Master’s Research Report

The Relationship between Multilingualism and Executive Function in Older Adults

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Abstract

This study explored the possible benefits of multilingualism for executive functioning (EF) as evidence for a bi/multilingual advantage is not yet established. Using multiple regression analyses, the aim of this study was to investigate whether proficiency in multiple languages is related to EF, namely task-switching and inhibitory control, in a sample of 50 South African older adults (aged 65 years or more), while controlling for socioeconomic status (SES) and mild cognitive impairment. Proficiency in multiple languages, as well as age of second language (L2) and third language (L3) acquisition and frequency of L2 and L3 use were measured using the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007). The EF of task-switching was measured using the Simon task which produced variables such as response time on incongruent trials, total amount of errors, and the Simon effect. For the EF of inhibitory control, the Victoria Stroop Task (VST) was used which produced variables such as response times on the incongruent colour-word condition, number of errors made on the colour-word condition, and an interference effect. For the control variables, SES was measured using the Living Standards Measure and mild cognitive impairment was measured using the Montreal Cognitive Assessment (REF). Socioeconomic status emerged as the only significant predictor of total errors made on the Simon task, such that higher SES predicted fewer errors. In addition, L3 frequency of use was the only significant predictor of incongruent response time on the Simon task, with more frequent L3 use related to slower response times on the incongruent condition of the Simon task. This suggests that speaking a third language may add a processing cost to EF. Overall, the results of this study suggest that SES, rather than bi/multilingualism, is related to better EF in older adults. In effect, SES may be more important for cognitive reserve than bi/multilingualism in older South African adults.

Dedication

I would like to thank the following people who have been invaluable to my research and academic journey throughout my Master’s degree.

Firstly, to my supervisor, Professor Kate Cockcroft, thank you for all your time and patience in guiding me through this research project. Your input has taught me so much and I am in awe of your academic capabilities.

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Declaration

I, Elfrieda Wheeler, declare that this research report is my own, unaided work. It is submitted for the degree of Master of Arts in Social and Psychological Research by Coursework and Research Report at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at this or any other university.

Sign: E. Wheeler

Date: 5 June 2020

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Chapter One: Literature Review

Introduction

Multilingualism is common practice around the world and the use of multiple languages has moved beyond local and private capacities into a broader and more global role (Aronin, 2019). Many factors have contributed to the increase in multilingualism and its perceived value, such as globalisation, transnational migration, ease of travel, and access to new technologies (Cenoz, 2013). Learning other languages is increasing in popularity, as being able to use multiple languages enables greater access to social, economic, educational, and political opportunities across various contexts.

In South Africa, there are 11 official languages where second- or third languages are taught in school and further acquired for entrance into the labour market (Casal & Posel, 2011). Consequently, the numbers of people reporting both English and Bantu languages[1] as a second- or third language have increased over the past decade. Thus, South Africa is now considered a multilingual country (Kamwangamalu, 2003; Posel & Zeller, 2016). Due to the rising multilingual status of the South African population, there is a need to research the effects of speaking multiple languages, especially the under-researched African languages.

Over the past few decades, psychological and linguistic research have sought to understand the cognitive effects of speaking multiple languages (Friedman, 2016). Research mainly explored the educational and cognitive advantages or disadvantages of speaking two languages compared to speaking only one. Concerning the advantages, there is contention

[1] Bantu languages form part of a major linguistic group in Africa that consists of many different African languages (approximately 500), but it is also used locally to identify the group of languages spoken by many Africans in sub-Saharan Africa. It is generally asserted that nine discrete Bantu languages are spoken in South Africa: Zulu, Xhosa, Venda, Tswana, Tsonga, Swati, Sesotho (Southern), Ndebele, and Northern Sotho (Herbert & Bailey, 2002).

that speaking more than one language has the possibility of increasing executive function (EF; Bialystok 2017; Friedman, 2016), a set of cognitive processes that controls goal-directed behaviour (Jurado & Rosselli, 2007).

This is based on the suggestion that bilingual language control recruits domain-general executive functions (EFs) in order to manage attentional processes and switch between multiple languages (Bialystok, Craik, Green, & Gollan, 2009). The claim is that the daily use and practice of these processes will strengthen those EFs involved in managing multiple languages, resulting in an advantage on non-verbal EF tasks over monolinguals, which is referred to as the bilingual advantage (Bialystok et al., 2009). On the other hand, due to the task of managing more than one language, bilinguals also show disadvantages on verbal tasks relative to monolinguals, which is a result of cross-language interference (Kroll & Gollan, 2014), a situation where both languages active and compete during talk (Green, 1998).

This bilingual advantage has mostly been observed in studies where bilinguals outperformed monolinguals on tasks that involve inhibitory control and conflict resolution (Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Luk, 2008; Costa, Hernández, & Sebastián-Gallés, 2008). Inhibitory control is needed to inhibit any potential cross-language interference during communication and has further been shown to influence both task-switching and language switching (Green, 1998; Linck, Schwieter, & Sunderman, 2012; Liu, Fan, Rossi, Yao, & Chen, 2016). As such, advantages have also been found for bilinguals in task-switching (Prior & MacWhinney, 2010; Prior & Gollan, 2011) and working memory (Morales, Calvo, & Bialystok, 2013) compared to monolinguals, although to a lesser extent. These processes, namely, inhibitory control, conflict resolution, task-switching (or set shifting), and working memory are collectively regarded as EFs in the theory of Friedman and Miyake (2017) which guided this study. These functions work independently of each other to carry out tasks, but also share a common cognitive element, hence the observation of the bilingual advantage in multiple EFs (Miyake et al., 2000).

Overall, studies that show an advantage in EF for bilinguals suggest that bilingual language control and domain-general EFs share some of their functions and facilitate each other (Bialystok et al., 2009). However, most of the evidence is based on bilingual populations and less is known about how a third or fourth language could influence EF. There is limited evidence on whether adding more languages could increase or decrease the efficiency of EF (Diamond, 2010). The few studies that have focused on speakers of three or more languages have found either comparable results between bilinguals and multilinguals (Poarch & Van Hell, 2012) or that multilinguals outperformed bilinguals (Madrazo & Bernardo, 2018) on tasks of inhibitory control and conflict resolution. Consequently, the current study employed a multilingual sample of older adults in order to investigate the relationship between proficiency in multiple languages and two EFs, namely, inhibitory control and task-switching.

The choice of an older adult sample of multilinguals stems from the idea that the cognitive benefits offered by bi/multilingualism may reinforce EF in older age to prevent or delay cognitive decline, and consequently, symptoms of dementia (Alladi et al., 2013; Woumans et al., 2015). Thus, bi/multilingualism has further been proposed to contribute to cognitive reserve in older age. Many studies have found evidence for a bilingual advantage in older age where older bilinguals outperformed their monolingual counterparts on tests of EF (Bialystok et al., 2004; Bialystok et al., 2008; Gold, Kim, Johnson, Kriscio, & Smith, 2013). However, evidence is very mixed, as many studies have failed to replicate such findings in older adults (Antón, García, Carreiras, & Duñabeita, 2016; de Bruin, Bak, Della Sala, 2015; Kousaie & Phillips, 2013) as well as with younger samples (Duñabeitia et al., 2014; Gathercole et al., 2014; Paap & Greenberg, 2013).

There are many reasons for the mixed results between studies, including the use of different tests of EF, the lack of reliability of some of these tests (Paap & Sawi, 2014), as well as the different study designs that that operationalised bi/multilingualism in varying ways (Laine & Lehtonen, 2018). Overall, research has produced varied conclusions regarding the associations between multilingualism and EF and so the complexities of the bi/multilingual advantage are not clear. More recent research in the field has moved away from group comparison (bilinguals vs. monolinguals) to investigating the cognitive factors (such as EF) that contribute towards bilingualism and multilingualism (Laine & Lehtonen, 2018). Thus, the current study aimed to address this issue by investigating the relationships between various aspects of proficiency in multiple languages and inhibitory control and task-switching in older adults. The literature review that follows will discuss the theoretical underpinnings of multilingual language control and EF, give a critical overview of the empirical studies addressing the bi/multilingual advantage, as well as address some methodological issues in researching the bi/multilingual advantage.

Multilingualism in the South African Context

In South Africa, its history of colonial rule and Apartheid led to the recognition of only English and Afrikaans as official languages when it became a republic in 1961 (UNICEF, 2016). Certain policies of Apartheid, including the Bantu Education Act of 1953, enforced racial segregation in schools and mandated the teaching of English and Afrikaans in poor quality government schools for the Black population (UNICEF, 2016). The end product was a gross disregard for the recognition and promotion of the country's indigenous Bantu languages, spoken by majority of the population. Since the demise of Apartheid and the country's first democratic elections in 1994, the new government established a language policy spelt out in the 1996 Constitution that recognises 11 official languages, which includes nine Bantu languages as well as English and Afrikaans.

Further efforts by the government to promote multilingualism were rooted in the Language in Education Policy of 1996 (Department of Education, 1997). This policy gave learners the right to choose their language of learning, although the choice had to be made from the eleven official languages. From Grade one to two, learners are offered one language as a subject, and from Grade three to twelve, learners must pass two languages, one offered in the home language, and the other in the first additional language, in order to be promoted to the next year (Department of Basic Education, 1997).

South Africa is now recognised as a multilingual country rather than a bilingual country (Kamwangamalu, 2003). The most recent census data from 2011 shows the following distribution of first language speakers: Zulu (22,7%), Xhosa (16%), Afrikaans (13,5%), English (9,6%), Northern Sotho (9,1%), Tswana (8%), Sotho (7,6%), Tsonga (4,5%), Swati (2,5%), Venda (2,4%), and Ndebele (2,1%) (Statistics South Africa, 2011). Despite the high numbers of African home languages, English is still given higher status in education and the labour market (Casale & Posel, 2011; Makgamatha, Heugh, Prinsloo, & Winnaar, 2013) and is further recognised as the lingua franca.

Given these trends, there is an increase in the number of South Africans who are learning English together with their mother-tongue (de Klerk & Gough, 2003). A national survey on language use, conducted by the Pan-South African Language Board (PANSALB), showed that English is the medium of tuition in 80% of schools and universities across the country (PANSALB, 2001). These trends appear to signal a language shift happening from indigenous African languages to English, especially in urban Black communities (Kamwangamalu, 2003). A number of socio-political factors have contributed to this shift, including the economic value and global status of English and the perceived lower status of African languages that was instilled by the past (Kamwangamalu, 2003).

With regards to the concern about the future of South Africa's Bantu languages, efforts have been made to investigate the proposed language shift to English (Posel & Zeller, 2016). The Census data from 1996, 2001, and 2011 show that the prevalence of English among Africans has indeed increased significantly, however, this increase was from a very low base to begin with and English remained a minority first language spoken by less than 3% of all Africans in 2011 (Posel & Zeller, 2016). The increase of English language prevalence is argued to be due to the reporting of English as a second home language, which is attributed to education and time spent in the labour markets, rather than being acquired in the home itself. In addition, the numbers of people speaking Bantu languages as a second- or third language have also increased, and the use of Bantu languages has increased overall. These numbers may speak to the rise of multilingualism and the decrease of monolingualism, rather than a shift to English, as it does not appear to be replacing Bantu languages as the home language (Posel & Zeller, 2016). With regard to these trends, the multilingual status of the South African population provides an ideal context for exploring the multilingual advantage as few studies have focused on multilinguals (speakers of three or more languages), as well as those who speak African languages.

Conceptualising multilingualism.

Given the importance and growing nature of multilingualism, it has attracted a great amount of attention in the fields of linguistics, psychology and education. However, research on multilingualism is described as heterogenous and disorganised due to the various theoretical frameworks and methodological approaches used within studies (Cenoz, 2013). One source of this disorganisation lies in the definitions offered for bi/multilingualism in the literature, which lack consensus and often overlap or are used interchangeably (Higby, Kim, & Obler, 2013). Table 1 highlights the various definitions of bi/multilingualism.

The definition offered by Li (2008) is fitting in the South African context, where most of the population (who are not first language English speakers) may acquire a second- or third language passively for the sake of educational access or for employment. This definition would then also accept that speakers of two or more languages can be considered multilingual (Aronin & Singleton, 2012; Sternberg & Sternberg, 2012). Apart from defining multilingualism, there are further issues that revolve around the specific classification of a person as a certain type of bi/multilingual based on the proficiency he/she possesses in each language. In the past, bi/multilinguals were defined as individuals who possess a 'native-like control' in both (or all) their languages (Bloomfield, 1933). However, it has been pointed out that such a narrow definition would exclude majority of the population from being categorised as bi/multilingual, and that the concept of 'native-like control' would be difficult to operationalise (Butler, 2013). On the other hand, some earlier definitions have also suggested that bi/multilingualism would incur any meaningful communication that is produced in another language (Haugen, 1953). Bassetti and Cook (2011) cluster these two opposing definitions into two groups: One where maximal proficiency is required and one where minimal proficiency is required. The maximal definition requires that the bi/multilingual must possess the complete linguistic competence of a monolingual native speaker in both (or all) languages (Cenoz, 2013). However, such a static distinction between 'native' and 'non-native' speakers does not always hold in a pragmatical sense because bi/multilinguals have varying levels of knowledge of their first- and additional languages, driven by specific needs that monolinguals do not have (Grosjean, 2010).

Table 1

Definitions of bilingualism and multilingualism

Bilingualism	Multilingualism	Author(s)
	Apply the term *multilingualism* “in a broad, inclusive sense, in such a way that they include the concepts of bilingualism and bilingual within their respective ambits”	Aronin & Singleton (2012, p.7)
“The term bilingual is used to refer to one type of multilanguage user who uses two languages”	“whereas multilingual refers to users of more than two languages such as trilinguals, quadrilinguals, and so forth”	Butler (2013, p.112)
	“multilingual speakers use different languages, either in isolation or mixed, according to their communicative needs and their interlocutors”	Cenoz (2013, p.11)
	“anyone who can communicate in more than one language, be it active (through speaking and writing) or passive (through listening and reading”	Li (2008, p.4)
“people who can speak two languages”	“Multilinguals speak at least two and possibly more languages”	Sternberg & Sternberg (2012, p.412)

However, in South Africa, it is also difficult to find purely monolingual speakers who have not been exposed to second language. Thus, bi/multilinguals cannot be considered as two or three monolinguals in one person (Grosjean, 2010). It would also be insufficient to assume that the benefits offered by bi/multilingualism may only manifest in maximal bi/multilinguals, as effects may appear even at a low level of exposure to a second- or third language (Bassetti & Cook, 2011).

Given the aforementioned literature, this study employed a broad definition of multilingualism that includes any person who can speak more than one language (which includes bilingualism) and has varying degrees of proficiency in different domains of each spoken language, be it active or passive (Aronin & Singleton, 2012; Grosjean, 2010; Li, 2008). The current study evaluated language proficiency in each spoken language across different domains, such as reading, speaking, and comprehension, as well as age of acquisition and frequency of language use. These variables were analysed together with EF measures, given the debates around the extent to which language proficiency influence the proposed cognitive advantage of bi/multilinguals (Bassetti & Cook, 2011; Paap, Johnson, & Sawi, 2014).

Executive Function

There is a long history of research on the concept of EF (Lezak, 1983; Norman & Shallice, 1986; Welsh & Pennington, 1988), however, various studies have pointed out that the definitions surrounding EF, its components, and functional organisation still lack clear consensus (Baggetta & Alexander, 2016; Banich, 2009; Jurado & Rosselli, 2007). Nonetheless, there is some agreement on the idea that EF refers to the various cognitive processes involved in controlling goal-directed behaviour and adaptive responses, especially in novel, demanding, or ambiguous situations (Ahmed & Miller, 2011; Banich, 2009; Lezak, 1995; Shallice, 1982; Stuss, 1992). When moving from the broader definition to the specific components that make up the construct of EF, there are many different executive components proposed by various investigators. Table 2 provides a summary of the various components suggested by key authors in the field.

Table 2

Various components of executive function

Components/abilities	Author(s)
Anticipation, planning, mental flexibility, goal selection, initiation of activity, self-regulation, deployment of attention, and utilisation of feedback.	Anderson (2002)
Inhibition, cognitive flexibility, and working memory.	Diamond (2013)
Interference control, response inhibition, working memory updating, and set shifting.	Friedman & Miyake (2017)
Planning, purposive action, volition and effective performance.	Lezak (1995)
Inhibition, working memory, and monitoring of behaviour.	Robbins (1996)
Goal-selection, preplanning, anticipation, and monitoring.	Stuss & Benson (1986)

In a review of the literature on EF, Baggetta and Alexander (2016) explored how contemporary empirical studies defined and measured EF and concluded that, despite a large number of identified EFs, there was an overall consensus regarding three functions in particular: Inhibitory control, cognitive flexibility or shifting, and working memory. Regarding these components of EF, there are also questions surrounding their functional organisation. It has been suggested that the different functions represent a particular unitary ability, such as general intelligence (Duncan, Emslie, Williams, Johnson, & Freer, 1996; Duncan, Johnson, Swales, & Freer, 1997). On the other hand, the existence of a core ability is questioned by the fact that some patients with frontal lobe damage perform well on certain tests of EF but not on others (Godefroy et al.,1999). Studies have consistently shown that the intercorrelations between different tests of EF are usually low to moderate and in some cases lack statistical significance (Lehto, 1996, Miyake et al., 2000; Paap & Greenberg, 2013; Paap & Sawi, 2014), which may be due to the influence of other non-executive functions or may reflect different and separable functions (Salthouse, Atkinson, & Berish, 2003).

The current study adopted the unity and diversity framework of Miyake et al. (2000), which is a widely accepted account that reconciles the many opposing perspectives of EF. In their seminal study with young adults, Miyake et al. (2000) found evidence for three components of EF: Inhibition of irrelevant stimuli, switching between mental sets (cognitive flexibility), and updating (working memory). A confirmatory factor analysis of nine widely used EF measures showed that these three latent variables were all significantly correlated with one another, which supports the assumption that each component shares a common function. A second-order confirmatory factor analysis further revealed that all the EF measures load on common EF, however, updating and shifting still made unique contributions, which supports the separability of the components. Miyake et al. (2000) concluded that this pattern of results supports a model of both unity and diversity wherein EFs work independently of each other but also share a core underlying function.

