbit attached to the sorters. In each condition, 5 cards depicted the first object in one colour (e.g., blue boat), 5 cards depicted the second object in the second colour (e.g., red rabbit), and 16 cards depicted each of the objects in the opposite colour (e.g., 8 red boats and 8 blue rabbit). Additional 7 cards depicted the same objects but also had a yellow star placed at the top right corner of the card. For each condition three starred cards were used for training and 4 were used for testing: 1 blue rabbit, 1 red rabbit, 1 red boat, 1 blue boat with a star in each case. Thirteen cards (10 plain and 3 starred cards) were used for the training phase and 20 cards (16 plain and 4 starred cards) were used for the testing phase.
During the session, the child sat at a table facing the experimenter in a child-friendly laboratory room. The sorters were placed in front of the child. The experimenter started the task by saying “we are going play the shape game” and the child was trained to sort the cards by the shape dimension (e.g., boat or rabbit). After this learning phase, the experimenter announced that it is time to play the “colour game”, and this time the child was trained to sort the cards by colour. After passing this first part of the training phase, the experimenter said to the child “you are too good for this, so I am going to make it a bit trickier; now we are going to play the star game”. The child was then trained on the advanced version of the test where rules from the pre and post switch were merged. The experimenter explained that the cards marked with a star had to be sorted by colour and cards without a star had to be sorted
by shape. After training was completed (i.e., when the 13 training cards were sorted correctly), the testing phase began. In this phase, the 20 testing cards were used: 16 of them were not marked with a star and had to be sorted by shape, while four were marked with a star and had to be sorted by colour. The number of correctly sorted cards with a star (0-4) was used for analysis (Carlson & Meltzoff, 2008). Including instructions and training phase, this test took between 5 and 10 minutes.

**Day-Night Stroop Task (Day-Night) (Diamond et al., 2002; Martin-Rhee & Bialystok, 2008):** The stimuli consisted of 24 laminated pictures depicting a yellow shiny sun on a white background (12 pictures) and a moon with stars on a dark background (12 pictures) (Figure 3.2). The experimenter announced that it was time to play the “day and night game”. First, in the training phase, children were shown 12 cards (6 of each type) and were instructed to say “day” when they saw the sun cards and to say “night” when they saw the moon cards, as fast as they could. Then, children proceeded to the test phase where they were shown 12 cards (6 of each type) and instructed to say “night” when they saw the sun cards and “day” when they saw the moon cards, as fast as they could (Diamond et al., 2002; Martin-Rhee & Bialystok, 2008). The number of correct responses produced in the testing phase (out of 12) was used in the analysis. This task took around 5 minutes to complete, including the time for instructions.
3.3. Results

Children’s performance was analysed using Univariate Analyses of Variance (ANOVA) for each task. The analyses were conducted independently for each task. Results did not show a significant difference between monolingual ($M = 3.76, SD = .66$) and bilingual children’s performance ($M = 3.71, SD = .67$) in the DCCS task $F(1, 33) = .07, p = .801, \eta^2 = 0.002$. Similarly, in the Day-Night task, monolingual ($M = 11.06, SD = .90$) and bilingual children’s ($M = 11.59, SD = .62$) performance approached but did not reach statistical significance, $F(1, 33) = 4.00, p = .054, \eta^2 = 0.111$.

In order to further explore participants’ performance, response times for each of the tasks were also recorded and analysed using Univariate Analyses of Variance (ANOVA). It was found that monolingual children’s response time when sorting all the cards in the DCCS’s testing trial ($M = 62.39$ sec, $SD = 7.69$) did not differ from bilingual children’s response time ($M = 57.84$ sec, $SD = 8.46$), $F(1, 33) = 2.69, p = .111, \eta^2 = 0.076$. Similarly, there was not a significant difference between monolingual ($M = 26.14$ sec, $SD = 2.11$) and bilingual children’s ($M = 25.20$ sec, $SD = 2.11$) response times.
response time in the Day-Night whole testing trial $F (1, 33) = 1.227$, $p = .276$, $\eta^2 = 0.037$.

![Graph showing group differences for non-language processing tasks.](image)

**Figure 3.3.** Group differences for non-language processing tasks

Subsequently, the data was coded as binary, where “1” meant no mistakes and “0” represented one or more mistakes made in a task. It was found that, in the monolingual group fifteen of the 17 children did not make a mistake in the DCCS, and a chi-square test revealed that this number exceeded chance $X^2 (1, N = 17) = 9.941$, $p = .002$; as well that six of the 17 monolingual children did not make a mistake in the Day/Night and this number was not different from chance $X^2 (1, N = 17) = 1.471$, $p = .225$. Similarly, in the bilingual group it was found that fourteen of the 17 children did not make a mistake in the DCCS; and a chi-square test revealed that this number exceeded chance $X^2 (1, N = 17) = 7.118$, $p = .008$ and that eleven of the 17 bilingual children did not make a mistake in the Day/Night and this number was not different from chance $X^2 (1, N = 17) = 1.471$, $p = .225$. This further analysis
suggests that a comparable number of monolingual and bilingual children did not make mistakes in each of the tasks.

3.4. Discussion

In the present Chapter, bilingual and monolingual attentional control performance under non-verbal tasks was compared. Particularly performance was assessed under two levels of attentional control demands, namely, high attentional control demands with the DCCS and low demands with the Day-Night Stroop task. It was predicted that bilingual children would outperform monolinguals in the DCCS and that both language groups would perform similarly in the Day-Night Stroop task.