It is apparent that EF is a highly complex construct with no universal definition, although there is high consensus that inhibitory control, task-switching (or cognitive flexibility), and working memory are key aspects needed for successful adaptive behaviour. Executive functions are also essential for emotional, social, and cognitive development, and are needed for success in school and in life (Diamond, 2013). One important feature of EF that has been consistently shown throughout research is its plasticity. Many stimulating activities, such as computerised training, non-computerised games, yoga, aerobics, mindfulness training, and martial arts, have all been shown to improve children’s EFs (Diamond & Lee, 2011). Improving EF is not only possible in children but at any stage in life including old age. For the most part, physical exercise has been shown to improve EF in the elderly and increase hippocampal volume, suggesting that physical exercise may attenuate the age-related loss of memory (for a review, see Kramer & Colcombe, 2018). Computerised cognitive training that targets EFs has also been shown to have both immediate and long-term effects on improving cognitive performance in older adults (Nguyen, Murphy, & Andrews, 2019).

One particular experience that has been a key area of focus for potentially improving EF is bilingualism, which has been suggested to accelerate EF development during infancy and childhood, as well as maintain its integrity and protect against cognitive decline in older age (for a review, see Bialystok, 2017). The general assertion is that managing two languages is a mentally challenging, but stimulating, activity that improves EF.

The Relationship between Bilingualism and Executive Function

A central question of research on bilingualism and cognition has been whether bilingual language control processes share some mechanisms with domain-general EF processes (Friedman, 2016). In communicative situations, bilinguals must choose between the two languages in their repertoire which require switching between representational systems and directing attention to the target language, while avoiding interference from the non-target language (Bialystok et al., 2009).

This assumption is grounded on evidence that bilinguals activate the ‘vocabularies’ (or lexicons) from both of their languages even when only a single language is required, a configuration that is not present for monolinguals (Green, 1998; for a review, see Kroll & Bialystok, 2013; and Kroll, Dussias, Bogulski, & Kroff, 2012). For example, it has been shown that bilinguals read cognates (words that are similar in form and meaning across two languages) faster than matched noncognate words (Costa, Caramazza, & Sebastián-Gallés, 2000). In contrast, when bilinguals read homographs (words that are similar in form but different in meaning across two languages), there is a decrease in reading speed, suggesting interference between two languages (Dijkstra, 2005). Taken together, the increased activity of the non-target language is shown to either facilitate word processing when form and meaning converge (cognates) or slow down processing when there is interference (homographs), where the latter is an example of cross-language competition (Kroll, Dussias, Bice, & Perrotti, 2015). Consequently, word retrieval becomes more challenging for bilinguals due to the co-activation of both languages.

This co-activation of bilinguals' two languages has been shown to put them at a disadvantage on many verbal tasks. There is evidence for the weaker performance of bilinguals on measures of vocabulary (Bialystok & Luk, 2012), verbal fluency tasks (Portocarrero, Burright, & Donovick, 2007), picture-naming tasks (Gollan, Montoya, Fennema-Nostestine, & Morris, 2005), and bilinguals also encounter more tip-of-the-tongue experiences than monolinguals (Gollan & Acenas, 2004). The reason for weaker performance on verbal measures could be attributed to the task of managing more than one lexicon, such that increased lexical interference slows down word production and comprehension for bilinguals (Kroll & Gollan, 2014). Secondly, each language gets used less frequently in bilinguals compared to monolinguals resulting in weaker links between lexical representations which could account for the weaker performance on measures of vocabulary (Gollan, Montoya, Cera, & Sandoval, 2008).

However, the fact that proficient bilinguals are able to move between their two languages quite fluently during communication suggests that they develop some kind of cognitive control that allows them to resolve any potential cross-language competition (Kroll et al., 2012). As mentioned before, this co-activation creates a situation where attention must be directed to the target language while suppressing interference from the competing non-target language. The claim is that the daily use of these cognitive processes strengthens those EFs that are recruited during language control, resulting in raised performance on non-verbal EF tasks relative to monolinguals (Bialystok, Craik, & Luk, 2012). Evidence for this has been found in inhibitory control, and to a lesser extent, task-switching and working memory (Bialystok, 2017). However, most research on the bilingual advantage has focused on speakers of two languages, where multilinguals have been relatively under-researched. The following sections will look at empirical evidence for the bilingual advantage in inhibitory control and task-switching, as well as studies that included multilinguals in their sample.

A Bilingual Advantage in Executive Function.

Bilinguals' raised performance in EF tasks relative to monolinguals have been empirically demonstrated at all stages across the lifespan, from infancy and toddler-hood (Kovács & Mehler, 2009; Poulin-Dubois, Blaye, Coutya, & Bialystok, 2011), continuing through childhood (Morale et al., 2013; Poarch & Van Hell, 2012; Tse & Altarriba, 2014), into young adulthood (Calabria, Hernández, Martin, & Costa, 2011; Costa et al., 2008; Yang & Yang, 2017), adulthood, and older age (Bialystok et al., 2004; Bialystok et al., 2008). Within these studies, participants are required to resolve conflict from distracting cues, switch between different types of trials, and maintain rules in working memory, for example, the Simon task (Bialystok et al., 2004), the Stroop task (Bialystok et al., 2008), and the Flanker task (Costa et al., 2008). All these actions form part of EF, the component in which bilinguals outperformed monolinguals.

Inhibitory control.

Inhibitory control allows one to selectively attend to stimuli while suppressing attention and the need to make a prepotent response to non-relevant stimuli, which is also referred to as conflict resolution (Miyake et al., 2000). For example, in the Stroop task, people generally show a preference for naming colours in congruent conditions (e.g. the colour of the word's ink matches the word itself), which is reflected by faster response times. In contrast, when faced with incongruent conditions (e.g. the word 'green' written in blue ink), a salient conflict arises and attention must be directed to the relevant feature to choose the correct response, in the face of distracting features that persuade the opposite response (Diamond, 2013). It is under these incongruent conditions that bilinguals generally show an advantage (i.e., inhibitory control and conflict resolution) (Bialystok et al., 2008).

A widely used account for this advantage in inhibitory control and conflict resolution is based on Green's (1998) Inhibitory Control (IC) model. This model suggests that all words contain tags that specify which language they belong to. During lexical access, words in the non-target language are activated but subsequently inhibited due to their non-target language tag. This allows words in the target language to be selected for successful speech production. An important assumption is that the amount of inhibition required for these operations is proportional to the degree of proficiency in each language. That is, the dominant language will have stronger levels of activation, thus, more inhibition is required to suppress its intrusions when switching to another language.

Overcoming the inhibition of the previous irrelevant language will take time, and so the IC model predicts a switch cost which is reflective of a slower processing speed (Green, 1998). This explanation has been supported by studies that found asymmetric switch costs in bilinguals where switching into the stronger first language (L1) takes longer than switching to the weaker second language (L2) (Costa and Santesteban, 2004; Linck et al., 2012; Meuter & Allport, 1999). In contrast, highly proficient bilinguals have equally strong representations of both their L1 and L2, which result in symmetric switch costs (Costa & Santesteban, 2004; Costa et al., 2008; Costa, Santesteban, & Ivanova, 2006). Given this, it is important to consider and measure proficiency in each language when undertaking a study of the bilingual advantage.

The role of inhibitory control in language switching is emphasised by studies that found performance in the Simon task to be related to language switching costs. Linck et al. (2012) found that a smaller Simon effect (reflecting better inhibitory control) predicted smaller switching costs in a picture-naming tasks for trilinguals. More specifically, the Simon effect had a positive correlation with the L1 switching costs, but the correlations were weaker when switching into the weaker L2 or third language (L3). Similarly, Liu et al. (2014) compared Chinese-English bilinguals' switching costs in a picture-naming task. Participants who had smaller Simon effects showed symmetrical switching costs, whereby participants with larger Simon effects showed asymmetrical switching costs. As with Linck et al. (2012), larger Simon effects correlated with larger L1 switching costs, supporting Green's (1998) IC model.

Lastly, taking a slightly different approach, Liu et al. (2016) examined the role of cognitive flexibility (CF) in both task-switching and language switching. Chinese-English bilinguals were divided into either a high CF group (N = 26) or a low CF group (N = 26) based on their performance on the Wisconsin Card Sorting Task. Both groups then performed a Simon switch task and a picture-naming task. The Simon switch task consisted of both congruent and incongruent repetition/switch trials which were similar to the L1 and L2 repetition/switch trials of the picture-naming task. Participants in the high CF group showed symmetrical switch costs in both the Simon task (for congruent and incongruent trials) and the picture-naming task. In contrast, the low CF group showed larger switch costs for congruent trials in the Simon task. They also had larger L1 switch costs relative to their L2 switch costs in the picture-naming task. The authors concluded that cognitive flexibility has a controlling influence in language switching performance through the same inhibitory control mechanisms involved in task-switching, supporting the unitary and diversity model of Miyake et al. (2000).

Task-switching.

With regards to the above, a second EF, task-switching, is also implicated in bilingual language control. Task-switching is the ability to shift between multiple task demands, each with their own goal sets (Monsell, 2003). More specifically, it requires the ability to switch or allocate attention to a single task while disengaging from the previous task in order to make a correct task-specific response. Thus, switching between task demands involve loading a new goal set onto working memory while inhibiting the prior goal set that is no longer relevant (Miyake et al., 2000). Bilinguals must similarly monitor their environment and switch between languages according to contextual demands or goals. This qualitative similarity between task-switching and language switching is then also said to be mediated by domain-general EF processes (Liu et al., 2016; Prior & Gollan, 2011; Weissberg, Gollan, Bondi, Clark, & Wierenga, 2015).

In classic switching paradigms, participants are instructed to perform one task (single task blocks) as well as switch between tasks from trial to trial (mixed blocks) (Meuter & Allport, 1999). Within mixed blocks, some trials cue participants to switch tasks (switch trial) while others cue the participants to perform the same task as the previous trial (repetition trial). In general, studies show robust switching costs between switch and repetition trials and mixing costs between repetition trials and single-task trials (Christoffels, Firk, & Schiller, 2007; Meuter & Allport, 1999; Rogers & Monsell, 1995).

Empirical studies using this task-switching paradigm have shown reduced switching costs for bilinguals relative to monolinguals. Prior and MacWhinney (2010) compared monolingual and bilingual university students on a switching task where participants had to respond to either the shape or colour of the stimuli based on a preceding cue. Bilinguals showed reduced switching costs relative to monolinguals, where no differences were observed for mixing costs. Prior and Gollan (2011) obtained similar results using the same task. In their case, they had two groups of highly proficient bilinguals (Mandarin-English and Spanish-English) who differed in frequency of daily language switching and one group English monolinguals. The Spanish-English bilinguals reported more frequent daily language switching than the Mandarin-English bilinguals. Results showed a reduced switch cost for them compared to the Mandarin-English bilinguals and monolinguals, after controlling for socioeconomic status and overall speed. In addition, participants also completed a picture-naming task to assess language switching and the results showed the same pattern for the Spanish-English bilinguals compared to the other two groups. This study implicates frequency of language switching as a possible moderating variable in the bilingual advantage as there were no differences between the Mandarin-English bilingual and monolinguals.

Cognitive advantages of speakers of three or more languages.

There are many studies that show increased EF for bilinguals when compared to monolinguals (for a review, see Bialystok, 2017). These studies show that one extra language offers cognitive benefits, but little is known about how a third or fourth language could influence language processing and EF. It is unclear whether adding more languages could increase or decrease the efficiency of EF (Diamond, 2010).

A few studies have found comparable advantages for speakers of three languages. For example, Poarch and Van Hell (2012) compared the inhibitory control processes across three groups of children that differed in terms of L2 and L3 proficiency and a fourth monolingual group. The four groups consisted of five-to-eight-year-old German-English bilinguals (N=18), German-English-language X trilinguals (N=18), German children learning English as a L2 (N=19), and German monolinguals (N=20). The participants all performed the Simon task and the Attentional Networks Task (ANT). Both the bilingual and trilingual groups showed significant advantages in both tasks compared to the monolinguals and the L2 learners. The bilingual and trilingual groups did not differ in their performances on both tasks. From this study, it appears that multilinguals have enhanced conflict resolution abilities, but that proficiency in three languages does not increase this effect compared to proficiency in two languages.

In contrast, Madrazo and Bernardo (2018) found that young adults trilinguals outperformed their bilingual counterparts on a series of Simon Arrow tasks. They compared a group of Filipino-English bilinguals (N=85) and Chabacano-Filipino-English trilinguals (N=106), whereby the trilinguals were more efficient and accurate in the more demanding trials (involving interference suppression and response inhibition) but not in the less demanding trials (involving only response inhibition). Concerning working memory, a trilingual advantage has also been reported in South African young adults (Cockcroft, Wigdorowitz, & Liversage, 2017). The trilinguals spoke African languages as their L1 and L3 and English as their L2. The advantages were observed in visuospatial working memory after controlling for socioeconomic status and verbal IQ. The contradictory results for these two studies and that of Poarch and Van Hell (2012) concerning a trilingual advantage may be due to the young adult samples who are at a different developmental stage in terms of their EF. It may also be due to the differences in task demands between the studies, as it has been demonstrated that the bilingual advantage is more prominent when task demands are high (Costa, Hernandez, Costa-Faidella, & Sebastián-Gallés, 2009; Martin-Rhee & Bialystok, 2008).

Lastly, a cognitive advantage of speaking more than two languages has also been observed in older adults. Kavé, Eyal, Shorek, and Cohen-Mansfield (2008) conducted a twelve-year longitudinal study in which they examined whether the number of languages predicted performance on two cognitive tests, namely Katzman et al.'s (1983) cognitive-screening test and the Mini-Mental State Exam (Folstein et al., 1975). Variables assessed in these tests include time orientation, memory, concentration, language, and copying. After controlling for demographic variables, results showed significant differences between bilingual, trilingual, and multingual speakers (of four or more languages) in their performance on the tests. More specifically, the 75-95-year-old individuals who spoke four (or more) languages showed the best cognitive state across all the interview waves that took place over the twelve years, suggesting that proficiency in more than two languages has cognitive /benefits.

Bilingualism and Multilingualism in Older Age.

The study above by Kavé et al. (2008) suggests that multingualism might be an important determinant of cognitive state in older adults. However, none of the measures used in this study tapped EF. Executive functions underlie the successful navigation of the demands of everyday life, but these abilities decline significantly with normal ageing (Daniels, Toth, & Jacoby, 2006). For example, age-related decline of inhibitory control has been shown in studies where older adults showed slower response times for conflict resolution in the Simon task (van der Lubbe & Verlegger, 2002), the Flanker task, and the Stroop task (for a review, see Mcdowd & Shaw, 2000). Ageing has also been associated with increased costs in task-switching (Cepeda, Kramer, & Gonzalez, 2001; Kray & Lindenberger, 2000). It must be noted that slower information processing is a normal part of the ageing process (Daniels et al., 2006). However, there is a growing body of research that demonstrates that lifelong bilingualism and multilingualism can offset age-related declines in EF of older adults.

For example, Bialystok et al. (2004) compared bilinguals and monolinguals who were middle-aged (30-60 years, N=20) and older (60-80 years, N=20) on the Simon task and found both language- and age group differences in performance. In the task, either a blue or red square appears that cues the response of either a left or a right key respectively. Half of the trials consisted of congruent conditions (the square appears on the same side as the correct response key) and the other half consisted of incongruent conditions (the square appears on the opposite side). Overall, both age groups of bilinguals responded faster to both congruent and incongruent trials and also had a smaller Simon effect. More importantly, the study also showed an increase in the Simon effect for the older adults compared to the middle-aged adults, but this age-related increase was substantially less for the bilingual group.

A similar study by Bialystok, Poarch, Luo and Craik (2014) also compared younger and older bilinguals and monolinguals on the Stroop task as well as verbal and non-verbal working memory tasks that measured proactive interference. Concerning the Stroop task, bilinguals in both age groups had faster reaction times in the incongruent colour-word condition and showed less interference than the monolinguals, with greater benefits found for older adults. Bilinguals in both age groups also showed an advantage in the non-verbal proactive interference task which was the more complex task. Again, the bilingual advantage was more prominent in the older age group. Other studies that focused on older adults have also found bilinguals to outperform their monolingual counterparts in tests of perceptual task-switching (Gold et al., 2013), the Simon Arrow task and Stroop task (Bialystok et al., 2008).

In light of these advantages found in older adults, bilingualism is argued to attenuate the age-related loss of EFs in older age and contribute to cognitive reserve. Cognitive reserve refers to resilience against cognitive decline in older age (Stern 2002). The central tenet of cognitive reserve is that the active engagement in stimulating intellectual, social and physical activities can prolong healthy cognitive function and delay the onset of dementia symptoms.

Factors that correlate with cognitive reserve include higher levels of education and occupational attainment, participation in leisure activities, and premorbid intelligence (Buckner, 2004; Sattler, Toro, Schönknecht, & Schröder, 2012; Valenzuala & Sachdev, 2006). Concerning bilingualism, Bialystok et al. (2004) argue that the lifelong management of two languages reinforces inhibitory control that may counteract or diminish the age-related loss of this EF.

Several studies have analysed the medical records of individuals referred to memory clinics and found that bilinguals tend to be diagnosed with dementia four to five years later than monolinguals (Alladi et al., 2013; Bialystok, Craik, & Freedman, 2007; Craik, Bialystok, & Freedman, 2010; Freedman et al., 2014; Woumans et al., 2015). Chertkow et al. (2010) undertook a similar approach but included multilingual participants together with bilinguals and their sample consisted of both non-immigrant (Canadian) and foreign multilinguals. Overall, there were no significant protective effects in bilinguals in relation to age at diagnosis or age at symptom onset, although a small but significant effect was found for speakers of more than two languages. However, when looking at the immigrant group alone, speakers of two or more languages had a delay in the diagnosis of Alzheimer's disease by almost five years.