Predictions were not fully confirmed as findings showed that bilingual and monolingual children performed similarly in the advanced version of the DCCS. Even though previous studies using DCCS showed bilingual advantages in children (Bialystok & Martin, 2004; Carlson & Meltzoff, 2008), their participants were younger than the ones in the present study. It is possible that around seven to eight years of age, monolingual and bilingual children’s development of cognitive processes involved in these tasks have reached a similar stage. This interpretation coincides with observations in Ross and Melinger (2016) study with similar age group (children from 6 to 9 years old) pointing out that advantages in bilinguals are associated to the characteristics of the task and the participant sample included in the study. Thus, in the present study, it is likely that participants’ age was linked to low sensitivity to this version of the task, as children performed close to ceiling in both tasks (Zelazo, 2006). Therefore it may be that this task, which is commonly employed to test younger participants, was not an age-appropriate measure for interference
suppression (Best & Miller, 2010; Zelazo, 2006). It would be of interest for future research to include a more challenging adaptation of the task in order to reach sensitivity of the intended attentional components. For instance this task could be adapted into a more challenging one by adding sorting rules (i.e. additional shapes and colours) as well as by increasing the number of trials, as previously done by Zelazo, Craik & Booth (2004) and Qu et al. (2016).

Predictions were partially confirmed in that both groups performed similarly in the Day-Night task, which indicates that monolingual and bilingual children handled their cognitive resources similarly under a response inhibition task. This observation aligns with (Martin-Rhee and Bialystok (2008) that found four to five-year-old monolingual and bilingual children performing similarly in this task, suggesting that lower attentional control demands (i.e., response inhibition) may not be enhanced by bilingualism. In the present experiment, however, this suggestion it is still disputable because in this case, the analyses approached significance showing a trend for bilingual children to outperform monolinguals in the Day-Night task. Appendix C shows the comparative individual scores for monolingual and bilingual participants in each of the non-verbal tasks. As can be seen in the table, both individual and average performance is comparable across the monolingual and bilingual children.

Therefore, it is also plausible that bilinguals’ attentional control skills were slightly enhanced under response inhibition demands due to their practice on inhibiting cross-language interference in daily communication. This is conceivable because in this case bilingual participants were exposed to two languages from birth,
and they were also highly proficient receptive and productive bilinguals, which may have provided them with an extra boost in their cognitive skills.

3.5. Chapter Summary

In summary, the present Chapter showed no differences in performance in attentional control tasks between bilingual children and their monolingual matched counterparts, possibly because of low task sensitivity. These results are in contrast with the findings in Chapter 2 that showed evidence of an attentional bilingual advantage in the language processing domain under VFT-letter and VFT-category. Chapter 4 addresses the final research question (i.e., does attentional control performance in children correlate across domains?), by relating verbal and non-verbal measures using correlation and regression analyses. Specifically, the next Chapter will investigate how verbal tasks, linguistic proficiency, and non-verbal attentional control interact, with the aim of unraveling the attentional control mechanisms underlying verbal performance in bilingual and monolingual children.
Chapter 4: Relating performance in verbal and non-verbal tasks of attentional control in bilingual and monolingual children

Chapters 2 and 3 presented experiments comparing bilingual and monolingual children’s performance in attentional control tasks in the verbal and non-verbal domains respectively. Chapter 2 showed differences between bilingual children and their monolingual matched counterparts in letter and category VFTs, evidencing a bilingual advantage in the verbal domain. In Chapter 3, assessments in the DCCS and Day-Night Stroop task revealed similar results in both language groups. It remains unknown whether there is an interaction between children’s performance in the verbal and non-verbal tasks. In the present Chapter the data from the verbal and non-verbal tasks is assessed in order to address research question 2 of the present thesis: Does attentional control performance in children correlate across domains?

4.1. Introduction

As discussed in Chapters 2 and 3, both the verbal and non-verbal tasks selected for this study have been proposed to rely on attentional control abilities. This reliance on attentional control when solving verbal tasks has been supported in neurophysiological research, which indicates that attentional neural regions largely account for language control and processing and that this occurrence is more prominent in bilinguals (See Abutalebi & Green, 2008 for a review). Similarly, Bialystok et al. (2009) reviewed several neuroimaging studies showing brain areas used when solving non-verbal complex conflict (i.e., interference suppression), namely the prefrontal cortex and the anterior cingulate cortex, were involved while

3 A version of this Chapter is currently under review in Bilingualism, Language and Cognition (Pino Escobar, Kalashnikova, & Escudero, under review)
bilinguals performed on verbal tasks. Furthermore, it was also found that different neural correlates are utilised during interference suppression and response inhibition tasks by monolingual and bilingual young adults (Luk et al., 2010). This evidence therefore points out that both verbal and non-verbal attentional control processes occur in the same brain areas.

There are only few studies that have directly explored this relation. For instance, Blumenfeld and Marian (2011) tested bilingual and monolingual young adults with a receptive linguistic task (receptive cross-linguistic competition) and a non-verbal Stroop task, both reliant on response inhibition. The study found that even though the relation between linguistic and non-linguistic tasks was stronger in bilinguals than monolinguals, there was a consistent relationship between nonverbal inhibition and resolution of phonological competition across both language groups. To add to this line of research, I assessed children’s performance across verbal (letter and category VFT) and non-verbal (DCCS and Day-Night Stroop task) behavioral tasks to determine whether the same cognitive processes underlie performance in both domains. Furthermore, the relation between both domains in tasks that pose two levels of cognitive demands in attentional control (high = interference suppression versus low = response inhibition) was explored, which can clarify contrasting results across studies that have used tasks with different levels of difficulty. Identifying a link between verbal and non-verbal attentional control could potentially provide empirical support for cognitive benefits during language processing in bilinguals.

The aim of the present study was therefore to further investigate the interplay between vocabulary size, general non-verbal attentional control abilities and
monolingual and bilingual children’s performance in verbal tasks. The two verbal measures from this study (reported in detail in Chapter 2) were the letter and category VFTs, which assessed respectively high- or low-order demands of attentional control and lexical access. The advanced version of the Dimensional Card Change Sort (DCCS) and the Day-Night Stroop Task (Day-Night) were the non-verbal measures of attentional control (reported in Chapter 3), which assessed high- or low-order demands of attentional control via interference suppression or response inhibition respectively. Thus, verbal and non-verbal tasks were categorised according to their cognitive demands as follows: category VFT (verbal - low demand), letter VFT (verbal – high demand), Day/Night Stroop (non-verbal - low demand), and advanced DCCS (non-verbal - high demand).

Regression models were constructed to investigate the relations described above. It was predicted that both general attentional control skills and English vocabulary size would predict performance in letter VFT. This prediction is based on previous studies showing that letter VFT demands greater cognitive exertion, potentially engaging interference suppression skills (Luo et al., 2010). As well, vocabulary size is expected to predict letter VFT performance because previous studies have shown that high vocabulary proficiency leads to a better performance in this task (Bialystok et al., 2008; Luo et al., 2010). I expected therefore that performance in the non-verbal task with high cognitive demands (DCCS), would predict performance in the letter VFT for both monolingual and bilingual children, as both tasks exert high cognitive efforts related to interference suppression. In contrast, children’s English vocabulary size and not their general attentional control skills are
expected to underlie performance in the category VFT because previous findings suggest that this task relies mostly on children’s lexical semantic knowledge rather than on general cognitive skills (Luo et al., 2010).

4.2. Analysis and results

Performance in the four tasks completed by participants and reported in Chapters 2 and 3 were considered for correlation and regression analyses. First, Pearson correlations were conducted to assess the relationships between children’s performance in the non-verbal and verbal tasks and their English language proficiency measured by PPVT (Table 4.1). As expected, PPVT scores were positively correlated with the number of words retrieved in both letter and category VFT. In line with our predictions regarding the levels of cognitive demands incurred by each task, DCCS and letter VFT scores were significantly correlated, and the correlation between Day-Night and category VFT scores approached significance. These correlational patterns confirm that the non-verbal and verbal tasks engaged different aspects of attentional control, whereby letter VFT and DCCS engaged interference suppression, while category VFT and Day-Night engaged response inhibition.

Additional correlational analyses were conducted separately for each language group (p-values adjusted to .025 using the Bonferroni correction) to assess whether results differed across the two language groups. In this case, only the correlation between category VFT and PPVT scores was significant in the monolingual group, \( r(17) = .687, p < .001 \), and the correlations between letter VFT and PPVT and category VFT and PPVT scores in the bilingual group, \( r(17) = .651, p = .005 \) and \( r(17) = .637, p = .006 \), respectively. Also, in the bilingual group, the correlation
between DCCS and letter VFT scores did not reach significance, \( r(17) = .457, p = .065 \), as well all other correlations did not reach statistical significance, all \( p > .2 \).

These additional analyses confirm the significant role of vocabulary size in monolingual and bilingual children’s VFT performance, but it is possible that they did not reveal the correlations between the verbal and non-verbal domains that were found for the entire sample due to the small size of the two language groups.

Table 4.1.

**Correlations for monolingual and bilingual children’s scores on the non-verbal and verbal experimental tasks and PPVT scores.**

<table>
<thead>
<tr>
<th></th>
<th>Day/Night</th>
<th>Letter VFT</th>
<th>Category VFT</th>
<th>PPVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCCS</td>
<td>-.118</td>
<td>.346*</td>
<td>.027</td>
<td>.099</td>
</tr>
<tr>
<td>Day/Night</td>
<td>.134</td>
<td>.333+</td>
<td></td>
<td>.136</td>
</tr>
<tr>
<td>Letter VFT</td>
<td></td>
<td></td>
<td>.499**</td>
<td>.391+</td>
</tr>
<tr>
<td>Category VFT</td>
<td></td>
<td></td>
<td></td>
<td>.493**</td>
</tr>
</tbody>
</table>

\[* p = .055, ^p < .05; ** p < .01.\]

To further investigate the role of vocabulary proficiency and attentional control in children’s VFT performance, multiple linear regression analyses were conducted with letter and category VFT scores as the dependent variables, and PPVT, DCCS, and Day-Night scores as the predictor variables (see Table 4.2). The first model with letter VFT as the dependent variable, explained 19% of variance with both PPVT and DCCS, but not Day-Night as significant predictors. The second model that included category VFT as the dependent variable, the only significant predictor was PPVT explaining 25% of variance. Thus, while vocabulary knowledge plays a
significant role in children’s performance in both versions of the VFT, attentional control abilities, specifically interference suppression assessed by DCCS, only predicted performance in the letter VFT.

Table 4.2.