Increased protective effects of speaking three languages compared to two were also found in a study by Perquin et al. (2013). They recruited a sample (N=232) of non-demented multilinguals (aged 65 or older) who spoke two to seven languages and found varying degrees of protection against dementia. The participants underwent neurogeriatric and neuropsychological evaluations to classify participants as presenting either cognitive impairment without dementia (CIND) or free of any cognitive impairment (CIND-free). Forty-four participants (19%) were classified as having CIND. Using bilingual participants as reference, those who regularly spoke more than two languages showed lower risk of CIND, after controlling for age and education. More specifically, it was found that speaking three languages, rather than two, was associated with a seven-fold protection against CIND. Concerning those who spoke four or more languages, the protective effects hit a ‘plateau’, indicating that speaking four or more languages has the same reduced probability of developing CIND as speaking three languages. Lastly, this study also confirmed that participants who were free of CIND performed more leisure- and social activities and had higher levels of education than participants with CIND. Thus, these variables may be seen as moderating or confounding variables in exploring the relationship between number of languages spoken and cognitive function.

Despite these findings, the scenario with multilingual older adults is not consistent as several studies have found no significant differences in EF between older monolinguals and bilinguals on the Stroop task (Antón, García, Carreiras, & Duñabeitia, 2016) and Simon task (de bruin, Bak, & Della Sala, 2015; Kirk, Fiala, Scott-Brown, & Kempe, 2014; Kousaie & Phillips, 2012). It has further been pointed out that the cognitive reserve offered by bi/multilingualism can be obscured by interactions with other factors, where protective effects may only surface for bi/multilinguals from immigrant groups (Chertkow et al., 2010) and those with low educational levels (Gollan, Salmon, Montoya, & Galasko, 2011). This could signal an upper limit on the amount of benefits that can be offered by bi/multilingualism for delaying the onset of dementia symptoms. Bi/multilinguals from immigrant groups or with lower levels of education still have the potential to increase their L2 or L3 proficiency, whereby bilinguals with higher levels of education already have a higher or even maximal level of proficiency. Thus, the potential for cognitive reserve to delay dementia symptoms has reached an upper limit which does not offer any further benefits (Gollan et al., 2011). Nonetheless, studies that have taken a longitudinal approach, repeatedly testing participants from a baseline stage with no signs of dementia, have found no consistent delay in the onset of symptoms for bilinguals (Lawton, Gasquoine, & Weiner, 2015; Sanders, Hall, Katz, & Lipton, 2012; Zahodne, Schofield, Farrel, Stern, & Manly, 2014). Thus, the issue of whether bi/multilingualism offers any advantages in EF for older adults is far from clear.

Challenges in Researching the Multilingual Advantage

In addition to the above, there are many studies that have not found evidence for the existence of a bilingual advantage in EF tasks across a range of ages (Antón et al., 2014; Duñabeitia et al., 2014; Gathercole et al., 2014; Paap & Greenberg, 2013; Paap, Johnson, & Sawi, 2014; Paap & Sawi, 2014; von Bastian, Souza, & Gade, 2015). With regard to the non-significant results found in these studies, Paap, Johnson, and Sawi (2015) propose that bilingualism does not enhance EF at all or may be very small and/or may occur in very specific circumstances. The inconsistencies in the research also speak to the inherent difficulties in measuring EF. Firstly, testing for bi/multilingual advantages in EF may covary with many other factors that can influence the development and maintenance of EF, including genetics (Friedman et al., 2008), socioeconomic status (SES; Bradley & Corwyn, 2002; Hackman, Gallop, Evans, & Farah, 2015), immigrant status (Chertkow et al., 2010), and cultural differences (Morton & Carlson, 2014). Also, apart from proficiency in multiple languages, the acquisition of various specialised skills, like video game playing (Boot, Kramer, Simons, Fabiani, & Gratton, 2008), musical training (Moreno, Friesen, & Bialystok, 2011), and even experience in spatial navigation (Bialystok, 2017), all have the potential to modify cognitive systems.

These issues relate to the complex nature of EF which makes it difficult to isolate how specific experiences may modify specific components. Thus, measuring EF is also a difficult endeavor which is reflected in the lack of convergent validity between standard measures of inhibition (Paap & Sawi, 2014; Rey-Mermet, Gade, & Oberauer, 2018). For example, Paap and Greenberg (2013) demonstrated that the interference effects from the Simon task do not correlate with the interference effects from the Stroop or Flanker tasks. These lack of intercorrelations between tasks may suggests that individual or group differences are more likely due to chance factors and/or task-specific factors than differences in domain-general EF (Paap et al., 2015). In fact, even the seminal study by Miyake et al. (2000) showed that the correlations between various EF tasks were low (*r*'s ranging from .00-.41), and that the EF tasks shared less than 17% of the variance in test performance, while other factors accounted for 83% of the variance. Therefore, tasks that measure the same EF construct will inevitably engage other cognitive processes, such as fluid intelligence, perceptual speed, episodic memory and/or vocabulary, and some error variance may be due to issues with reliability (Salthouse et al., 2003).

Valian (2016) summarised the present inconsistencies in the findings relating bilingualism to domain-general EF as a product of the many potential connections among the variables of interest. Firstly, there is a lack of consensus about the concept of EF and the multiple functions it encompasses, as well as the tasks that are used to measure it. Secondly, there is also a lack of understanding of the cognitive processes involved in bilingual language processing and how this differ between individuals and different types of bilinguals, even more so when considering speakers of three or more languages. Consequently, another factor that may account for some of the inconsistencies in the literature is that bilingualism is operationalised in many different ways across studies.

Operationalising Proficiency in Multiple Languages

Bi/multilingualism is a complex linguistic and cognitive experience that will present with varying levels of attainment over a person's lifetime. This experience will also vary greatly amongst heterogenous populations in diverse sociocultural contexts. Thus, many studies have assessed bi/multilingualism in different ways when considering its relationship to EF, for example, age of acquisition, level of proficiency/balance, and extent of daily use.

Theoretically speaking, if the bilingual advantage is due to the continuous practice of managing different languages throughout one's life, longer, more frequent and/or more intensive practice should manifest in larger EF gains. For example, Luk, de Sa and Bialystok (2011) divided young adult bilinguals into two groups: early bilinguals (who became actively fluent in their L2 before the age of ten) and late bilinguals (who became actively fluent in their L2 after the age of ten). These two groups, together with a monolingual group, performed a Flanker task, and results showed that early bilinguals had reduced response time costs for incongruent trials (Flanker effect), whereas performance was similar between the late bilinguals and monolinguals. This makes the age at which each language was acquired important to consider.

Early bilingual children have also been found to response faster on the ANT compared to late bilingual and monolingual children (Kapa & Colombo, 2013). An early age of acquisition has further been shown to positively predict the interference effect in the Stroop task (Tse & Altarriba, 2012; Yow & Li, 2015). In terms of balance (equal proficiency in both languages), there is also evidence for balanced bilinguals to outperform unbalanced bilinguals in working memory tasks and the Wisconsin Card Sorting Task (Roselli, Ardila, Lalwani, & Vélez-Uribe, 2015; Vega & Fernandez, 2011). Thus, the extent to which the bi/multilingual has balanced proficiency between languages is also an important variable to consider.

Concerning task-switching, both de Bruin et al. (2015) and Prior and Gollan (2011) found that bilinguals who frequently switch between languages showed reduced switch costs, whereas bilinguals who do not switch languages often and monolinguals performed equivalently. Further evidence was provided by Hartanto & Yang (2016) who found that bilinguals in a dual-language context (who use two languages within the same context) showed reduced switch costs compared to bilinguals in a single-language context (who use only one language in one context). Furthermore, highly proficient bilinguals also show symmetrical switch costs in picture-naming tasks compared to less proficient bilinguals (Costa & Santesteban, 2004; Costa et al., 2008; Costa, Santesteban, & Ivanova, 2006). Thus, the frequency of language use becomes an important variable to consider.

Overall, the aforementioned studies suggest that the degree of proficiency and specific interactional contexts may influence the quality and extent of cognitive benefits offered by bilingualism, where early age of L2 acquisition, frequent use of both languages and high (or equal) proficiency in both languages may offer more cognitive benefits. Again, it is emphasised that there is less known about how these factors would influence the cognitive benefits offered by proficiency in three or more languages. However, these claims should be interpreted with caution as not all studies have found differences between early and late bilinguals (Bak, Vega-Mendoza, & Sorace, 2014; Pelham & Abrams, 2014; Tao, Marzecová, Taft, Asanowicz, & Wodniecka, 2011; Vega-Mendoza, West, Sorace, & Bak, 2015), or between bilinguals who differed in terms of L2 acquisition and L2 proficiency (Paap & Greenberg, 2014).

As seen in all of the studies mentioned so far, most of the research within this field has sought to use a bilingual (or in rarer cases, a multilingual) sample that is generally matched with, and compared to, a monolingual group. As a result, language became dichotomised both in the participants (bilingual versus monolingual) as well as in the possible outcome (advantage versus no advantage; Tabori, Mech, & Atagi, 2018). However, there is some critique regarding these research studies. For example, Luk and Bialystok (2013) argue that although such designs are important for establishing group differences, they are prone to overlook differences within each group. It is also difficult to find language groups that are comparable on all demographic variables and which differ only in terms of language experience, which is in itself influenced by other factors. For example, it has been shown that the benefits offered by bilingualism on EF may stem from correlated SES effects, with bilinguals belonging to higher SES performing much better (Morton & Harper, 2007).

To resolve these issues, it has been suggested that multilingualism should not be defined as a categorical variable, but rather that designs that study this issue should operationalise language proficiency as a continuous variable, ranging on a continuum of proficiency for each language. This approach was taken in the current study where participants rated their proficiency in each language on a self-report multilingual language proficiency questionnaire, a shortened version of the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007). Participants rated their proficiency in reading, speaking, and comprehension on a Likert-scale (from 0 for non, to 10 for perfect) for each identified language. They also reported the age at which they acquired their languages and the frequency of use for each language.

Although the LEAP-Q has been shown to be comparable to other objective measures of language proficiency (Marian et al., 2007), a recent study by Tomoschuk, Ferreira, and Gollan (2019) found significant problems with self-ratings of bilingual proficiency, especially when comparing bilinguals of different language combinations and bilinguals with varying acquisition histories and dominance of the same language. The relationship between self-ratings and an objective measure of picture-naming (expressive vocabulary), differed significantly between two bilingual populations (Chinese-English and Spanish-English), as well as within the two populations. Tomoschuk et al. (2019) further established that objective measures of language proficiency (like picture-naming tasks) are more accurate and consistent relative to self-report measures. In line with this issue, Luk and Bialystok (2013) suggests a more complete approach by examining performance and quantifying the distinct, but overlapping, dimensions of bi/multilingual experiences by using both self-report measures and standardised tests of language proficiency. Thus, in addition to the LEAP-Q, the current study also included an objective measure of receptive English language ability, namely, a shortened version of the Token Test (TT-SV; De Renzi & Faglioni, 1978), in order to assess the validity of the LEAP-Q.

Aims and Rationale

This study investigated the relationship between proficiency in multiple languages and EF, specifically, inhibitory control and task-switching, in older South African adults. There is considerable research on the relationship between multilingualism and EF, yet it lacks consensus. Firstly, the precise nature of the organisation and interrelationships between EFs are elusive. Secondly, there are also many disputes about the effect that proficiency in multiple languages may have on the management and development of EF, as bi/multilingual proficiency is also a multifactor construct. Lastly, most studies have focused on bilingual participants and far less is known about any potential cognitive advantages for multilinguals.

This study contributes to the existing research by undertaking a comprehensive measurement of proficiency in multiple languages and EF that should give insight into the contribution of each variable of interest, as well as the interrelationships between them. This study also evaluated these processes in multilinguals who speak African languages, which have not been extensively researched. This study used a self-report measure of multilingual proficiency that assessed various aspects of proficiency in each language (LEAP-Q-SV, Appendix D). In addition, an objective measure of receptive English language comprehension (TT-SV) was also used to validate the self- ratings of English proficiency derived from the LEAP-Q. This study used two measures of EF, namely, the Victoria Stroop Test and the

Simon task in order to assess the relationship between the different EFs and proficiency in multiple languages. These aspects of EF were selected as they have been the most studied (Bialystok, 2017; Bialystok et al., 2004; Bialystok et al., 2008; Miyake et al., 2000) and allowed for the findings from this study to be compared to what is already known.

The proposed benefits of bi/multilingualism have further been suggested to provide cognitive reserve in older adults in the form of protection or delay of age-related cognitive decline (Bialystok et al., 2004; Craik et al., 2010; Woumans et al., 2015). However, the matter is contentious as other studies dispute these findings (Lawton et al., 2015; Sanders et al., 2012; Zadhodne et al., 2014). By focusing on an elderly sample, the current study will contribute to the understanding of how certain executive processes are affected by ageing and whether or not proficiency in multiple languages contributes to the maintenance of EF.

The current study addressed two main research questions. The first was whether there is a relationship between proficiency in multiple languages (as measured by the LEAP-Q) and inhibitory control (as measured by the Victoria Stroop Task). The second question asked whether there is a relationship between proficiency in multiple languages and task-switching (as measured by the Simon task). Based on the literature review, it was predicted that higher proficiency in each spoken language will be related to faster reaction times and fewer errors in the incongruent trials of both the Victoria Stroop Task and the Simon task. Secondly, it was predicted that higher proficiency in each spoken language will be related to a smaller Simon effect (in the Simon task) and a smaller interference score (in the Victoria Stroop Task).

Secondary research questions were also included in the current study. First, it was investigated whether there is a significant relationship between inhibitory control and task-switching in the sample of older adults. Based on the literature concerning the unity and diversity of EFs (Friedman & Miyake, 2017; Miyake et al., 2000), it was predicted that these two EFs will be significantly related. Second, the current study wanted to assess whether self-reported proficiency in English correlated with an objective measure of English language proficiency. Based on the study of Marian et al. (2007), it was predicted that performance on the LEAP-Q will be related to performance on an objective language measure (the TT-SV).

Lastly, as addressed in the literature review, it is proposed that age of second- and third language acquisition, as well as frequency of language use, may be important variables to consider when investigating the bi/multilingual advantage (de Bruin et al., 2015; Luk et al., 2011; Prior & Gollan, 2011). Thus, this study investigated whether age of acquisition of a second- and third language moderate the relationship between language proficiency and EF. Similarly, frequency of language use was also investigated as a possible moderator between language proficiency and EF. The hypotheses were that early age of L2 and L3 acquisition and higher frequency of language use will be related to better performance on the EF tasks.

Chapter Two: Methodology

This chapter outline the methods used in this study. The current study formed part of a larger project concerned with aspects of creativity, intelligence, multilingualism, and EF in the elderly. Thus, the methods employed in this study mirrored that of the larger project. The collected data was used to supplement the larger project's data but only a segment of it was used in this study to answer different research questions pertaining to the relationship between proficiency in multiple languages and EF.

Research Design

A quantitative approach was adopted wherein measures were used to yield numerical data that were analysed using statistical procedures (Creswell & Creswell, 2017). This study was non-experimental as there was no manipulation of variables and participants were not randomly assigned to groups (Salkind, 2010). A correlational design was followed in order to assess the magnitude and direction of any relationships between multilingual language proficiency variables and EF in a group of elderly multilinguals (Lavrakas, 2008). Lastly, this study was cross-sectional in nature as data were collected from the sample at one point in time (Shaughnessy, Zechmeister, & Zechmeister, 2000).

Sample and Sampling

The sample consisted of 50 elderly participants, where 'elderly' is defined as those who are 65 years and older (Orimo, Suzuki, Araki, Hosoi, & Sawabe, 2006). The inclusion of participants was determined by their ability for independent daily living. This was determined through the administration of the Shortened version of the Lawton Instrumental Activities of Daily Living (IADL-SV) (Appendix E), where participants had to execute all items in order to be included in the study. In addition to the IADL-SV, the Montreal Cognitive Assessment

(MoCA) (Appendix F) was used as a brief administration tool used to detect mild cognitive impairment. A cut-off score of 23/30 were used to differentiate between healthy cognitive ageing and mild cognitive impairment (Carson, Leach, & Murphy, 2018). The MoCA was entered as a covariate in the analyses to control for mild cognitive impairment. Furthermore, participants had to have no history of mental illness or head injury to be included in the study. These inclusion and exclusion criteria served to limit the influence of extraneous variables that may arise out of cognitive impairments. Lastly, all participants had to have a good self-reported understanding of English that was sufficient to complete the tests and questionnaires.

This study made use of non-probabilistic methods to recruit participants. Efforts were made to recruit participants who spoke a varied range of South African languages. The sample came from various community centres such as churches, retirement villages, old-age homes, and non-profit organisations. These institutions were contacted by the researcher who asked permission to distribute flyers to its members. Snowball sampling was also used as participants and institutions helped to identity or recruit other members that met the eligibility criteria (Henry, 2009). Lastly, the study reimbursed participants with R300 to cover any costs that was associated with participation such as travel, food, and other costs.

Instruments

Demographic questionnaire.

The participants each completed a paper-and-pencil demographic questionnaire (Appendix C) to gather personal information. This included their gender, age, home language, and level of education. The Living Standards Measure (LSM) was also included in the demographic questionnaire as a measure of SES. The LSM is a widely used tool in South Africa that segments the population into ten deciles according to their living standards using criteria such as ownership of major appliances, cars, and degree of urbanisation. Participants answered true or false on 29 items, each weighted differently. The sum of the weighted scores reflects the final LSM score. An LSM score of one indicates the lowest living standard and a score of ten indicates the highest living standard. This information was used for descriptive purposes and analyses.

Shortened Version of Language Experience and Proficiency Questionnaire (LEAP-Q-SV; Marian, Blumenfield, & Kaushanskaya, 2007).

The LEAP-Q is a self-report measure developed by Marian et al. (2007) that was used to assess degree of multilingual language proficiency in various domains. The validity of self-report measures is often questioned within the research field, but the internal validity of the LEAP-Q has been well established by Marian et al. (2007) and it has proven to be a reliable tool to measure self-reported multilingual language proficiency that can be compared to behavioural linguistic measures. The LEAP-Q has also been validated within a South African context in a sample of multilingual university students from low socioeconomic backgrounds (Cockcroft & Laher, 2018).