*Multiple regression analyses with factor scores for PPVT Standard Scores, DCCS Task, and Day-night Stroop task as the predictor variables and VFT-letter or VFT Category as the dependent variable*

<table>
<thead>
<tr>
<th></th>
<th>Letter VFT: $R^2 = .19$, $F(3, 33) = 3.587$, $p = .025$</th>
<th>Category VFT: $R^2 = .247$, $F(3, 33) = 4.603$, $p = .009$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B$</td>
<td>$SE$</td>
<td>$T$</td>
</tr>
<tr>
<td>PPVT</td>
<td>.341</td>
<td>.037</td>
</tr>
<tr>
<td>DCCS</td>
<td>.328</td>
<td>.820</td>
</tr>
<tr>
<td>Day-Night</td>
<td>.127</td>
<td>.680</td>
</tr>
</tbody>
</table>

4.3. Summary and discussion

The present Chapter addressed research question 2: Does attentional control performance in children correlate across domains? To answer this question, the results of the verbal tasks reported in Chapter 2 and those of the non-verbal tasks reported in
Chapter 3 were entered in correlation and regression analyses. These analyses enabled us to examine the interaction between language-based tasks, vocabulary proficiency and non-verbal attentional control in monolingual and bilingual children.

Correlational analyses showed that the verbal and non-verbal tasks with high demands of attentional control, namely the DCCS and the letter VFT, were positively correlated. The correlation between verbal and non-verbal tasks with lower demands of attentional control, namely the Day-Night Stroop task and the category VFT, approached significance. As well, a strong positive correlation between both VFTs performance scores and vocabulary size (as measured by PPVT scores) was observed. Regression analyses confirmed that both bilingual and monolingual children’s letter and category VFT performance was predicted by their English receptive vocabulary scores, but only performance in the letter VFT was also predicted by higher order attentional control skills (i.e., performance in the DCCS task).

Previous behavioral and neurological evidence has demonstrated that the letter and category versions of the VFT relate to two different underlying constructs (Friesen et al., 2015; Luo et al., 2010; Sandoval et al., 2010). While letter VFT incurs greater levels of attentional control, category VFT relies primarily on semantic knowledge. The present results provide further evidence for this dissociation. Specifically, results show that higher order non-verbal attentional control skills only underlie performance in letter VFT. These findings suggest that both monolingual and bilingual eight-year-olds are capable of engaging their attentional control skills to perform successfully in this complex lexical retrieval task. Contrastingly, the regression analyses showed that vocabulary size scores rather than non-verbal
measures of attentional control predicted performance in the category VFT. This result indicates that children employed their vocabulary knowledge and did not recruit general attentional control skills during category VFT, as proposed in Friesen et al. 2015. This study therefore supports previous neurophysiological research showing that monolingual and bilingual performance in a highly demanding verbal task, such as letter VFT relies on general attentional control skills (Abutalebi & Green, 2008; Bialystok et al., 2009); incurring particularly in interference suppression. It also evidences that interference suppression and response inhibition tasks recruit different cognitive components, confirming observations from previous neuroimaging studies (Luk et al., 2010). Next, Chapter 5 will present the General Discussion detailing this study’s key findings, its limitations and suggestions for future research.
Chapter 5: General Discussion

5.1. Thesis summary

The overarching goal of this thesis was to investigate the impact of bilingual experience on the cognitive attentional control skills in children in two different areas: the verbal domain and the non-verbal domain. Furthermore, it was of interest to explore the relation between the verbal and non-verbal cognitive domains during childhood. To address these aims, the following specific research questions were formulated:

1. Do bilingual and monolingual children display differences in performance in behavioural measures of attentional control? And if so;
   1. A. Is there a difference in the verbal domain?
   1. B. Is there a difference in the non-verbal domain?

2. Does attentional control performance in children correlate across the verbal and non-verbal domains?

For this thesis, bilingual participants were heterogeneous Australian-born, simultaneous bilinguals from birth, recruited under stringent criteria (Chapter 2). Two versions of the VFT were selected as measures for the verbal domain (Chapter 2) and two standard cognitive tasks were selected for the non-verbal domain (Chapter 3). The tasks in each domain incurred two levels of attentional control that were matched across domains: high and low. That is, the two versions of VFT used to measure monolingual and bilingual children’s performance under high (letter VFT) and low levels (category VFT) were matched respectively with the DCCS (high level) and the Day-Night Stroop task (low level).
Findings in Chapter 2 partially confirmed the prediction that bilingual children outperformed their monolingual counterparts in the letter VFT. However, expectations that both language groups would perform similarly in category VFT were not confirmed as bilingual children also outperformed their monolingual counterparts in this version of the task. In Chapter 3 no performance differences between bilingual children and their age-matched monolingual counterparts were revealed in either of the nonverbal tasks.

Finally, Chapter 4 examined the relation between children’s performance in the verbal and non-verbal tasks. In this part of the thesis, the two verbal and the non-verbal tasks were selected according to their attentional control demands as follows: the letter VFT (verbal – high demand) was paired with the advanced DCCS (non-verbal - high demand) and the category VFT (verbal - low demand) was paired with the Day/Night Stroop (non-verbal - low demand). The PPVT was entered as a measure of lexical proficiency (i.e. vocabulary size). It was found that both receptive vocabulary size (i.e. PPVT scores) and interference suppression measures (i.e. DCCS scores) predicted performance in the letter VFT. However receptive vocabulary size (i.e. PPVT) predominantly underlies category VFT over response inhibition (i.e. Day-Night) which only appears to approach as a significant predictor. It was hence proposed that during lexical retrieval that exerts complex attentional control (i.e. letter VFT), seven to eight-year-old monolingual and bilingual children are capable to recruit high levels of attentional control (i.e. interference suppression) to efficiently classify and retrieve lexical units whenever semantic cues are not available.
5.2. General discussion and future research