The questionnaire consists of a combination of open-ended, forced choice, and Likert-type scale responses. This study used an adapted version of the original measure to shorten the administration time (LEAP-Q-SV; Appendix D). Information was asked pertaining to the number of languages the participants spoke, as well as proficiency across three domains (reading, speaking, and comprehension) for each identified language on a scale from 0 (none) to 10 (perfect ability). Average frequency of each language used was also assessed and this was reported in percentages where all spoken languages together had to add up to 100. Lastly, age of acquisition for each spoken language was also assessed (Marian et al., 2007). Several questions from the original version were excluded. These included items that were already covered in the demographic questionnaire, as well as items that were not relevant to the present study, for example questions related to culture and immigration.

Shortened Version of Lawton Activities of Daily Living (IADL-SV; Roehrig, Hoeffken, Pientka, & Wedding, 2007).

Inclusion in the study depended on participants' ability to live independently. This was measured by a shortened version of the original IADL developed by Lawton & Brody (1969). The original IADL test was developed to assess instrumental activities needed for independent daily living by evaluating a complex set of behaviours that rely on cognitive and/or physical function. It is a reliable tool to for cognitive screening as impairment of such instrumental activities has been shown to be the most severely affected in people with both mild and severe cognitive impairment (Durant, Leger, Banks, & Miller, 2016; Jekel et al., 2015).

The shortened version (IADL-SV; Appendix E) contained some items from the original test, including 'grocery shopping' and 'food preparation'. Individuals who had difficulties with any of these two items are assumed to have general limitations that prevent independent living (Roehrig et al., 2007). Other items included 'medication use', 'laundry', and 'traveling via car or public transportation'. Individuals who were unable to execute these activities were assumed to have difficulties in independent daily living, thus, their ability to undertake the cognitive tests and provide informed consent would have been compromised. Participants had to be able to execute all activities on the IADL-SV in order to be included in the study.

Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005).

The MoCA (Appendix F) is a brief assessment of cognitive ability with a focus on distinguishing normal ageing from mild cognitive impairment (Nasreddine et al., 2005). The MoCA is a highly sensitive diagnostic tool with good test-retest reliability and internal consistency for patients with mild cognitive impairment (Nasreddine et al., 2005). It has further been validated in conditions such as Alzheimer's Disease and Parkinson's Disease (Dalrymple et al., 2010; Smith, Gildeh, & Holmes, 2007). The test is simple and brief to administer and is scored out of 30 points. The original cut-off score was 26/30 with scores below suggesting mild cognitive impairment. To control for the influence of education, it was also suggested that one point be added to the total scores of individuals with 12 or fewer years of formal education (Nasreddine et al., 2005). However, a recent study by Carson et al. (2018) suggested that a cut-off score of 23/30 should be used as this will reduce the rate of false positives and thus increase the accuracy of the test. Consequently, this study used this cut-off score of 23/30 to assess participants cognitive capacity to participate in the study as well of control for cognitive impairment in the statistical analyses.

Victoria Stroop Test (VST; Spreen & Strauss, 1998).

The VST was developed by Spreen and Strauss (1998) as an evaluation of selective attention, cognitive flexibility, and inhibitory control. It is a brief version of the Stroop task that takes about five minutes to complete, making it an appropriate test to use with the elderly who are more prone to fatigue during psychological testing (Bayard, Erkes, Moroni, & Roussillon, 2011; Troyer, Leach, & Strauss, 2006). The VST is a valid tool that has shown high test-retest reliability in healthy adult samples from Canada aged 18-94 (Troyer et al., 2006), Iranian bilingual adolescents (Malek & Amiri, 2013), and German-speaking adults (Wöstmann et al., 2013).

The test consists of three parts where a card is presented with coloured items arranged in a four by six matrix, each printed in the colours red, green, blue, and yellow (Troyer et al., 2006). In each part, participants were instructed to examine the items across each row and name their colour as quickly and accurately as possible. The first part's items were made up of coloured dots. The second part's items were neutral words (e.g. when, hard, and over) printed in colour. The third part's items were colour names (yellow, blue, green, and red) printed in colours that were either congruent or incongruent to the word itself, which served as the interference condition.

During the administration of the VST, the participant was interrupted by the examiner when an error was made in naming, after which the participant had had to correct the error before moving on to the next item. Errors that were spontaneously corrected by the participant before interruption were not counted as errors. Scores were made up of the amount of time required to complete each task together with the number of errors that were not spontaneously corrected. To calculate an interference score, the response times from the first two conditions are added together and then divided by two. This result is then subtracted from the response time of the third (colour-word) condition. (Strauss, Sherman, & Spreen, 2006). Higher interference scores reflect lower inhibitory control and cognitive flexibility.

Simon task (Bialystok et al., 2004)

The Simon task is a widely used measure of task-switching and inhibitory control. It requires the ability to switch between competing alternatives and to supress a prepotent association to irrelevant spatial information while attending to task-relevant nonspatial information (Bialystok et al., 2004). The task has been shown to have good internal consistency and test-retest reliability in a sample of healthy German-speaking adults (mean age 23.7 years; Wöstmann et al., 2013). It is also sensitive to age-related declines in task-switching and inhibitory control for healthy older adults (mean age 61 years; van der Lubbe & Verleger, 2002).

In this study, the test was administered in accordance with the procedure carried out by Bialystok et al. (2004). The test was presented on a computer screen for the participant. The trials began with a fixation cross in the centre of the screen that acted as a warning cue, which was followed by a blank interval. Thereafter, a red or blue square was presented on either the right or left side of the display. The side of the presented square was irrelevant, but the participant had to press the left shift key when it was a blue square or the right shift key when it was a red square. Participants were given eight practice trials before moving on to the 28 experimental trials. All trials consisted of an equal number of congruent and incongruent conditions. During the incongruent trials, the participant had to supress the automatic tendency to respond congruently to the stimulus position, and rather pay attention to the colour of the stimulus. Scores were made up of the number of correct responses, as well as the reaction times for congruent and incongruent trials. In addition, the difference between the incongruent and congruent trial were calculated as an index of the Simon effect.

Shortened Version of the Token Test (TT-SV; De Renzi & Faglioni, 1978).

Given the subjective nature of the LEAP-Q, the TT-SV was used as an objective measure of receptive English language ability. The Token Test was originally developed by De Renzi and Vignolo (1962) as a screening tool for mild receptive language disorders in aphasic patients. The original test contains 62 commands, but a shorter version was developed by De Renzi and Faglioni (1978) which contains 36 commands. Thus, the TT-SV is simpler and faster to administer making it an appropriate test to use with the elderly

(Moreira et al., 2011). The TT-SV is a robust measure of language comprehension and has shown good internal consistency reliability in healthy older adults and patients with mild Alzheimer's Disease (Paula, Bertola, Nicolato, Moraes, & Malloy-Diniz, 2012), as well as good inter-rater reliability in patients with poststroke aphasia (Paci, Lorenzini, Fioravanti, Poli, & Lombardi, 2015).

This study used a computerised version of TT-SV which consists of 20 colour tokens (red, black, green and white) made up of ten squares and ten circles (Lezak, Howieson, & Loring, 2012). There were five large circles and squares and five small circles and squares. These tokens were laid out in front of the participant horizontally in four parallel rows. The test was divided into six parts: part one contained seven items, part two to five contained four items each and part six contained thirteen items. In each part, participants were instructed to understand and carry out verbal commands that became progressively more complex. The first part required only one element, for example, "Touch the green square", whereas later parts required participants to understand and complete multiple elements, such as, "Touch the large yellow circle" and "Before touching the yellow circle, pick up the red square". In the first five parts of the test, if the participants responded incorrectly (or failed to respond in five seconds), the examiner returned the tokens to their original position and repeated the instructions. One point was awarded for success on the first try and half a point is awarded for success on the second try (Lezak et al., 2012). In the last part, there was only one chance to respond where one mark was awarded if correct and zero if incorrect (De Renzi & Faglioni, 1978). The final score out of 36 indicated an overall language comprehension score.

Procedure

Each session took place at a time and location that was convenient for participants and had suitable research conditions (i.e. a quiet room at a community centre or at the participant's home). The testing procedure started by providing the participant with an information sheet pertaining to the relevant details of the study and a consent form. After the consent form has been signed, the researcher explained to the participant how to complete the demographic form and the LEAP-Q. Next, the researcher administered the IADL-SV and MoCA to assess whether the participant met the criteria for inclusion. Participants were also asked if they have a history of head injury and mental illness. The IADL-SV and MoCA were only scored after the testing procedure, thus, participants who did not make the inclusion criteria still completed all the tests and were excluded afterwards.

After participants have signed the consent form the assessment stage began. The questionnaires and battery of cognitive tests were administered to participants and each assessment was conducted under the standardised conditions and scoring criteria provided. First, the demographic form was completed, followed by the LEAP-Q. Thereafter, participants completed the MoCA, followed the Stroop test, the Token test, and lastly, the Simon task. The order of presentation of tasks was counterbalanced to control for order effects. The administration time was between 50-60 minutes and breaks were given approximately halfway through or as required. After completion, the participant was reimbursed with R300 and signed a reimbursement form (Appendix G). A pilot study with approximately 34 elderly adults was undertaken prior to the commencement of the study to ensure that the instruments were manageable and appropriate. No changes were _ following the pilot study.

Ethical Considerations

It is important to consider the various ethical issues that may arise when working with human subjects to ensure the well-being of participants. In working with an elderly sample, certain issues may become apparent concerning informed consent. This not because the elderly are an inherently vulnerable sample but because they may often become vulnerable due to certain aspects related to ageing. These may include changes in physical and cognitive ability as well as chronic illness and loss of support systems, all of which could interfere with their autonomy to make choices (Walsh, 2009). To address this issue, the process of informed consent made sure that participants were aware that participation was voluntary and that they could withdraw from the study at any point without any negative consequences. Participants were also given all the relevant information pertaining to the study's protocol, including its aims and purposes, testing procedures, duration and any anticipated risks involved. This information was provided to participants on an information sheet and participants were free to ask the researcher any questions pertaining to the study.

After this process, participants were required to sign an informed consent sheet before any data collection could take place. After all the data was collected, the participants were reimbursed with R300 and signed a reimbursement form (Appendix G). Lastly, capacity assessments accompanied the informed consent process to assure that participants were able to make free decisions regarding their participation. If any cognitive anomalies were detected during the screening process, the participants were referred to a Neuropsychologist.

This study also ensured that participants' identities were protected through practicing confidentiality and anonymity. Due to the nature of the data collection process, complete anonymity was not assured as participants had to interact with the researcher as well as provide demographic information. Nevertheless, the researcher ensured that any information provided by participants was kept confidential. Data was also anonymised following collection by assigning participant codes and was subsequently analysed and reported as a group. An identification file was used to keep a record of the participants' names and their assigned codes in case any information was missing or misplaced. The identification file and data records that contain the participants' information was stored on a password-protected computer that remained private and only accessible to those involved in the research. Participants were informed that the researchers cannot guarantee complete anonymity and that confidentiality will be ensured in the reporting of the results and findings. Lastly, this study received ethical clearance from the Human Research Ethics Committee (Medical) of the University of Witwatersrand (Protocol number M190717; Appendix I).

Data Analyses

Data analysis was done in three stages to answer each of the research questions. In the first stage, the data was analysed using descriptive statistics to describe features of the sample. Means, standard deviations and ranges were reported for all interval variables, while frequencies were used to summarise categorical variables. These tests were also used to assess whether parametric or non-parametric tests were appropriate for further analyses. To test for normality, skewness and kurtosis coefficients and Kolmogorov-Smirnov tests were used, together with the central limit theorem (CLT).

The second stage of analysis assessed bivariate relationships between the various language proficiency variables and the two measures of EF through Pearson and Spearman correlations. To calculate the L1, L2, and L3 language proficiency variables, scores in reading, speaking and comprehension in each spoken language were added to together to make a composite score for each spoken language. Frequency of language use and age of acquisition (in months) for each identified language were also recorded as language variables. The EF variables consisted of reaction times, frequency of errors and interference scores for both the Simon task and the VST. Secondly, the relationship between English language proficiency and TT-SV scores were examined to assess the accuracy of the self-report measures from the LEAP-Q. Lastly, scores from the VST and Simon task were correlated to see if they assess overlapping skills.

After checking the relevant assumptions and assessing the various relationships between language proficiency and EF, the third phase of analyses included running a set of multiple regressions which were used address the main research questions. This technique showed how much of the variance in the EF measures were explained by the various aspects of proficiency for each language (Hair, Black, Babin, Anderson, & Tatham, 2006). These analyses also assessed the interrelationships between all the variables of interest to make judgements regarding the distinct effects of each (Hair et al., 2006). The analyses also controlled for mild cognitive impairment and socioeconomic status, measured by the MoCA and the LSM respectively. These were entered as independent variables in the multiple regressions.

Chapter Three: Results

This study investigated whether proficiency in multiple languages is related to executive function (EF) in older multilinguals (aged 65 and older). The statistical analyses used to answer this question were a combination of bivariate correlations and multiple regressions. Two aspects of EF, namely task-switching and inhibitory control, were assessed using the Simon task and the Victoria Stroop Task (VST), respectively. These variables acted as the dependent variables and were interval in nature. Proficiency in multiple languages was measured by the Language Experience and Proficiency Questionnaire (LEAP-Q) which assessed proficiency in speaking, reading and understanding in each spoken language, rated on a scale of zero to 10. Due to issues of multicollinearity, these three variables were added together to make a composite score of each spoken language. Age of acquisition (AoA) and frequency of language use were also recorded for each spoken language. The variables from the LEAP-Q were interval and acted as the independent variables. To assess the validity of the LEAP-Q, the Token Test was used as a measure of receptive English language ability. Consequently, English language proficiency was calculated from the LEAP-Q to assess the relationship between these two interval variables. Lastly, two covariates were identified, namely presence of mild cognitive impairment and socioeconomic status (SES). These two interval variables were measured by the Montreal Cognitive Assessment (MoCA) and the Living Standards Measure (LSM) respectively. This chapter will describe the various descriptive statistics for each of these variables, the tests for normality that were undertaken, and the inferential statistics that were conducted to answer the research questions.

Descriptive Statistics

The following section is divided into three subsections which will describe the sample on all of the measures used in this study. The first describes the demographic variables of the sample, the second describes the descriptive language variables derived from the LEAP-Q and Token Test, and the third describes the descriptive cognitive variables derived from the Simon task, VST, and the MoCA.

Demographic variables.

A demographic questionnaire (Appendix C) was used to capture various characteristics of the sample. Table 3 presents the sample's distribution on gender, age, number of years of education, SES, number of languages spoken, and home language. It must be noted that all participants satisfied the inclusion criteria of the Lawton Activities of Daily Living (IADL) measure by being able to perform each of the listed tasks.

Table 3
Demographic variables of the sample (N = 50)

	N (%)	*M*	*SD*	*Range*
Female	33 (66)			
Male	17 (34)			
Age in Years		73.34	6.14	65-85
Years of Education		12.42	2.86	5-17
SES		8.06	1.99	2-10
No. of Languages Spoken.		3.04	1.20	2-5
Home Language				
English	23 (46)			
Afrikaans	13 (26)			
Setswana	5 (10)			
IsiZulu	3 (6)			
IsiNdebele	1 (2)			
Sesotho	1 (2)			
Northern Sesotho	1 (2)			
Tshivenda	1 (2)			
German	1 (2)			
French	1 (2)			

Note. SES = Socioeconomic status. No. of Languages Spoken = Number of languages spoken.

The sample consisted of mostly females (66%) and had a mean age of 73.34 years (*SD* = 6.14). The number of years of education (*M* = 12.42, *SD* = 2.86) suggests that participants mostly had a high school education up to Grade 12. The SES score was derived from the LSM questionnaire and scores could range from one (lowest SES) to 10 (highest SES). The sample's LSM scores ranged between two and 10 and had a mean score of 8.06 (*SD* = 1.99), which suggests that participants mostly came from higher socioeconomic backgrounds. Furthermore, the sample can be considered as multilingual as the mean number of languages spoken was 3.04 (*SD* = 1.20), with some participants speaking up to five languages. Concerning home language, English was reported as the most frequently spoken L1 (*N* = 23), followed by Afrikaans (*N* = 13), and then Setswana (*N* = 5). Other African languages and two European languages were also represented but were spoken by only a few individuals (collectively *N* = 9).

Language variables.

The LEAP-Q was used to capture various elements of participants' multilingual language abilities. This section will describe the multiple languages that participants spoke, their self-rated proficiency in reading, speaking and understanding in each language, the age at which they acquired these languages, and the average frequency of use for each spoken language. As this study was guided by the idea that that higher language proficiency will be related to better EF, it was decided to include up to three spoken languages in the analyses as participants' fourth- and fifth language proficiency scores were quite low. In addition, a minority of the total sample reported speaking a fourth or fifth language which would compromise normality.

The first languages spoken by participants are the same as the home languages reported in the previous section. In Table 4, English (*N* =23) and Afrikaans (*N* = 22) were the most prominent L2. The rest of the second languages consisted of IsiZulu, Sesotho, IsiXhosa, Spanish, and Italian, but were only reported by a few individuals (collectively *N* = 5). A variety of third languages were reported but were only spoken by about half of the sample (*N* = 26). Five individuals reported IsiZulu as their L3, whilst four spoke German. Afrikaans, English and Setswana were each spoken by three participants. The rest of the third languages included five African languages and one European language, but were only reported by a few individuals (collectively *N* = 8). Overall, the sample reported speaking a variety languages which included all 12 official South African languages. Some European languages were also represented.

Table 4
Frequencies and percentages of first, second, and third languages spoken by sample (N=50)

	L1	L2	L3
	N (%)	*N* (%)	*N* (%)
English	23 (46)	23 (46)	3 (6)
Afrikaans	13 (26)	22 (44)	3 (6)
Setswana	5 (10)		3 (6)
IsiZulu	3 (6)	1 (2)	5 (10)
Sesotho	1 (2)	1 (2)	2 (4)
Northern Sesotho	1 (2)		
IsiNdebele	1 (2)		
Tshivenda	1 (2)		
Sepedi			1 (2)
Shangaan			1 (2)
Shona			1 (2)
IsiXhosa		1 (2)	2 (4)
German	1 (2)		4 (8)
French	1 (2)		1 (2)
Spanish		1 (2)	
Italian		1 (2)	
N	50	50	26

Note. L1 = First language. L2 = Second language. L3 = Third language.