Findings in Chapter 2 of a bilingual advantage in the letter and category VFT are explained in light of two important elements in the design of this study. First and utmost, the characteristics of the bilingual population have been carefully considered and strictly followed during this study. Previous studies have indicated that the onset of bilingual acquisition and the degree of bilingual proficiency are crucial aspects that potentially impact on children’s cognitive outcomes (Friesen et al., 2015; Kroll, 2015; Kroll, Dussias, Bice, & Perrotti, 2015). Selecting bilingual children from birth with high receptive and productive bilingual proficiency has been deliberate and crucial in the design of this thesis. These characteristics directly influence the attentional control bilinguals constantly exert in order to avoid cross-language interference. The more opportunities and time of usage of both languages, the more high attentional control bilinguals are able to attain (Kroll & Bialystok, 2013; Kroll et al., 2015). Previous studies have shown that bilinguals’ both languages are concurrently active during receptive and productive communication (See Kroll et al., 2015, pp. 380-382 for a review). Therefore, bilingualism shapes bilinguals’ attentional control skills in order to suppress the language not being used while at the same time organizing, sorting and retrieving elements from the language in use. The present study attributes the bilingual advantage in both letter and category VFT to the bilingual experience.

The second and complementary element in the design of this study is the similarity between bilingual and monolingual groups in age and gender, which were closely matched. It has been observed by previous studies that children cognitively develop in short time frames, so that age differences would naturally impact on the
study’s results (Korkman, et al., 2001). In similar way, gender balance across language groups plays a crucial role in cognitive studies in childhood, as it has been proposed that around four to seven years of age girls display a better performance in many behavioural tests when compared with boys (Palejwala & Fine, 2015) and after that, slight cognitive advantages in the linguistic area are displayed by girls (Hyde, 2016). Furthermore, in the present study both groups of children exhibited similar parental education background and schooling (as SES indicators). It has been shown that SES influences performance in a range of behavioural tasks (Valian, 2015). The factors included in the SES construct significantly influence children’s cognitive experience (Christensen et al., 2014; Lee & Burkam, 2002) and their long term cognitive outcomes (Roberts et al., 2007).

In the case of the non-verbal measures of attentional control assessed in Chapter 3, no significant differences were found between the two language groups in this study. It is possible that by eight years of age monolinguals and bilinguals’ development of cognitive processes involved in these non-language processing tasks have reached a similar stage, as it was proposed by Ross and Melinger (2016) for children between six and nine years of age. Performance in the two language groups approached ceiling, so it is also possible that these two tasks, which are commonly employed to test younger participants, were not age-appropriate measures for response inhibition and interference suppression (Best & Miller, 2010; Zelazo, 2006). However it has been also observed that previous studies have adapted computarised versions of the task and successfully used it with adults (Qu et al., 2016); which indicates that the task was appropriate. Another more likely explanation is that the
small size of each language group lacked enough power to reveal differences. It would be of interest for future research to include a larger number of participants and a more comprehensive battery of non-verbal measures in order to test further the dissociation between response inhibition and interference suppression and their relation to children’s performance in verbal fluency tasks.

Even though no group differences were found in the analyses presented in Chapter 3, it is noteworthy that Chapter 4 that integrated experiments from Chapters 2 and 3, reported different results. Results evidenced that higher order general attentional control skills (i.e. interference suppression assessed by the DCCS task) only underlie performance in letter VFT. These findings indicate that both monolingual and bilingual eight-year-olds are capable of engaging their attentional control skills to perform successfully in this complex lexical retrieval task, and this ability is particularly important for bilingual children. This is because compared to their monolingual counterparts, bilinguals tend to have lower linguistic abilities in each of their languages, and they experience cross-language competition manifested in language production tasks (Bialystok et al., 2008; Blumenfeld & Marian, 2009; Sandoval et al., 2010). Thus, the ability to recruit their attentional control skills in a language production task allows bilingual children to overcome these additional challenges. Friesen et al. (2015) demonstrated a similar effect in ten-year-old children. In their study, the bilingual disadvantage usually detected in lexical tasks became non-apparent after participants were matched for vocabulary size in the target language. In this study, I extend those findings by demonstrating that by eight years of age, bilingual children already have the ability to balance their deficits in linguistic
proficiency with their advanced executive functioning skills to overcome the verbal and attentional control demands of the letter fluency task. The letter VFT used in this study however was more demanding than the version previously used with child participants (Friesen et al., 2015; Kormi-Nouri et al., 2012) as it required children to avoid proper nouns and morphologically related words. This may have provided a more sensitive measure of interference suppression skills in the process of lexical retrieval leading to a bilingual advantage, which has not been found in previous studies (Friesen et al., 2015; Kormi-Nouri et al., 2012). While it is possible that this task’s characteristic may have impacted children’s performance, I would argue that the advanced English proficiency in the bilingual sample is a more likely explanation for the present findings. As discussed above, when bilingual children’s vocabulary size in the target language is lower, they are able to engage their attentional control skills as a protective factor in lexical retrieval and achieve similar performance to same-aged monolinguals. However, in a highly proficient bilingual sample as in the case of the present study, advanced English vocabulary ability and attentional control skills allowed bilinguals to outperform their monolingual counterparts in both the letter and category VFTs.