For each spoken language, the LEAP-Q recorded self-reported proficiency in speaking, reading, and understanding, as shown in Table 5. These scores could range from zero (none) to 10 (perfect). A composite score for each spoken language (L1, L2, and L3) was calculated from these scores, which could range from zero to 30. This was to prevent any multicollinearity issues for the multiple regressions that will be described later. Furthermore, L2- and L3 AoA were also calculated in months, as well as theaverage frequency of L2 and L3 use, rated out of 100 percent. It was also possible to calculate English language proficiency in reading, speaking, and understanding from the LEAP-Q because all participants reported that they could speak English either as a L1, L2, or L3. Lastly, Token Tests scores are also included in the last row which were scored out of 36.

Participants' proficiency was highest in their L1 across all three indicators, where understanding (*M* = 9.14, *SD* = 1.09) was rated highest, followed by reading (*M* = 9.06, *SD* = 1.08), and then speaking (*M* = 8.84, *SD* = 1.22). Scores got progressively lower in participants' L2 and L3. However, L2 scores were still above 5 for all three indicators where understanding was rated highest (*M* = 7.08, *SD* = 2.12), followed by speaking (*M* = 6.60, *SD* = 2.37), and then reading (*M* = 6.44, *SD* = 3.01), thus, participants could still be considered as highly proficient in their L2. Concerning participants' L3, scores averaged around 5 for understanding (*M* = 5.81, *SD* = 2.62) and reading (*M* = 5, *SD* = 3.27), but fell just below 5 for speaking (*M* = 4.92, *SD* = 2.40). Consequently, the composite scores followed the same pattern where participants were most proficient in their L1 (*M* = 27.04, *SD* = 3.10), followed by their L2 (*M* = 20.12, *SD* = 7.06), and least proficient in their L3 (*M* = 15.73, *SD* = 7.78). Looking at the ranges and standard deviations of each indicator, L2 scores and L3 scores became more variable than L1 scores.

Participants reported and early age of L2 acquisition (*M* = 106.80, *SD* = 82.54) of 8.9 years. This could reflect the requirement of the South African schooling system that learners

Table 5

Descriptive statistics of the language variables

	M	*SD*	*Range*	*Skewness*	*Kurtosis*
L1 Speaking	8.84	1.22	5-10	-.88	.34
L1 Reading	9.06	1.08	6-10	-.94	.05
L1 Understanding	9.14	1.09	6-10	-1.08	.24
L2 Speaking	6.60	2.37	1-10	-.76	-.30
L2 Reading	6.44	3.01	0-10	-.95	-.27
L2 Understanding	7.08	2.12	2-10	-.75	-.32
L3 Speaking	4.92	2.40	1-10	.02	-.41
L3 Reading	5.00	3.27	0-10	-.36	-1.18
L3 Understanding	5.81	2.62	1-10	-.26	-.61
L1 Composite Score	27.04	3.10	19-30	-.74	-.42
L2 Composite Score	20.12	7.06	6-30	-.67	-.71
L3 Composite Score	15.73	7.78	2-30	-.17	-.77
L2 AoA (in months)	106.80	82.54	12-480	2.41	9.10
L3 AoA (in months)	126.46	76.29	12-348	.965	1.30
L2 Frequency	24.50	16.66	0-70	.36	-.39
L3 Frequency	11.27	13.24	0-50	1.81	2.78
English speaking	7.88	1.53	4-10	-.60	-.11
English reading	8.24	1.39	4-10	-.780	.65
English understanding	8.16	1.43	5-10	-.60	-.14
Token Test	29.42	2.67	23-34	-.53	-.29

Note. L1 = First language. L2 = Second Language. L3 = Third language. AoA = Age of acquisition. Frequency = Frequency of language use, scored out of 100%.

must pass at least two languages from Grade three onwards (Department of Basic Education, 1997). The age of participants' L3 acquisition (*M* = 126.46, *SD* = 76.29) were also reported at an early age of 10.54. Concerning the frequency of language use, participants reported on average that they use their L2 only 24.50% (*SD* = 16.66) of the time and their L3 11.27% (*SD* = 13.24) of the time. Thus, participants are not speaking their L2 and L3 very often.

As proficiency in English was a prerequisite for participation in the study, all participants reported that they spoke English, which dominated as a first- and second language overall. Consequently, participants had high proficiency in English where reading ability (*M* = 8.24, *SD* = 1.39) was rated as highest, followed by understanding (*M* = 8.16, *SD* = 1.43), and then speaking (*M* = 7.88, *SD* = 1.53).

Overall, participants were highly proficient in their L2 and generally had an early age of L2 acquisition. Secondly, participants had a moderate L3 proficiency but still and early age of L3 acquisition. However, the frequency at which participants use their L2 and L3 were quite low. Lastly, all participants were highly proficient in English which mirrored generally high scores on the Token Test.

Cognitive variables.

This study required that participants complete cognitive tests in order to examine the relationship between multilingual language proficiency and EF. In addition, mild cognitive impairment (measured by the MoCA) was used as a control variable alongside SES. The EF of task-switching was measured by the Simon task which was made up of the following variables: Total number of errors, response time (RT) in milliseconds for congruent conditions, RT in milliseconds for incongruent conditions, and a score representing the Simon effect. The EF of inhibitory control was measured by the VST and was made up of the following variables: RT (in seconds) and number of errors on the first dots condition, RT and amount of errors on the second word condition, and RT and amount of errors on the third incongruent colour-word condition. Lastly, an interference effect was also calculated. The descriptive statistics for these variables are presented in Table 6.

Performance on the MoCA had a mean score of 24.42 (*SD* = 2.92) which indicates that most of the sample satisfied the cut-off score of 23 (Carson et al., 2018). However, the range shows that the lowest score was 18. Participants who scored lower than 23 was not excluded from the analyses because the MoCA was included as a covariate. Looking at the VST, the response times (in seconds) for the three conditions increased progressively, which

Table 6
Descriptive statistics of the cognitive measures

	M	*SD*	*Range*	*Skewness*	*Kurtosis*
MoCA	24.42	2.92	18-29	-.12	-.74
Victoria Stroop Task					
Dots RT	18.50	5.45	11-38	1.41	2.23
Dots errors	.12	.39	0-2	3.45	12.38
Words RT	24.16	7.13	15-46	1.21	1.42
Words errors	.06	.24	0-1	3.82	13.12
Colour-word RT	35.53	9.60	22-55	.50	-.95
Colour-word errors	.72	1.51	0-8	2.97	10.64
Total errors	.96	1.74	0-9	2.64	8.74
Interference score	14.39	6.44	5-29	.38	-.54
Simon Task					
Total errors	1.40	1.75	0-7	1.69	2.49
Congruent RT	614.75	114.11	430.71-939.36	.337	.533
Incongruent RT	694.31	114.67	498.86-956.63	.554	-.168
Simon effect	79.56	56.07	-63.66-176.38	-.47	-.21

Note. MoCA = Montreal Cognitive Assessment. RT = Response time. The response times of the VST are recorded in seconds. The response times of the Simon Task are recorded in milliseconds.

is expected, as each condition becomes more difficult. The Dots condition (*M* = 18.50, *SD* = 5.45) had the fastest RT, followed by the Words condition (*M* = 24.16, *SD* = 7.13), and the Colour-word condition (*M* = 35.53, *SD* = 7.13). The standard deviations indicate that the variation in scores also increased as the conditions became more difficult. In general, participants did not make many errors in all three conditions, with a mean score of less than one on each condition. Lastly, the interference score of the VST had a mean of 14.39 (*SD* = 6.44) and ranged between five and 29. The interference score demonstrates how well participants can inhibit word reading (as they are required to read the colour of the words). Higher scores indicate more interference (less inhibitory control).

The Simon Task showed the same progression in response times (measured in milliseconds) as the VST, with the congruent condition (*M* = 614.75, *SD* = 114.67) being the fastest and the harder incongruent condition (*M* = 694.31, *SD* = 114.67) being somewhat slower. The Simon effect, which indicates the time difference between these two conditions, shows an average difference of only 79.56 milliseconds (*SD* = 56.07). Participants' average number of errors on the Simon task was 1.40 (*SD* = 1.75). Overall, participants performed better in the congruent conditions of both the VST and the Simon task compared to the incongruent conditions and did not make many of errors.

Tests of Normality

As this study was relational in nature, Pearson's correlation coefficients were chosen to assess the various relationships between the variables of interest. In using this test, certain assumptions need to be in place such as normality of the data. There are multiple techniques to assess normality of which the following were used: The Central Limit Theorem (CLT), skewness and kurtosis coefficients, and Kolmogorov-Smirnov tests. These tests were run on the variables stated in the hypotheses.

The CLT states that a sample with at least 30 participants will produce a normal distribution (Howell, 2011). For this study, the sample size was 50, which satisfied the CLT's assumption. The skewness and kurtosis coefficients represent the spread of the distribution, namely, the symmetry of the distribution and the 'peakedness' of the distribution, respectively. Skewness and kurtosis values need to range between -1 and 1 in order to be considered normally distributed (Pallant, 2011). Concerning the Kolmogorov-Smirnov test, p-values must be non-significant to be accepted as normal (Field, 2017).

The normality indicators are summarised in Appendix J which show that most of the LEAP-Q variables had skewness and kurtosis values between -1 and 1, with the exception of L2 AoA, L3 AoA, and L3 frequency. Concerning the cognitive measures, only two variables exceeded values of -1 and 1, namely, the total errors on the VST and the Simon Task. Lastly, the Kolmogorov-Smirnov tests indicated that that the data was not normally distributed as the majority of the variables had significant p-values.

Taken together, the CLT and Skewness and Kurtosis coefficients indicate that most of the data are normally distributed. In contrast, the Kolmogorov-Smirnov tests of indicated that most of the data were not normally distributed, suggesting that non-parametric tests would be suitable. Because Pearson’s correlation coefficients are a precursor to multiple regressions, it was decided to run both Pearson’s- and Spearman’s Correlations (Appendix K) and to compare the results on both of these analyses. The results of the differences between them are reported in the next section.

Further assumptions for running Pearson’s Correlations include an interval scale of measurement, linearity between the two variables being correlated, and no significant outliers. All variables included in the correlations were interval in nature and most independent variables had linear relationships with the dependent variables, as shown in the scatterplots in Appendix L. Outliers were identified but it was decided to keep them in the analyses as some variables had more than two outliers which would reduce the sample. The data were transformed using Z transformations, but the transformations made no change to the normality distributions.

Correlations between key Variables

Table 6 shows the correlations among the key variables used in this study. This include the two covariates (LSM and he MoCA), variables derived from the LEAP-Q, (namely, L1 composite score, L2 composite score, L3 composite score, English reading, English speaking, and English understanding), as well as the Token Test. Three variables were included from the VST, namely, colour-word response times, colour-word errors, and the interference score. Lastly, three variables from the Simon task were also included, namely, incongruent response times, total number of errors, and the Simon effect. These correlations answered the secondary research questions of the study. The hypotheses of these secondary questions will be addressed in this discussion. The results of the correlations were also used to aid in the interpretation of the multiple regression analyses which were used to answer the two main research questions.

This section will only describe the significant correlations that are relevant to the hypotheses. First, it is noteworthy to look at the many statistically significant correlations between the two covariates, and the language and cognitive variables. First, SES had positive correlations with the MoCA, all three English proficiency indicators, and the Token Test (with r ranging from .257 to.504). Socioeconomic status was also negatively correlated with L3 frequency, L3 proficiency, and total errors on the Simon Task (with r ranging from -.442 to -.597). The MoCA had weak positive correlations with all three English proficiency indicators (r ranging between .321 and -.421) and the Token Test (r = .480, p = < .01). Furthermore, the MoCA had weak negative correlations with L3 proficiency, the VST's colour-word response time and errors (with r ranging from -.287 to -.368).

Looking at L2- and L3 AoA, it was hypothesised that earlier AoA will be related to faster reaction times (in incongruent conditions) and fewer errors in both the VST and the Simon Task, as well as smaller interference scores (VST) and Simon effects. Second language AoA had a weak positive correlation with the VST's interference score (r = 2.85, p = < .05), although this relationship became non-significant when running the Spearman's Correlations (Appendix K). Regarding L2 and L3 frequency, it was hypothesised that higher frequency of language use will be related to faster reaction times and fewer errors in both the VST and the Simon Task, as well as smaller interference scores (VST) and Simon effects. This hypothesis was rejected as L3 frequency had weak positive correlations with RT on the VST's colour-word condition (r = .339, p = < .05), the Simon Task's incongruent condition (r = .443, p = < .05) and total amount of errors on the Simon task (r = .361, p = < .05). These correlations also became non-significant with running the Spearman's Correlations (Appendix K).

It was hypothesised that higher proficiency in multiple languages will be related to better performance on both the EF tasks. Second language proficiency had weak negative correlations with the VST's interference score (r = -.299, p = <. 05) and the Simon effect (r = -.284, p = < .05). Third language proficiency was also negatively correlated with the VST's interference score (r = -.378, p < .05). These correlations remained significant in the Spearman's Correlations (Appendix K).

In validating the LEAP-Q, it was predicted that English language proficiency would be related to the Token Test, an objective measure of receptive English language ability. Confirming this hypothesis, the Token Test had weak positive correlations with English speaking (r = .418, p = < .01), English understanding (r = .376, p = < .01), and English reading (r = .369, p = < .01), and remained significant when running Spearman's Correlations (Appendix K). Lastly, to evaluate the unity and diversity model of EF (Miyake et al., 2000), it was predicted that performance on the VST will be related to performance on the Simon task. A few significant correlations were found between these two tests. First, RT on the VST's colour-word condition had a positive relationship with the RT on the Simon task's incongruent condition (r = .463, p = < .01) and remained significant when running Spearman's Correlations. Second, the VST's interference score also had a positive relationship with the RT on the Simon task's incongruent condition (r = .438, p < .01) and also remained significant in the Spearman's Correlations.

Table 7

Pearson's Correlations among covariates, language variables and cognitive variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. SES																			
2. MoCA	**.485****																		
LEAP-Q																			
3. L2 AoA	.110	-.220																	
4. L3 AoA	.193	-.189	.180																
5. L2 Freq	-.016	.012	-.215	-.221															
6. L3 Freq	**-.597****	-.208	.001	-.270	.204														
7. L1	-.183	.061	-.101	-.083	-.075	.281													
8. L2	-.107	.173	**-.347****	-.210	**.374****	-.141	**.373****												
9. L3	**-.511****	**-.368***	-.037	-.206	.291	**.631****	.297	.010											
10. Eng Speak	**.257***	**.321***	-.056	-.069	.026	-.030	**.408****	**.239***	.088										
11. Eng Under	**.276***	**.378****	.023	-.038	.074	-.128	**.407****	**.363****	.020	**.900****									
12. Eng Read	**.275***	**.421****	.094	.005	.043	-.178	**.432****	**.408****	-.171	**.806****	**.910****								
13. Token Test	**.504****	**.480****	-.086	.223	.105	**-.384***	.066	-.025	-.186	**.418****	**.376****	**.369****							
Victoria Stroop Task																			
14. CW RT	.175	**-.345****	.160	.069	-.040	**.339****	.093	-.196	0.29	-.098	-.147	-.174	-.217						
15. CW Errors	-.219	**-.287***	-.079	-.214	.074	-.105	-.011	.051	-.104	-.006	-.082	-.142	-.158	**.398****					
16. Interference	.215	-.062	**.285***	.239	-.118	-.141	-.111	**-.299***	**-.378***	-.038	-.088	-.146	.069	**.773****	**.312***				

Table 6

Pearson's Correlations among covariates, language variables and cognitive variables (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Simon Task																			
17. Incong RT	-.074	.011	.162	-.128	.110	**.443***	-.120	-.188	.059	.046	.059	-.015	-.159	**.463****	.119	**.438****			
18. Total Errors	**-.442****	-.177	-.028	-.242	**-.043***	**.361***	.057	.160	.195	-.164	-.213	-.116	-.203	.075	.059	-.055	.015		
19. Simon Effect	-.025	.144	-.050	-.282	-.084	.147	-.052	**-.284***	.071	-.226	-.195	**-.275***	.049	.003	-.084	.015	**.254***	-.127	

Notes. SES = Socioeconomic status. MoCA = Montreal Cognitive assessment. L1 = L2 AoA = Second language age of acquisition. L3 AoA = Third language age of acquisition. L2 Freq = Second language frequency. L3 Freq = Third language frequency. L1 = First language proficiency (composite score). L2 = Second language proficiency (composite score). L3 = Third language proficiency (composite score). Eng Speak = English speaking. Eng Under = English understanding. Eng Read = English reading. CW RT = Colour-Word response time. CW Errors = Colour-Word Errors. Interference = Interference score. Incong RT = Incongruent response time.

* = p < .05, ** = p < .01.

Multiple Regression Analyses

The main research questions of this study were addressed using multiple regressions in order to assess how much variance in EF can be explained by proficiency in multiple languages. Proficiency in multiple languages (L1, L2, and L3), L2 AoA, and L3 frequency, as measured by the LEAP-Q, acted as the independent variables. There were six EF variables which served as the dependent variables. From the VST, these included the colour-word response times, colour-word errors, and the interference score. From the Simon task, these included incongruent response time, total errors, and the Simon effect. Socioeconomic status and the MoCA were entered as independent variables in order to control for their effects on EF. This was necessary as these two variables shared many significant correlations with the language and cognitive variables. It was hypothesised that higher proficiency in each spoken language will be related to faster reaction times and fewer errors in the incongruent conditions of both the VST and Simon task. Furthermore, it was hypothesised that proficiency in multiple languages will be related to smaller interference scores on the VST and smaller Simon effects.