Concurrently, contrary to predictions in Chapter 2, the bilingual group in this study also outperformed monolinguals in the category VFT. This is an unexpected finding as category VFT incites semantic word retrieval and mostly relies on participants’ linguistic knowledge rather than in general non-verbal executive functions. This was also demonstrated by regression analyses in Chapter 4 where only PPVT but not non-verbal measures of executive functioning predicted performance in
this version of the VFT. Furthermore, category VFT may in fact represent a greater challenge for bilinguals (than for monolinguals) since the activation of lexical items from a particular semantic category leads to the concurrent activation of all translational equivalents for this item, requiring them to suppress non-target language’s items while performing the task. One possibility is that bilinguals in this study are linguistically overachievers. This observation is based in that bilinguals usually display lower vocabulary scores than monolinguals; however this sample exhibited high proficiency in both English and their other language. It is also possible that the English semantic abilities for the bilingual children in this study were higher than for bilinguals in other studies, as they grew up in an English-speaking environment from birth. Another potential explanation is that bilinguals’ performance in this task was also boosted by their non-verbal executive functioning skills. While bilinguals were not shown to outperform monolinguals in the non-verbal measure of response inhibition used here, the relation between response inhibition and category VFT scores approached significance. Therefore, it is plausible that bilinguals’ attentional control skills also allowed them to be more successful at inhibiting the cross-language interference while performing in this modality of the task.

5.3. Limitations

It is acknowledged that one intrinsic overall limitation of this research is that it is based on behavioural measures of executive functions. It has been recurrently observed in previous research that it is difficult to attribute the measure of one individual executive function to one specific task (Miyake & Friedman, 2012; Miyake et al., 2000), also known as the “task impurity problem” (See Valian, 2015 p. 7 for a
short review). That is, various dimensions of executive function are intertwined and working together at different extents under one given behavioural task. For instance in the DCCS task, working memory, shifting mental sets (e.g. flexibility) and inhibition are involved in conjunctly with interference suppression; whereas in the Day-Night, univalent response inhibition and shifting are required (Bunge et al., 2002; Martin-Rhee & Bialystok, 2008). Additionally, in the present thesis, the use of behavioral measures posed an unexpected difficulty on adjusting task demands. Particularly, the nonverbal tasks of DCCS and Day/Night initially were thought to be able to give a sensitive measure of eight-year-old performance. However, results were found to be close to ceiling and therefore insufficient to significantly reveal interference suppression and response inhibition in the nonverbal domain. The same occurs with the VFT where working memory and shifting are conjunctly required with attentional control during its execution. Still, attentional control is concurrently activated with other EF components during most tasks (Sorge et al., 2016). In the present study, it was also challenging to determine the cognitive processes involved in each of the VFT versions, particularly because results did not exactly fit our predictions. In particular, Category VFT showed a larger group effect than initially expected, requiring rethinking initial predictions that could be better tested in further studies.

Another limitation to be considered is participants’ individual differences within groups and more relevantly within the bilingual sample. It is crucial to consider each individual’s complexities and to acknowledge that the bilingual status is not a fixed quality (Valian, 2015). Particularly, it is crucial to acknowledge that
bilingualism is a dynamic construct that evolves in each individual depending on their unique experiences and variables (Hakuta, Ferdman, & Diaz, 1987). As it can be observed in the current bilingual participants, even though all of them were born in Australia with at least one parent that spoke to them in their heritage language, their bilingual proficiency varies from native like to low, corroborating once more that bilingual performance is variable. Thus, each individual’s cognitive world (regardless their language background) is complex enough to obstruct a clear cut vision in studies that assess cognitive processes. Therefore recent research trends that consider bilingualism status as a continuum rather than as a fixed variable (Sorge et al., 2016; Yow & Li, 2015) could be a useful pathway to take for a future complementary study of the present research.

5.4. Implications

The implications of these findings extend to children’s homes (and carers) and the education system (i.e. preschool, school). Parents and carers of both bilingual and monolingual children should be informed of the role of language input and exposure in children’s cognitive performance and be encouraged to help their children to enrich their vocabulary in different ways. Particularly in Australia, being a multicultural country with a good number of people born overseas, speaking two or more languages is a common occurrence. There, children may be brought bilingual as a result of a conscious decision by bilingual parent(s) or because there is no other choice for parents that only have a command of a language other than English (LOTE). Furthermore, in the former case, common misconceptions and fear for potential difficulties during early schooling may encourage bilingual parents to leave out the
LOTE when speaking to their children. Hence the importance of communicating the present findings as being fully exposed to bilingualism from birth benefits the attentional control and verbal proficiency in early-school-aged children. Therefore parents of bilingual children need to hear the present results clearly and loudly, and should be informed of the advantages to preserve both their languages.

The education system should also be aware of the advantages of being bilingual found in the present study and in other similar studies, so they can take actions to give more support to community languages schools (Cardona, Noble, & Di Biase, 2008) and to encourage bilingual students to keep and enrich their languages at mainstream schools. At the same time policies could be implemented to give more importance to foreign languages subjects at school, so that monolingual children can also enjoy some of the benefits of learning a second language.