Certain assumptions need to be in place in order to run multiple regressions. First, there needs to be linearity between each independent variable and dependent variable Field, 2017). Most of the independent variables (IVs) had linear relationships with the dependent variables (DVs), assessed via scatterplots (Appendix M). Second, there needs to be independence of residuals which can be assessed by the Durbin-Watson statistic, which should approximate a value of two (Field, 2017). This assumption was satisfied as all regressions showed Durbin-Watson statistics around the value of two. Third, there needs to be homoscedasticity, which is assessed by inspecting the scatterplots between studentised residuals and unstandardised predicted values. This assumption was also satisfied as most of the scatterplots did not follow a funnel shape, which indicated homoscedasticity. The fourth assumption states that there must not be multicollinearity between the independent variables. (Field 2017) As shown in Appendix L, there were a few intercorrelations between the L1, L2, and L3 reading, understanding and speaking variables. Therefore, composite scores were created for each spoken language which removed the intercorrelations among the IVs.

The fifth assumption states that there should be no unusual points in the data, which includes outliers, leverage points, and influential points. Outliers can be detected via casewise diagnostics (which highlights standardised residuals greater than ±3 standard deviations) and inspection of the studentised deleted residuals. There were no significant outliers in all the regressions and no studentised deleted residual greater than ±3 standard deviations, except for the VST's colour-word RT. To assess leverage points, no values should be greater than 0.2 (Huber 1981). The regression only showed four values greater than 0.2 which were kept in. To assess influential points, values for Cook's distance are inspected and should not exceed a value of one (Cook & Weisberg, 1982). All regressions produced Cook's distance values that had values of one or less, satisfying this assumption. The last assumption requires normality of the standardised residuals, although regressions are quite robust to violations of normality. Histograms (Appendix N) and normal probability plots (Appendix O) were assessed which indicated normality of residuals for most of the regressions.

Six regressions were run which are shown in Table 7. In the regression analysis for incongruent RT on the Simon task (R^2 = .37; *F* (7,18) = 1.54, *p* = .217), L3 frequency of use was the only significant predictor with a positive unstandardised beta (*B* = 7.92, *SE* = 2.81, *p* = .011). No other variable was a significant predictor of incongruent RT. In the regression for Simon errors (R^2 = .45; *F* (7,18) = 2.07, *p* = .101), SES was the only significant predictor with a negative unstandardised beta (*B* = -.59, *SE* = .25, *p* = .030). No other variable was a significant predictor of total errors made on the Simon task. When looking at the rest of the models, there were no significant predictors among the independent variables for each dependent variable, indicating poor goodness-of-fit and explanatory power.

To conclude, the results showed that L2 proficiency was significantly correlated with the VST's interference score and the Simon effect, while L2 AoA and L3 proficiency was also significantly correlated with the VST's interference score. However, these relationships became non-significant when controlling for SES and the presence of mild cognitive impairment in the multiple regression. Secondly, the results showed that SES was significantly correlated to numerous variables and negatively predicted errors made on the Simon task. A third key finding was that L3 frequency had weak positive correlations with RT on the VST's colour-word condition, incongruent RT on the Simon task, and total amount of errors made on the Simon task. In addition, L3 frequency was also the only positive predictor of incongruent RT on the Simon task. The fourth finding was that self-ratings on the LEAP-Q (for English language proficiency) had significant positive correlations with the Token Test. Lastly, some EF variables were found to be correlated with each other. Incongruent RT on the Simon task had significant positive correlations with RT on the colour-word condition of the VST and the VST's interference score. Overall, these findings have important answers to the question of whether proficiency in multiple languages is related to EF in older adults, which will be discussed in the next chapter.

Table 8

Multiple regression results

	(1) Colour-word RT	(2) Colour-word Errors	(3) Interference Effect	(4) Incongruent RT	(5) Simon Errors	(6) Simon Effect
Constant	122.36* (28.83)	6.86 (6.8)	57.76* (20.46)	800.13 (412.07)	4.63 (5.76)	118.56 (188.13)
MoCA	-1.26 (.79)	-.16 (.19)	-.57 (.56)	-1.80 (11.26)	.21 (.16)	.49 (5.14)
SES	-.43 (1.26)	-.23 (.30)	.04 (.89)	15.55 (17.97)	-.59* (.25)	10.61 (8.20)
L1	-1.12 (.79)	.01 (.19)	-.69 (.56)	-9.64 (11.25)	-.18 (.16)	-4.13 (5.14)
L2	-.48 (.34)	.03 (.08)	-.16 (.24)	1.37 (4.89)	.05 (.07)	-1.99 (2.23)
L3	-.51 (.31)	-.06 (.07)	-.42 (.22)	-4.83 (4.45)	-.01 (.06)	.89 (2.03)
L2 AoA	-.05 (.03)	-.0 (.01)	-.01 (.02)	.25 (.47)	.01 (.01)	-.12 (.21)
L3 Freq	.38 (.20)	-.02 (.05)	.09 (.14)	7.92* (2.81)	.03 (.04)	1.27 (1.28)
F (7,18)	2.72	.39	1.61	1.54	2.07	.70
R^2	.51	.13	.39	.37	.45	.21

Notes. For all the independent variables, unstandardised coefficients are shown with standard errors in parentheses. Models (1) to (6) were six separate regressions with the name of the model being the dependent variable.

Colour-word RT = Response time on the VTS's colour-word condition; Colour-word Errors = Errors made on the VST's colour-word condition; Interference Effect = The VST's interference effect. Incongruent RT = Response time on the Simon's task incongruent condition; Simon Errors = Total errors made on the Simon task; MoCA = Montreal Cognitive Assessment; SES = Socioeconomic status; L1 = First language proficiency; L2 = Second language proficiency; L3 = Third language proficiency; L2 AoA = Second language age of acquisition; L3 Freq = Third language frequency of use.

*p < .05

Chapter Four: Discussion

This study investigated whether proficiency in multiple languages (and other related indicators of multilingual language proficiency) are related to executive function (EF) in older multilinguals, while controlling for socioeconomic status (SES) and mild cognitive impairment. This chapter presents the key findings from the results of the multiple regression analyses and bivariate correlations that were carried out. The results are discussed in terms of the research questions, followed by an integration of how these results relate to the literature reviewed at the outset of this report. This chapter ends in a summary of the theoretical and practical significance of the results in light of multilingualism's effect on EF and its implications for cognitive reserve.

This study produced six key findings: (1) After controlling for SES and mild cognitive impairment, second language (L2) and third language (L3) proficiency and L2 age of acquisition (AoA) did not significantly predict variance in performance on any of the EF tasks; (2) Socioeconomic status was a significant and negative predictor of the number of errors made on the Simon task; (4) Third language frequency was a significant predictor of incongruent response time on the Simon task (this relationship was positive in nature); (4) Self-ratings on the The Language Experience and Proficiency Questionnaire (LEAP-Q; for English language proficiency) was significantly related to performance on the Token Test; (5) Response time on the incongruent condition of the Simon task was positively related to response time on the incongruent colour-word condition of the Victoria Stroop Task (VST), as well as the VST's interference score. The discussion that follows will expand on each finding.

Concerning the first key finding, L2 proficiency had statistically significant relationships with both the VST's interference score and the Simon effect (these relationships were negative in nature). In addition, L3 proficiency had a statistically significant (and negative) relationship with the VST's interference score. Both of these scores from the VST and the Simon task show the amount of interference experienced between the response times of congruent and incongruent conditions, where higher scores indicate more interference (Bialystok et al., 2004; Spreen & Strauss, 1998). It was hypothesised that, due to the increased efficiency in inhibitory control and task-switching of bi/multilinguals, those who are more proficient in their languages will take less time to resolve conflict in non-verbal EF tasks, resulting in smaller interference scores (Bialystok et al., 2009). The sample was very heterogeneous in terms of L2 and L3 proficiency, AoA, and frequency of languages use, and thus it was expected that participants with higher language proficiency would perform better on the EF tasks. The patterns of correlational results confirm this hypothesis as higher L2 and L3 language proficiency were related to smaller interference scores. However, once these variables were entered into the multiple regression analyses, and SES and mild cognitive impairment were controlled for, these relationships became non-significant. Hence, these results suggest that participants with higher proficiency in a L2 or L3 language performed equally to those with lower language proficiency on both the EF tasks. This finding suggests that bi/multilingualism does not contribute significantly to the executive functions (EFs) of inhibitory control and task-switching in older adults.

These results corroborate previous studies that found no effect of bilingualism on the Stroop task (Antón et al.,2016) and the Simon task (de Bruin et al., 2015; Kirk et al., 2014; Kousaie and Phillips, 2012) in older bilinguals (Lehtonen et al., 2018). More broadly, the results add to the body of research that found no improved EF performance of bilinguals across all stages of life (Antón et al., 2014; Duñabeitia et al., 2014; Gathercole et al., 2014; Paap & Greenberg, 2013; Paap et al., 2014; Paap et al., 2015; von Bastian, Souza, & Gade, 2015). The reason for the finding could be that some other non-linguistic factor(s), such as immigrant status, SES, and cultural differences (Paap et al., 2015) may be more indicative of EF than the practice of bi/multilingualism, as only SES and no language variable significantly predicted performance on any the EF tasks. It is possible that there was too much variation in task performance to establish a pattern, since the sample was quite heterogeneous in terms of language proficiency and languages spoken. Although the sample's average L2 proficiency scores tended to be high, there was a lot of variance in terms of proficiency levels for both their L2 and L3. In addition, their L3 proficiency was generally rated as much lower than that of their L2. In keeping with this finding, Antón et al. (2016) and Paap et al. (2014) also tested bi/multilinguals who were heterogeneous in terms of different languages spoken and exposure to second languages and found no significant evidence for a bi/multilingual advantage. More specifically, Paap et al. (2014) found no evidence that supports the hypothesis that either early bilingualism, highly fluent balanced bilingualism, or trilingualism, increased inhibitory control. Paap et al. (2014, 2015) have critiqued the many studies that have found bilingual advantages, stating that there is a tendency on the part of editors, reviewers and researchers to favour, and thus publish, significant and positive results opposed to studies that show null results. Paap et al. (2014) further showed that studies that found bilingual advantages tend to have smaller sample sizes and are underpowered. Lastly, the authors argue that the advantages found by these studies may be measuring more task specific inhibitory control processes than differences in domain-general ability in inhibitory control.

The reason for the non-significant results in the current study could be due to other non-linguistic factors that were controlled for in this study (such as SES and mild cognitive impairment) or other unknown factors that were not measured that also could have caused bi/multilinguals with varying levels of L2 and L3 proficiency to perform equivalently on the EF tasks. There are numerous non-linguistic factors that have been found to covary with EF, including immigrant status (Chertkrow et al., 2010), educational levels (Gollan et al., 2011), genetics (Friedman et al., 2008), SES (Bradly & Corwyn, 2002), and cultural differences (Morton & Carlson, 2014). Hence, these results suggest that higher L2 and L3 proficiency may covary with some of these factors. In this study, these factors would include SES and mild cognitive impairment.

In relation to the above, the second key finding was that SES significantly predicted the total number of errors made on the Simon task. This relationship was negative in nature, indicating that bi/multilinguals from higher socioeconomic backgrounds made fewer errors on the Simon task than bi/multilinguals from lower socioeconomic backgrounds. This result would suggest that SES is a more important indicator of successful task-switching than L2 or L3 proficiency, as L2 and L3 proficiency were not significant predictors of errors made on the Simon task. In the correlational analyses, SES also had significant negative correlations with L3 frequency, L3 proficiency, and total errors made on the Simon task.

This would suggest that coming from a higher socioeconomic background is related to lower proficiency in a L3 and lower frequency of L3 use. Socioeconomic status also had significant positive correlations with performance on the Montreal Cognitive Assessment (MoCA), on all three English language proficiency variables, and on the Token test. These correlations show that bi/multilinguals from higher socioeconomic backgrounds performed better on the MoCA, have higher English language proficiency and better English receptive vocabulary (Token test). Overall, these many correlations in the results suggests that SES has many relationships with language ability as well as cognitive function.

The results from the multiple regression show that bi/multilinguals from higher SES are less susceptible to the conflict created by the Simon task than bi/multilinguals from lower SES, even after controlling for mild cognitive impairment. This finding corroborates that of Morton and Harper (2007) who found that SES, rather than bilingualism, is a significant indicator of performance on tasks of EF. This is not surprising as socioeconomic factors, such as higher family income and higher parental education benefit cognitive development in children (Bradley & Corwyn, 2000; Hackman et al, 2015). The finding in the current study that SES is positively related to performance on the MoCA suggests that these benefits continue into older age, and may contribute to cognitive reserve (Sattler et al., 2012). However, it must be noted that this study's measurement of SES (i.e. the Living Standards Measure) is one of material resources where high scores are dependent on the ownership various appliances and degree of urbanisation. Thus, SES in this study is more indicative of material resources than of social resources, although the two are undoubtedly related (Bradley & Corwyn, 2000). Overall, the first two findings of this study suggest that SES, rather than proficiency in multiple languages and L2 AoA, is a significant predictor of performance on the Simon task, more specifically, of the number of errors made on the task.

The third key finding was unexpected, namely that frequency of L3 use was the only significant predictor of incongruent response times on the Simon task, a relationship that was negative in nature. Throughout the literature and in the hypotheses, it is suggested that higher frequency of L2 use would translate into more L2 practice, thus, more gains in EF (Bialystok et al., 2009). Thus, it was expected that the bi/multilinguals who use their L2 or L3 frequently would show better performance on the EF tasks, especially on incongruent trials, due to increased inhibitory control and task-switching required on these trials. These results suggest the opposite in that speaking a L3 frequently is related to slower response times on incongruent trials on the Simon task. Studies have typically found that bilinguals have faster response times on incongruent conditions in comparison to monolinguals (Bialystok et al., 2004; Bialystok et al., 2008; Costa et al., 2008). Most of these studies focused on speakers of two languages, while my sample spoke an average of three languages. It could be that speaking a L3 would not be as beneficial as speaking a L2. These findings suggest that a L3 adds a further cognitive load that may be detrimental to EF. However, most participants reported their lowest proficiency in their L3, and this lack of proficiency could have influenced the results, as mentioned earlier.

The majority of the sample reported a very low frequency of L3 and L2 use (less than 50%) indicating that they seldom use their L2 and/or L3 or switch between them. Theoretically speaking, this lack of practice would result in less (or no) benefit for task-switching abilities compared to monolinguals. These results confirm the findings of Prior and Gollan (2011) who found that bilinguals who do not switch often between their languages performed equivalently to monolinguals on task-switching tasks. Prior and Gollan (2011) only found a bilingual advantage for those bilinguals who reported more frequent daily language switching. Overall, the results of the correlations and multiple regressions around L3 frequency of language use would suggest that speaking a L3 does not contribute to EF, and could be related to lower EF.

The fourth key finding was that English Language proficiency scores on the LEAP-Q were significantly and positively correlated with scores on the Token Test, a measure of English receptive language ability. These relationships suggest that the LEAP-Q self-report scores for English proficiency were tapping a similar construct to the Token Test. The validity of self-report questionnaires of language ability has been questioned, especially when used with bilinguals from different backgrounds and languages (Tomoschuk et al., 2019). This result indicates that the self-report of English proficiency on the LEAP-Q is comparable to an objective measure of language ability, supporting its validity in a South African context in a heterogeneous sample of older adults. This result supports the conclusions of Marian et al. (2007) that the LEAP-Q is a reliable and valid tool that can be compared to objective behavioural linguistic measures.

The analyses of the validity of the LEAP-Q were limited to correlation analyses, which do not indicate causal relationships, but rather suggest relationships which may change once other factors are controlled for, as seen in the previous results of this study. For example, SES had significant relationships with both the Token Test and English language proficiency, thus, the effect of SES may alter the relationships between these two tests. Secondly, the Token Test measures only one aspect of English language ability and is not a comprehensive measure of bi/multilingual language proficiency. Future studies should include objective measures of more aspects of bi/multilingual language proficiency and use more stringent forms of data analyses to test the LEAP-Q's validity, such as factorial analysis.

The last and fifth finding of study was that response time on the incongruent condition of the Simon task was significantly and positively related to response time on the incongruent condition of the VST and the VST's interference score. This result suggests that the two incongruent conditions of these tests are tapping similar skills. Incongruent conditions of tasks pose an explicit conflict that needs to be resolved and thus recruit EFs to resolve these conflicts (Bialystok et al., 2009). This result supports the suggestions of Miyake and Friedman (2017) and Miyake et al. (2000) that that EFs co-operate to carry out cognitive functions, suggested by significant inter-correlations between different EF tasks. In addition, EFs also work in isolation, suggested by non-significant relationships between different tasks of EF. Overall, it is suggested that EFs are organised into a model of unity (overlapping functions) and diversity (distinct functions). In terms of the unity of EFs, it is not yet established what the common function is. One suggestion is that inhibitory control could be the unifying function as both updating (working memory) and shifting require some form of inhibitory control (Miyake et al., 2000)

In terms of the current study, the incongruent response times on both EF tasks were positively and significantly related, suggesting that they are recruiting some underlying common function. As described in the Methods chapter, both the VST and the Simon task recruit inhibitory control to resolve the conflict posed by the incongruent conditions in these tasks. Task-switching may require the suppression of a previous task set so that it does not interfere with the new task set (Green, 1998; Miyake et al., 2000). In the Simon task, participants must switch between congruent and incongruent options when pressing the correct response keys. Here, the tendency to respond congruently must be suppressed when switching over to incongruent trials. This skill is also required in the VST when reading the incongruently coloured words. For both of these tasks, the deliberate and controlled suppression of pre-potent (automated) responses is how inhibitory control manifest (Miyake et al., 2000), and this function is central to bilingual language control (Green. 1998). However, this simple account of inhibitory control is insufficient as there are different types of inhibitory functions that need further investigation (Miyake et al., 2000). In that sense, the current study was limited as it only had two measures of EF. It would have been beneficial to include other tasks that represent the different EFs described by Miyake and Friedman (2017) to fully understand how they may be related to each other. Therefore, this result is more indicative of the unifying factor of EFs and cannot comment on the diversifying factor.

Strengths of the Study

This study investigated whether proficiency in multiple languages is related to performance on tasks of EF with a sample of older adults. There are many studies that have shown better EF in bilinguals when compared to monolinguals (Bialystok, 2017); however, far less is known about the relationship between multilingualism and EF. It is not yet established whether adding a third (or fourth) language could increase or decrease the efficiency of EF (Diamond, 2010). In addition, there is also a dearth of this kind of research on bi/multilinguals who speak several African languages. Consequently, this study's sample focused on speakers of two or more language who spoke a diverse range of African, European, and South African languages. A few studies have investigated the bilingual advantage in South African school beginners (Cockcroft, 2016) and young adults (Cockcroft et al., 2017), but none have focused on older adults.

Methodologically speaking, this study used a valid tool of multilingual language proficiency, the LEAP-Q, which is reliable (Marian et al., 2007). This is study further validated this self-report measure by demonstrating that its scores were positively related to an objective measures of language ability, the Token Test. The LEAP-Q was included in the study as it provided a more in-depth and continuous measure of different aspects of multilingual language proficiency, including AoA and frequency of language use. The latter two variables influence the bilingual advantage such that bilinguals who often switch between their languages (Prior & Gollan, 2011) and/or have an early AoA (Luk et al., 2001; Tse & Altarriba, 2012) show better EF when compared to bilinguals who do not switch languages often or who have a later AoA in both languages. In this study, these measurements proved valuable as they revealed interesting relationships between EF and multilingual language proficiency. This was especially so in the case of frequency of L3 use, where higher frequency of L3 use was related to slower response times on the incongruent conditions of the Simon task, suggesting that speaking a third language may add a processing cost.

Limitations of the Study and Suggestions for Future Research

Given the increased prevalence of multilingualism in South Africa (Kamwangamalu, 2003; Posel & Zeller, 2016), it is important to identify the cognitive effects of speaking multiple languages as there is mixed evidence surrounding the existence of a bi/multilingual advantage. While this study contributed to the existing literature, there are also limitations to this study which must be acknowledged.

Firstly, the LEAP-Q measured self-reported proficiency in three aspects of multilingual language proficiency, namely, reading, speaking, and understanding. Due to issues of multicollinearity in the multiple regressions, these variables were collapsed so that each spoken language produced a composite first language (L1), L2, and L3 score. Therefore, it was not possible to explore the different contributions of each aspect of multilingual proficiency. Multilingualism is not a unitary construct but is actually quite difficult to conceptualise and operationalise (Bassetti & Cook, 2011; Butler, 2013). It would be beneficial for future studies to focus on conceptualising the different aspects of multilingualism and to explore the cognitive outcomes of each.

A second limitation of this study was that the sample was small and very heterogeneous. There was considerable variation in language proficiency, cognitive state (MoCA), and SES. Different life experiences are bound to have differential effect on cognitive function, like specialised skills (Bialystok, 2017) or cultural differences (Morton & Carlson, 2014). Therefore, the effects of these different factors could have impacted the results. Overall, it is difficult to isolate the different experiences that affect cognitive functioning (Valian, 2016). It is then important for future studies to consider the many different factors that have been shown to affect EF, over and above that of language proficiency. In this study, it became apparent that SES is an important factor to consider when measuring the relationship between proficiency in multiple languages and EF in a South African sample, such that it was a more important contributor than that of cognitive state or L2 and L3 proficiency. By utilising a more homogenous sample and controlling for more factors, future studies may be more able to isolate the effects of bi/multilingual language proficiency on EF.

In relation to the above, this study had methodological limitations. Due to the cross-sectional and correlational design of this study, the internal validity was compromised as there was no control of the independent variables (Salkind, 2010). This study did not have the capacity to control for confounding variables (such as educational level, immigration status, and intelligence, amongst others) and could not make any causal claims. Future studies should take a longitudinal and/or experimental approach to assessing the effects of language proficiency on cognitive function. Experimental studies can compare different groups of bi/multilinguals who vary in terms of language proficiency (such as good, average, and poor) and compare them to monolinguals.

Conclusion

The results of this study suggest that SES is a more important indicator of EF performance than bi/multilingual language proficiency and AoA. Morton and Harper (2007) also noted that bilinguals from higher SES might outperform bilinguals from lower SES on task-switching tasks. In the study, bi/multilingualism did not contribute to better EF in older adults, contrary to the suggestion of Bialystok et al. (2004). Theoretically speaking, the hypothesised benefits that bi/multilingualism brings for EF in older adults may contribute to cognitive reserve and therefore prevent, or delay, cognitive decline (Alledi et al., 2013; Woumans et al., 2015). This study did not find that L2 and L3proficiency or L2 AoA contributed to any of the EF tasks (Paap & Greenberg, 2013; Paap et al., 2014), and by extension, to cognitive reserve in older adults (Antón et al., 2016; de Bruin et al., 2015; Kousaie & Phillips, 2013). Instead, SES appeared to be the most important indicator of cognitive state in older adults than bi/multilingualism. The addition of a L3 is also questioned (Diamond, 2010) as the current study showed that higher frequency of L3 use contributed to worse performance on the Simon task, implying that speaking a third language may add a processing cost to EF.

These results have practical implications for future investigations of the bilingual advantage. It demonstrates that SES must be considered when measuring the contributions of bi/multilingual language proficiency to EF (Morton & Harper, 2007) as SES has an effect on cognitive development (Bradley & Corwyn, 2000; Hackman et al., 2015). On a societal level, initiatives aimed at fostering cognitive development in children, as well as in older adults, should consider relieving socioeconomic troubles. Future research should undertake comprehensive measurements of different socioeconomic factors in order to paint a better picture of the relationship between bi/multilingualism and EF.

References

Ahmed, F. S., & Miller, S. L. (2011). Executive function mechanisms of theory of mind. *Journal of Autism and Developmental Disorders, 41,* 667–678.

Alladi, S., Bak, T. H., Duggirala, V., Surampudi, B., Shailaja, M., & Shukla, A. K. (2013). Bilingualism delays age at onset of dementia, independent of education and immigration status. *Neurocase, 81,* 1e7

Anderson, P. (2002). Assessment and development of executive function during childhood. *Child Neuropsychology, 8,* 71–82.

Antón, E., Duñabeitia, J. A., Estévez, A., Hernández, J. A., Castillo, A., Fuentes, L. J., … Carreiras, M. (2014). Is there a bilingual advantage in the ANT task? Evidence from children*. Frontiers in Psychology, 5*, 398.

Antón, E., García, Y. F., Carreiras, M., & Duñabeitia, J. A. (2016). Does bilingualism shape inhibitory control in the elderly? *Journal of Memory and Language*, 90, 147–160. https://doi.org/10.1016/j.jml.2016.04.007

Aronin, L. (2019). What is multilingualism? In D. Singleton & L. Aronin (Eds.), *Twelve Lectures on Multilingualism* (pp. 3-34). Multilingual Matters.

Aronin, L., & Singleton, D. (2012). *Multilingualism.* Amsterdam: John Benjamins.

Baggetta, P., & Alexander, P. A. (2016). Conceptualization and operationalization of executive function. *Mind, Brain and Education, 10,* 10–33.

Bak, T. H., Vega-Mendoza, M., & Sorace, A. (2014). Never too late? An advantage on tests of auditory attention extends to late bilinguals. *Language Sciences, 5,* 1–6.

Banich, M. T. (2009). Executive function: The search for an integrated account. *Current Directions in Psychological Science*, *18*(2), 89–94.

Bassetti, B., & Cook, V. (2011). Language and cognition: The second language user. In V. J. Cook & B. Bassetti (Eds.), *Language and bilingual cognition* (pp. 143–190). Oxford, UK: Psychology Press.

Bayard, S., Erkes, J., & Moroni, C. (2011). Victoria Stroop Test: normative data in a sample group of older people and the study of their clinical applications in the assessment of inhibition in Alzheimer's disease. *Archives of Clinical Neuropsychology, 26*(7), 653 661.

Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin, 143*, 233-262.

Bialystok, E., Craik, F. I. M., & Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia, 45*, 459e464.

Bialystok, E., Craik, F. I., Green, D. W., & Gollan, T. H. (2009). Bilingual minds. *Psychological Science in the Public Interest, 10*, 89–129.

Bialystok, E., Craik, F. I., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology and Aging, 19*, 290 303.

Bialystok, E., Craik, F. I. M., & Luk, G. (2012). Bilingualism: consequences for mind and brain. *Trends in Cognitive Sciences, 16*, 240-250.

Bialystok, E., Craik, F. I. M, & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 859–873. https://doi.org/10.1037/0278-7393.34.4.859

Bialystok, E., Poarch, G., Luo, L., & Craik, F. I. M. (2014). Effects of bilingualism and aging on executive function and working memory. *Psychology and Aging, 29,* 696-705.

Bialystok, E., & Luk, G. (2012). Receptive vocabulary differences in monolingual and bilingual adults. *Bilingualism: Language and Cognition, 15*, 397–401.

Boot, W. R., Kramer, A. F., Simons, D. J., Fabiani, M., & Gratton, G. (2008) The effects of video game playing on attention, memory, and executive control. *Acta Psychologica 129,* 387–398.

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development, *Annual Review of Psychology, 53*, 371–99.

Buckner, R. L. (2004). Memory and Executive Function in Aging and AD: Multiple Factors that Cause Decline and Reserve Factors that Compensate. *Neuron, 44*, 195–208. https://doi.org/10.1016 /j.neuron.2004.09.006

Butler, Y. G. (2013). Bilingualism /multilingualism and second language acquisition. In T. K Bhatia, & W. C. Ritchie, (Eds.), *The handbook of bilingualism and multilingualism* (pp. 109-136). UK: Blackwell Publishing.

Calabria, M., Hernandez, M., Martin, C., & Costa, A. (2011). When the Tail Counts: The Advantage of Bilingualism Through the Ex-Gaussian Distribution Analysis. *Frontiers in Psychology, 2,* 250. https://doi.org/10.3389/fpsyg.2011.00250

Carson, N., Leach, L., & Murphy, K. J. (2018). A re-examination of Montreal Cognitive Assessment (MoCA) cutoff scores. *International Journal of Geriatric Psychiatry, 33*, 379–388.

Casale, D. and D. Posel (2011). English language proficiency and earnings in a developing country: The case of South Africa. *The Journal of Socio-Economics, 40,* 385–393.

Cenoz, J. (2013). The influence of bilingualism on third language acquisition: Focus on multilingualism. *Language Teaching, 46*(1), 71–86.

Cepeda, N. J., Kramer, A. F., & Gonzalez de Sather, J. C. M. (2001). Changes in executive control across the life span: Examination of task-switching performance. *Developmental Psychology, 37,* 715–730.

Chertkow, H., Whitehead, V., Phillips, N., Wolfson, C., Atherton, J., & Bergman, H. (2010). Multilingualism (but not always bilingualism) delays the onset of Alzheimer disease: evidence from a bilingual community. *Alzheimer Disease and Associated Disorders, 24*, 118—125. https://doi.org/10.1097/wad.0b013e3181ca1221

Christoffels, I. K., Firk, C., & Schiller, N. O. (2007). Bilingual language control: An event related brain potential study. *Brain Research, 1147*, 192–208.

Cockcroft (2016). A comparison between verbal working memory and vocabulary in bilingual and monolingual South African school beginners: implications for bilingual language assessment. *International Journal of Bilingual Education and Bilingualism, 19*, 74-88.

Cockcroft, K., & Laher, S. (2018). Assessing language proficiency in multilingual South African students using the Language Experience and Proficiency Questionnaire

(LEAP-Q). In G. J. Rich, A. Padilla-López, L. K. de Souza, L. Zinkiewicz, J. Taylor, & J. S. B. Jaafar (Eds.), *Teaching psychology around the world: Volume 4* (pp. 212 235). Cambridge Scholars Publishing.

Cockcroft, K., Wigdorowitz, M., & Liversage, L. (2017). A multilingual advantage in the components of working memory. *Bilingualism: Language and Cognition,* 1-15. doi:10.1017/S1366728917000475

Cook, R. D., & Weisberg, S. (1982). *Residuals and influence in regression.* New York: Chapman and Hall.

Costa, A., Caramazza, A., & Sebastian-Galles, N. (2000). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory and Cognition, 26,* 1283–1296.

Costa A, Hernandez M, Costa-Faidella J and Sebastián-Gallés N (2009) On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition 113*, 135–149. doi:10.1016/j.cognition.2009.08.001

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition, 106*(1), 59–86. https://doi.org/10.1016/j.cognition.2006.12.013

Costa, A., & Santesteban, M. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language, 50,* 491–511. https://doi.org/10.1016/j.jml.2004.02.002

Costa, A., Santesteban, M., & Ivanova, I. (2006). How do highly proficient bilinguals control their lexicalization process? Inhibitory and language-specific selection mechanisms are both functional. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 1057–1074. https://doi.org/10.1037/0278-7393.32.5.1057

Craik, F.I.M., Bialystok, E., & Freedman, M. (2010). Delaying the onset of Alzheimer's disease: Bilingualism as a form of cognitive reserve. *Neurology, 75*, 1726-1729.

Creswell, J. W., & Creswell, J. D. (2017*). Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Dalrymple-Alford, J. C., MacAskill, M. R., Nakas, C. T., Livingston, L., Graham, C., Crucian, G. P., …Anderson, T. J. (2010). The MoCA. *Neurology, 75*(19), 1717. https://doi.org/10.1212/WNL.0b013e3181fc29c9

Daniels, K., Toth, J., & Jacoby, L. (2006). The Aging of Executive Functions. In E. Bialystok & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 96-111). New York, NY, US: Oxford University Press.

de Bruin, A., Bak, T. H., & Della Sala, S. (2015). Examining the effects of active versus inactive bilingualism on executive control in a carefully matched non-immigrant sample. *Journal of Memory and Language, 85*, 15–26.

Department of Basic Education. (1997). *Language in Education Policy 14 July.* Pretoria, South Africa: Author.

De Klerk, V. and Gough, D. (2003) 'Black South African English', in R. Mesthrie (ed.) *Language in South Africa* (pp. 356–78). Cambridge: Cambridge University Press.

De Renzi, E., & Faglioni, P. (1978). Normative data and screening power of a shortened version of the Token Test. *Cortex, 14*, 41–49.

De Renzi, A., & Vignolo, L. A. (1962). Token test: A sensitive test to detect receptive disturbances in aphasics. *Brain: A Journal of Neurology, 85,* 665-678. http://dx.doi.org/10.1093/brain/85.4.665

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64*, 135–168.

Diamond, J. (2010). The benefits of multilingualism. *Science, 330*, 332-333.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4–12 years old. *Science, 333*, 959– 964. doi:10.1126/science.1204529

Dijkstra, T. (2005). Bilingual visual word recognition and lexical access. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 179 –201). New York: Oxford University Press.

Duñabeitia, J. A., Hernández, J. A., Antón, E., Macizo, P., Estévez, A., Fuentes, L. J., & Carreiras, M. (2014). The Inhibitory Advantage in Bilingual Children Revisited. *Experimental Psychology, 61*, 234–251.

Duncan, J., Emslie, H., Williams, P., Johnson, R., & Freer, C. (1996). Intelligence and the frontal lobe: The organization of goal-directed behavior. *Cognitive Psychology, 30,* 257-303.

Duncan, J., Johnson, R., Swales, M., & Freer, C. (1997). Frontal lobe deficits after head injury: Unity and diversity of function. *Cognitive Neuropsychology, 14*, 713–741.

Durant, J., Leger, G. C., Banks, S.J., & Miller, J. B, (2016). Relationship between the activities of daily living questionnaire and the Montreal Cognitive Assessment. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*, *4*, 43–46.

Field, A. (2017). *Discovering Statistics Using IBM SPSS Statistics: North American Edition, Edition 5* (5th ed.). Thousand Oaks, CA: Sage.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Psychiatric Research, 12,* 189 –198.

Freedman, M., Alladi, S., Chertkow, H., Bialystok, E., Craik, F. I. M., Phillips, N. A., Duggirala, V., Sarampudi, B. P., & Bak, T. H. (2014). Delaying onset of dementia: are two languages enough? *Behavioural Neurology, 2104,* Article ID 808137.

Friedman, N. P. (2016). Research on individual differences in executive functions. *Linguistic Approaches to Bilingualism, 6*, 535–548.

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex*, *86,* 186-204.

Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., & Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General, 137*, 201–225.

Gathercole, V., Kennedy, I., & Thomas, E. M. (2015). Socioeconomic level and bilinguals' performance on language and cognitive measures. *Language and Cognition 19*, 1057-1078.

Gathercole, V., Thomas, E., Kennedy, I., Prys, C., Young, N., Viñas-Guasch, N., … Jones, L. (2014). Does language dominance affect cognitive performance in bilinguals? Lifespan evidence from preschoolers through older adults on card sorting, Simon, and metalinguistic tasks. *Frontiers in Psychology, 5* (11).

Godefroy, O., Cabaret, M., Petit-Chenal, V., Pruvo, J. P., & Rousseaux, M. (1999). Control functions of the frontal lobes: Modularity of the central-supervisory system? *Cortex, 35*, 1–20.

Gold, B. T., Kim, C., Johnson, N. F., Kriscio, R. J., & Smith, C. D. (2013). Lifelong bilingualism maintains neural efficiency for cognitive control in aging. *Journal of Neuroscience, 33*, 387–396.

Gollan, T. H., & Acenas, L. A. R. (2004). What is a TOT? Cognate and translation effects on tip-of-the-tongue states in Spanish–English and Tagalog–English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 246–269.

Gollan, T. H., Montoya, R. I., Cera, C., & Sandoval, T. C. (2008). More use almost always means a smaller frequency effect: Aging, bilingualism, and the weaker links hypothesis. *Journal of Memory and Language, 58*, 787–814.

Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory & Cognition, 33*, 1220 1234.

Gollan, T. H., Salmon, D. P., Montoya, R. I., & Galasko, D. R. (2011). Degree of bilingualism predicts age of diagnosis of Alzheimer's disease in low-education but not in highly educated Hispanics. *Neuropsychologia, 49,* 3826–3830.

Grosjean, F. (2010). *Bilingual: Life and reality*. Cambridge, MA: Harvard University Press.

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition, 1*, 67–81. https://doi.org/10.1017/S1366728998000133

Hackman, D. A., Gallop, R., Evans, G. W., & Farah, M. J. (2014). Socioeconomic status and executive function: developmental trajectories and mediation. *Developmental Science*, 1-17.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis*. Uppersaddle River.