5.5. Conclusion

In sum, findings from this study indicate that the bilingual experience from birth does enhance children cognitive abilities required for verbal communication. Second, this study evidences that eight-year-old bilingual children recruit higher attentional processes during verbal tasks, exhibiting a more efficient processing and retrieval of words than their monolingual peers. This efficiency is apparent when bilinguals’ vocabulary size is similar than monolinguals’. However similar vocabulary proficiency between monolinguals and bilinguals is not a common situation in the broader population, but instead it is often smaller than in their monolingual peers (Bialystok et al., 2010). One of the main reasons is that bilingual children’s language learning process (exposure and production) is divided by two languages which
decreases learning time in each language, while monolingual children’s verbal interaction time is integrally dedicated on absorbing and learning only one language (Bialystok, 2017; Kroll et al., 2015). However the same situation that may cause bilinguals to have a smaller vocabulary size is what may be aiding them on achieving a better cognitive performance. This is because during the bilingual acquisition process from birth, extra cognitive resources are exerted. Bilingual children therefore manage to arrange and develop more complex cognitive strategies to cope with everyday communicative needs in both their languages at roughly the same pace of their monolingual counterparts do with only one language. Equipping bilingual children with a richer vocabulary in both their languages would further optimise their cognitive performance extending it to the verbal domain.
References


Friesen, D. C., Luo, L., Luk, G., & Bialystok, E. (2015). Proficiency and control in verbal fluency performance across the lifespan for monolinguals and


Appendix A: Child Language Background Questionnaire

Participant information – To be filled out by the researcher
Project code: ____________________ Today’s date: ________________

1. Demographic information

Child’s date of birth ____________________________________________

Which hand does your child use to write with (circle the one that best describes him/her):

always right  usually right  ambidextrous  usually left  always left

Does your child have a hearing impairment or reading difficulties (e.g., difficulties learning to read), or language development or speaking difficulties (e.g., delayed language development, stuttering, lisping, etc.)?

Yes  No

If yes, circle any/all that apply:

hearing  reading  speaking  language

Type/Degree? ..............................................................................................................................

Please tell us every place your child has lived for at least three months or more, starting with his/her infancy and childhood. If you lived in a city, please also indicate which area or town/suburb:

<table>
<thead>
<tr>
<th>Country</th>
<th>City/Town/Region</th>
<th>Between which ages?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Does your child attend school?  Yes(-------)  Not (--------)  .........................  Year of school  .................

Please circle: (Private) or (Public) school.
School postcode or suburb ............................................

Does this school teach a language other than English as part of the curricula?

(-------)Not.  (-------) Yes.
Language(s) it teaches: ..................................................
This language is taught ........ hours per week.
Does your child learn a language other than English in classes outside school hours? (eg. Community language schools, languages institutes, etc).
Not (.........). Yes (.........) Hours per week...............

**Extracurricular activities**

1. Does your child play a musical instrument? If so, please list the musical instrument(s) and the total time of practice playing the instrument per week.
   - ................................................................. Time per week ......................................
   - ................................................................. Time per week ......................................
   - ................................................................. Time per week ......................................

2. Does your child practice dance or a sport? If so, please list the physical activities your child practices and the total time of practice per week.
   - ................................................................. Time per week ......................................
   - ................................................................. Time per week ......................................
   - ................................................................. Time per week ......................................

3. Does your child practice(s) any other activity? (yes)   (not)
   - ................................................................. Time per week ......................................

4. Has your child practiced any of those of other activities in the past? (yes)   (not). If yes, please state ages and/or years.................................................................Activity(ies):.................................................................

5. How many siblings does your child have?.............. What is his/her order of birth in relation to his/her siblings? (i.e. first child, second, etc).........................

**1.1 Parent/Caregivers’ information**

**Parent/Primary caregiver:** (e.g. mother, father, etc) _________________________________

Native language(s)/accent(s): _______________________________________________________

Other language(s)/accent(s): _______________________________________________________

Language(s) used by this caregiver:
• with your child: _________________________________________________________________
• in the home: _________________________________________________________________
• with other family members: _____________________________________________________
• with people outside the home: __________________________________________________

Place of birth: _______________________________

Current residence: ___________________________ Postcode:________________

Please list all places where this caregiver has lived, when they lived there, and for how long, in chronological order:

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Higher education level achieved (please circle one)
- Primary school (year....)  - High school (year....)  - TAFE or college (complete or incomplete)  - University (Incomplete)  - University (Complete)  - University Postgraduate  - Other ............

Current occupation......................................................... (Part time) (Full time)

**Parent/Other primary caregiver:** ____________________________

Native language(s)/accent(s): ________________________________

Other language(s)/accent(s): ________________________________

Language(s) used by this caregiver:
- with your child: __________________________________________
- in the home: ____________________________________________
- with other family members: ________________________________
- with people outside the home: ______________________________

Place of birth: ________________________________

Current residence: ____________________________ Postcode:_________

Please list all places where this caregiver has lived, when they lived there, and for how long, in chronological order:

____________________________________________________________

Higher education level achieved (please circle one)
- Primary school (year....)  - High school (year....)  - TAFE or college (complete or incomplete)  - University (Incomplete)  - University (Complete)  - University Postgraduate  - Other ............

Current occupation......................................................... (Part time) (Full time)

**Other caregiver(s):** ____________________________

Native language(s)/accent(s): ________________________________

Other language(s)/accent(s): ________________________________

Language(s) used by this caregiver:
- with your child: __________________________________________
- in the home: ____________________________________________
- with other family members: ________________________________
- with people outside the home: ______________________________

Place of birth: ________________________________

Current residence: ____________________________ Postcode:_________

Please list all places where this caregiver has lived, when they lived there, and for how long, in chronological order:

____________________________________________________________________________
Higher education level achieved (please circle one)
- Primary school (year.....)
- High school (year.....)
- TAFE or college (complete or incomplete)
- University (Incomplete)
- University (Complete)
- University Postgraduate
- Other .................

Current occupation................................................................. (Part time) (Full time)

Please list these caregivers in order of amount of time your child has spent with them. Also indicate approximately how many hours per week your child spends with each of them during a typical week.

1. ______________________________ Approx. hours spent per week: _____________
2. ______________________________ Approx. hours spent per week: _____________
3. ______________________________ Approx. hours spent per week: _____________

1.2 Languages in your child’s environment

Please list all the languages that your child is regularly exposed to, and for each language and accent, the approximate percentage of the time that your child hears it on a weekly basis. Note: This should add up to 100%.

<table>
<thead>
<tr>
<th>Language(s)/Accent(s)</th>
<th>Percentage of the time that your child hears this language on a weekly basis:</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

2. Current Language/Accent Proficiency

Please evaluate your child’s current level of proficiency for all languages that he or she has ever been exposed to (begin with your child’s stronger language):
If your child has been exposed to more than the above 3 languages or accent, please list the others here and comment on your child’s general proficiency for each:

<table>
<thead>
<tr>
<th>Language: ______________________________</th>
<th>Accent(s) ____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral comprehension: very low low intermediate advanced near-native native</td>
<td></td>
</tr>
<tr>
<td>Oral production: very low low intermediate advanced near-native native</td>
<td></td>
</tr>
<tr>
<td>Pronunciation: very accented accented slightly accented near-native native</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language: _____________________________</th>
<th>Accent(s) ____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral comprehension: very low low intermediate advanced near-native native</td>
<td></td>
</tr>
<tr>
<td>Oral production: very low low intermediate advanced near-native native</td>
<td></td>
</tr>
<tr>
<td>Pronunciation: very accented accented slightly accented near-native native</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Language: ______________________________</th>
<th>Accent(s) _____________________________</th>
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</thead>
<tbody>
<tr>
<td>Oral comprehension: very low low intermediate advanced near-native native</td>
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<tr>
<td>Oral production: very low low intermediate advanced near-native native</td>
<td></td>
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<tr>
<td>Pronunciation: very accented accented slightly accented near-native native</td>
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</table>

<table>
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<tr>
<th>Language: ____________________________</th>
<th>Accent(s) ____________________________</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Oral production: very low low intermediate advanced near-native native</td>
<td></td>
</tr>
<tr>
<td>Pronunciation: very accented accented slightly accented near-native native</td>
<td></td>
</tr>
</tbody>
</table>
3. Evolution of Language/Accent Use (Fill only if your child speaks more than one language)

1. In the first row, fill in the age or calendar years corresponding to your child’s education level specified on top of each column. **Please ask the researcher if you need help.**

2. In each cell, use **percentages** to indicate your child’s usage of/exposure to English and other languages (combined) for the corresponding context and age.

<table>
<thead>
<tr>
<th>Age 2 to kindergarten</th>
<th>Kindergarten</th>
<th>Early elem. (Year 1-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>School:</strong> i.e. language of instruction. If language immersion, please specify in comments</td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
<tr>
<td><strong>At home:</strong> interactions with immediate (mum, dad and siblings) and</td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
<tr>
<td><strong>Friends:</strong> interactions with friends</td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
<tr>
<td><strong>Media use:</strong> media, leisurely reading, television, cinema,</td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
<tr>
<td><strong>Extracurricular activities:</strong> sports, hobbies, work (if part-time)</td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
<tr>
<td><strong>Daily activities in the community:</strong> grocery store, shopping mall, restaurant, gas station</td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
<tr>
<td><strong>Other:</strong></td>
<td>AusEng: other:</td>
<td>AusEng: other:</td>
</tr>
</tbody>
</table>
Comments:

________________________________________________________________________________________
____________________________________________________________________________________________

Please use the following table to indicate the usual daily activities of your child and the language that he/she listens to when involved in these activities. For instance, your items may include: Play time – Australian English, Grandparents visit – Spanish, Library Play Group – British English, etc.

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>8am – 10am</td>
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<td></td>
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<tr>
<td>10am – 12pm</td>
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<tr>
<td>12m – 2pm</td>
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<tr>
<td>2pm – 4pm</td>
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<td>4pm – 6pm</td>
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<tr>
<td>6pm – 8pm</td>
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<tr>
<td>8pm – 10pm</td>
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</tbody>
</table>

3. How much does your child speak ............................................... with his/her parents, out of 100%? .........................................%
4. How much does your child speak .................. with his/her siblings, out of 100%? .......................% 

Thank you!
Appendix B: Individual row data of monolingual and bilingual participants’ performance in verbal tasks.

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (Months)</th>
<th>1=female 2= male</th>
<th>VFT-Letter</th>
<th>VFT-Category</th>
<th>PPVT standard score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>101</td>
<td>2</td>
<td>5</td>
<td>12</td>
<td>138</td>
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<tr>
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<td>4</td>
<td>12</td>
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<td>2</td>
<td>4</td>
<td>82</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (Mths.)</th>
<th>1=female 2= male</th>
<th>VFT-Letter</th>
<th>VFT-Category</th>
<th>PPVT standard score</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>96</td>
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<td>13</td>
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</tr>
</tbody>
</table>

**MEANS** 93.53 10F-7M 4.65 11.59 109.24  **MEANS** 93.94 10F-7M 6.94 16.35 106.82
Appendix C: Individual row data of monolingual and bilingual participants’ performance in non-verbal tasks.

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (Months)</th>
<th>1=female, 2= male</th>
<th>DCCS</th>
<th>Day-Night</th>
<th>No.</th>
<th>Age (Months)</th>
<th>1=female, 2= male</th>
<th>DCCS</th>
<th>Day-Night</th>
</tr>
</thead>
<tbody>
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MEANS: 93.94 10F-7M 3.71 11.59