Hartanto, A., & Yang. H. (2016). Disparate bilingual experiences modulate task-switching advantages: A diffusion-model analysis of the effects of interactional context on switch costs. *Cognition, 150,* 10–19.

Haugen, E. (1953). *The Norwegian Language in America.* Philadelphia: University of Pennsylvania Press.

Herbert, R. K., & Bailey, R. (2002). The Bantu languages: sociohistorical perspectives. In Mesthrie, R. (ed.) *Language in South Africa*. Cambridge: Cambridge University Press, pp 50–78.

Higby, E., Kim, J., & Obler, L. K. (2013). Multilingualism and the Brain. *Annual Review of Applied Linguistics*, *33*, 68–101.

Howell, D. C. (2011). *Fundamental Statistics for the Behavioural Sciences* (7th ed.). Canada: Wadsworth.

Huber, P.J. (1981) *Robust Statistics.* New York: Wiley.

Jekel, K., Damian, M., Wattmo, C., Hausner, L., Bullock, R., Connelly, P. J., … Graessel, E. (2015). Mild cognitive impairment and deficits in instrumental activities of daily living: a systematic review. *Alzheimer's Research & Therapy, 7*(1)*,* 17.

Jurado, M. B., & Rosselli, M. (2007). The Elusive Nature of Executive Functions: A Review of our Current Understanding. *Neuropsychology Review, 17*, 213–233.

Kamwangamalu, N. M. (2003). Social Change and Language Shift: South Africa. *Annual Review of Applied Linguistics*, *23,* 225-242.

Kapa, L. L., & Colombo, J. (2013). Attentional control in early and later bilingual children. *Cognitive Development*, *28,* 233–246. doi: 10.1016/j.cogdev.2013.01.011

Kave´, G., Eyal, N., Shorek, A., & Cohen-Mansfield, J. (2008). Multilingualism and cognitive state in the oldest old. *Psychology and Aging, 23,* 70–78.

Katzman, R., Brown, T., Fuld, P., Peck, A., Schechter, R., & Schimmel, H. (1983). Validation of a short orientation-memory-concentration test of cognitive impairment. *American Journal of Psychiatry, 140,* 734 –739.

Kirk, N. W., Fiala, L., Scott-Brown, K. C., & Kempe, V. (2014). No evidence for reduced Simon cost in elderly bilinguals and bidialectals. *Journal of Cognitive Psychology, 26*, 640–648. https://doi.org/10.1080/20445911.2014.929580

Kousaie, S., & Phillips, N. A. (2012). Ageing and bilingualism: Absence of a "bilingual advantage" in Stroop interference in a nonimmigrant sample. *The Quarterly Journal of Experimental Psychology, 65*, 356–369.

Kovács, Á. M., & Mehler, J. (2009). Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Sciences, 106,* 6556-6560.

Kramer, A. F., & Colcombe, S. (2018). Fitness effects on the cognitive function of older adults: A meta-analytic study—revisited. *Perspectives on Psychological Science, 13*, 213–217. https://doi. org/10.1177/1745691617707316

Kray, J., & Lindenberger, U. (2000). Adult age differences in task switching. *Psychology and Aging, 15*, 126–147. https://doi.org/10.1037/0882-7974.15.1.126

Kroll, J. F., & Bialystok, E. (2013). Understanding the consequences of bilingualism for language processing and cognition. *Journal of Cognitive Psychology, 25*, 497–514. https://doi.org/10.1080/20445911.2013.799170

Kroll, J. F., Dussias, P. E., Bice, K., & Perrotti, L. (2015). Bilingualism, Mind, and Brain. *Annual Review of Linguistics, 1,* 377–394

Kroll, J. F., Dussias, P. E., Bogulski, C. A., & Kroff, J. R. V. (2012). Juggling Two Languages in One Mind: What Bilinguals Tell Us About Language Processing and its Consequences for Cognition. In B. H. Ross (Ed.), *Psychology of Learning and Motivation* (Vol. 56, pp. 229–262). https://doi.org/10.1016/B978-0-12-394393 4.00007-8

Kroll, J. F., & Gollan, T. H. (2014). Speech planning in two languages: What bilinguals tell us about language production. In Ferreira, V., Goldrick, M., & Miozzo, M. (Eds.), *The Oxford handbook of language production.* Oxford: Oxford University Press.

Laine, M., & Lehtonen, M. (2018) Cognitive consequences of bilingualism: where to go from here? *Language, Cognition and Neuroscience*, *33,* 1205-1212.

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Sage Publications.

Lawton, D. M., Gasquoine, P. G., & Weimer, A. A. (2015). Age of dementia diagnosis in community dwelling bilingual and monolingual Hispanic Americans. *Cortex*, *66*, 141–145. https://doi.org/10.1016/j.cortex.2014.11.017

Lawton, M., & Brody, E. (1969). Instrumental activities of daily living scale (IADL). *The Gerontologist, 9*, 179–186.

Lehto, J. (1996). Are executive function tests dependent on working memory capacity? *Quarterly Journal of Experimental Psychology, 49A*, 29–50.

Lehtonen, M., Soveri, A., Laine, A., Järvenpää, J., De Bruin, A. & Antfolk, J. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta analytic review. *Psychological Bulletin, 144,* 394–425.

Lezak, M. D. (1983). *Neuropsychological assessment.* New York: Oxford University Press.

Lezak M. D. (1995). *Neuropsychological Assessment (2nd ed.)*. New York: Oxford University Press.

Lezak M, Howieson D, Loring D. (2012). *Neuropsychological assessment. (5th ed.)*. New York: Oxford University Press.

Li, Wei (2008). Research perspectives on bilingualism and bilingual education. In K. A. King & N. H. Hornberger (Eds.*), Encyclopedia of language and education, Volume 10: Research methods in language and education* (pp. 137-149). Berlin: Springer.

Linck J. A., Schwieter, J. W., & Sunderman, G. (2012). Inhibitory control predicts language switching performance in trilingual speech production. *Bilingualism: Language and Cognition, 15*, 651–662. https://doi.org/10.1017/S136672891100054X

Liu, H., Fan, N., Rossi, S., Yao, P., & Chen, B. (2016). The effect of cognitive flexibility on task switching and language switching. *International Journal of Bilingualism, 20,* 563–579.

Liu, H., Rossi, S., Zhou, H., & Chen, B. (2014). Electrophysiological evidence for domain-general inhibitory control during bilingual language switching. *PloS one*, *9*, e110887.

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, *25*(5), 605–621. https://doi.org/10.1080 /20445911.2013.795574

Luk, G., de Sa, E., & Bialystok, E. (2011). Is there a relation between onset age of bilingualism and enhancement of cognitive control? *Bilingualism: Language and Cognition.* doi: 10.1017/S1366728911000010.

Madrazo, A. R., & Bernardo, A. B. I. (2018). Measuring Two Types of Inhibitory Control in Bilinguals and Trilinguals: Is There a Trilingual Advantage? *Psychological Studies, 63,* 52-60.

Makgamatha, M. M., Heugh, K., Prinsloo, C. H., & Winnaar, L. (2013). Equitable language practices in large-scale assessment: Possibilities and limitations in South Africa. *Southern African Linguistics and Applied Language Studies, 31*, 251-269.

Malek, A., & Amiri, S. (2013). The standardization of Victoria Stroop color-word test among Iranian bilingual adolescents. *Archives of Iranian Medicine, 16*, 380-384.

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research, 50*, 940-967.

Martin-Rhee, M. M., & Bialystok, E. (2008) The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition*, *11*, 81–93. doi:10.1017/S1366728907003227.

McDowd, J. M., & Shaw, R. J. (2000). Attention and aging: A functional perspective. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (2nd ed., pp. 221–292). Mahwah, NJ: Erlbaum.

Meuter, R. F. I., & Allport, A. (1999). Bilingual language switching in naming: Asymmetrical costs of language selection. *Journal of Memory and Language, 40*, 25-40.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49 –100.

Mohanty, A. (2017). Multilingualism, education, English and development: Whose development? In H. Coleman (Ed.), *Multilingualisms and Development* (pp. 261-280). London: British Council.

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences, 7*, 134 –140.

Morales, J., Calvo, A., & Bialystok, E. (2013). Working memory development in monolingual and bilingual children. *Journal of Experimental Child Psychology, 114*, 187–202. https://doi.org/10.1016/j.jecp.2012.09.002

Moreira, L., Schlottfeldt, C. G., de Paula, J. J., Daniel, M. T., Paiva, A., Cazita, V… Malloy Diniz, L. F. (2011). Normative study of the Token Test (short version): preliminary data for a sample of Brazilian seniors. *Revista de Psiquiatria Clínica, 38*, 97–101.

Moreno, S., Friesen, D., & Bialystok, E., (2011). Effect of music training on promoting preliteracy skills: Preliminary causal evidence. *Music Perception: An Interdisciplinary Journal, 29*, 165-172.

Morton, J. B., & Carlson, S. (2014). The bilingual advantage: evidence and alternative views. In M. Hoskyn, G. Iarocci, and A. Young (Eds.), *Executive Functioning in the Classroom*. Oxford: Oxford University Press.

Morton, J. B., & Harper, S. N. (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10*, 719–726.

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., … Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*, 695–699.

Nguyen, L., Murphy, K., & Andrew, G. (2019). Immediate and long-term efficacy of executive functions cognitive training in older adults: A systematic review and meta-analysis. *Psychological Bulletin, 145*, 698-733.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. J. Davidson, G. E. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation: Advances in research and theory* (Vol. 4, pp. 1–18). New York: Plenum.

Orimo, H., Ito, H., Suzuki, T., Araki, A., Hosoi, T., & Sawabe, M. (2006). Reviewing the definition of “elderly.” *Geriatrics & Gerontology International*, *6*(3), 149–158.

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*, 232–258.

Paap, K.R., Johnson, H. A., & Sawi, O. (2014). Are bilingual advantages dependent upon specific tasks or specific bilingual experiences? *Journal of Cognitive Psychology, 26,* 615-639.

Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances. *Cortex, 69*, 265–278. https://doi.org/10.1016/j.cortex.2015.04.014

Paap, K. R., & Sawi, O. (2014). Bilingual advantages in executive functioning: problems in convergent validity, discriminant validity, and the identification of the theoretical constructs. *Frontiers in Psychology, 5*, 962. https://doi.org/10.3389/fpsyg.2014.00962

Paci, M., Lorenzini, C., Fioravanti, E., Poli, C., & Lombardi, B. (2015). Reliability of the 36 item version of the Token Test in patients with poststroke aphasia. *Topics in Stroke Rehabilitation*, *22*, 374–376.

Pallant, J. (2011*). SPSS survival manual: A step by step guide to data analysis using SPSS (4th ed.).* Australia: Allen and Unwin.

Pan South African Language Board (PANSALB). (2001). *Language use and language interaction in South Africa: A national sociolinguistic survey.* Summary Report. Cape Town: Author.

Paula, J. J. de, Bertola, L., Nicolato, R., Moraes, E. N. de, & Malloy-Diniz, L. F. (2012). Evaluating Language Comprehension in Alzheimer’s disease: the use of the Token Test. *Arquivos de Neuro-Psiquiatria, 70,* 435–440.

Pelham, S. D., & Abrams, L. (2014). Cognitive advantages and disadvantages in early and late bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 313–325.

Perquin, M., Vaillant, M., Schuller, A. M., Pastore, J., Dartigues, J. F., & Lair, M. L., MemoVie G. (2013). Lifelong exposure to multilingualism: new evidence to support cognitive reserve hypothesis. *PLoS One*, *8,* e62030.

Poarch, G. J., & van Hell, J. G. (2012). Executive functions and inhibitory control in multilingual children: Evidence from second-language learners, bilinguals, and trilinguals. *Journal of Experimental Child Psychology*, *113*(4), 535–551.

Portocarrero, J. S., Burright, R. G., & Donovick, P. J. (2007). Vocabulary and verbal fluency of bilingual and monolingual college students. *Archives of Clinical Neuropsychology, 22,* 415–422.

Posel, D., & Zeller, J. (2016). Language Shift or Increased Bilingualism in South Africa: Evidence from Census Data. *Journal of Multilingual and Multicultural Development 37*, 357–370.

Poulin-Dubois, D., Blaye, A., Coutya, J., & Bialystok, E. (2011). The effects of bilingualism on toddlers' executive functioning. *Special Issue: Executive Function, 108*, 567 579. https://doi.org/10.1016/j.jecp.2010.10.009

Prior, A., & Gollan, T. H. (2011). Good language-switchers are good task-switchers: Evidence from Spanish-English and Mandarin-English bilinguals. *Journal of the International Neuropsychological Society*, *17*, 682–691.

Prior, A., & MacWhinney, B. (2010). A bilingual advantage in task switching. Bilingualism: *Language and Cognition, 13*, 253–262.

Rey-Mermet, A., Gade, M., & Oberauer, K. (2018). Should we stop thinking about inhibition? Searching for individual and age differences in inhibition ability. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 44*, 501-526.

Robbins, T. W. (1998). Dissociating executive functions of the prefrontal cortex. In Roberts, A. C., Robbins, T. W., & Weiskrantz, L. (Eds.), *The prefrontal cortex: Executive and cognitive functions* (pp. 117– 130). New York, NY: Oxford University Press.

Roehrig, B., Hoeffken, K., Pientka, L., & Wedding, U. (2007). How many and which items of activities of daily living (ADL) and instrumental activities of daily living (IADL) are necessary for screening. *Critical Reviews in Oncology/Hematology, 62*(2), 164 171.

Rogers, R. D., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General, 124*, 207.

Rosselli, M., Ardila, A., Lalwani, L. N., & Vélez-Uribe, I. (2015). The effect of language proficiency on executive functions in balanced and unbalanced Spanish-English bilinguals. *Bilingualism: Language and Cognition, FirstView,* 1-15.

Salkind, N. J. (2010). *Encyclopedia of research design* (Vol. 1). Sage.

Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. Journal of *Experimental Psychology: General, 132,* 566– 594.

Sanders, A. E., Hall, C. B., Katz, M. J., & Lipton, R. B. (2012). Non-native language use and risk of incident dementia in the elderly. *Journal of Alzheimer's Disease, 29*, 99 108.

Sattler, C., Toro, P., Schonknecht, P., & Schroder, J. (2012). Cognitive activity, education and socioeconomic status as preventive factors for mild cognitive impairment and Alzheimer's disease. *Psychiatry Research*, *196*, 90-95.

Shallice, T. (1982). Specific impairments of planning. Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences, *298*, 199–209.

Shaughnessy, J. J., Zechmeister, E. B., & Zechmeister, J. S. (2000). *Research methods in psychology*. McGraw-Hill.

Smith, T., Gildeh, N., & Holmes, C. (2007). The Montreal Cognitive Assessment: validity and utility in a memory clinic setting. *The Canadian Journal of Psychiatry, 52*(5), 329–332.

Spreen, O., & Strauss, E. (1998). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary.* New York: Oxford University Press.

Statistics South Africa (2011). *Census 2011: Census in brief.* Retrieved on 28 February 2018 from: https: http://www.statssa.gov.za/?page_id=3839

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society, 8,* 448–460.

Sternberg, R. J., & Sternberg, K. (2012). *Cognitive Psychology (6th ed.).* Belmont, CA: Wadsworth.

Strauss, E., Sherman, E. M.S., & Spreen, O. (2006). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary.* Oxford University Press.

Stuss, D.T. (1992). Biological and psychological development of executive functions. *Brain and Cognition, 20*, 8–23.

Stuss, D., & Benson, F. (1986). *The frontal lobes.* New York: Raven.

Tabori, A. A. T., Mech, E. N., & Atagi, N. (2018). Exploiting Language Variation to Better Understand the Cognitive Consequences of Bilingualism. *Frontiers in Psychology, 9.* http://doi.org/10.3389/fpsyg.2018.01686

Tao, L., Marzecová, A., Taft, M., Asanowicz, D., & Wodniecka, Z. (2011). The efficiency of attentional networks in early and late bilinguals: The role of age of acquisition. *Frontiers in Psychology, 2*, 1–19.

Tomoschuk, B., Ferreira, V. S., & Gollan T. H. (2019). When a seven is not a seven: self-ratings of bilingual language proficiency differ between and within language populations. *Bilingualism: Language and Cognition*, *22,* 1–21.

Troyer, A. K., Leach, L., & Strauss, E. (2006). Aging and response inhibition: Normative data for the Victoria Stroop Test. *Aging, Neuropsychology, and Cognition, 13*, 20–35.

Tse, C., & Altarriba, J. (2012). The effects of first- and second-language proficiency on conflict resolution and goal maintenance in bilinguals: Evidence from reaction time distributional analyses in a stroop task. *Bilingualism: Language and Cognition, 15,* 663–676.

UNICEF (2016). *The Impact of Language Policy and Practice on Children's Learning: Evidence From Eastern and Southern Africa – South Sudan.* UNICEF: New York.

van der Lubbe, R. H. J., & Verleger, R. (2002). Aging and the Simon task. *Psychophysiology, 39*, 100–110.

Valenzuela, M. J., & Sachdev, P. (2006). Brain reserve and dementia: a systematic review. *Psychological Medicine, 36*, 441–454.

Valian, V. (2016). Putting together bilingualism and executive function. *Linguistic Approaches to Bilingualism, 6,* 565–574.

Vega, C., & Fernandez, M. (2011). Errors on the WCST correlate with language proficiency scores in Spanish–English bilinguals. *Archives of Clinical Neuropsychology, 26*, 158 164. doi: 10.1093/arclin/acq097.

Vega-Mendoza, M., West, H., Sorace, A., & Bak, T. H. (2015). The impact of late, nonbalanced bilingualism on cognitive performance. *Cognition, 137,* 40-46.

von Bastian, C. C., Souza, A. S., & Gade, M. (2016). No evidence for bilingual cognitive advantages: A test of four hypotheses. *Journal of Experimental Psychology: General, 145*, 246–258. https://doi.org /10.1037/xge0000120

Walsh, S. A. (2009). Conducting research with the elderly: Ethical concerns for a vulnerable population. *Southern Online Journal of Nursing Research, 9*, 1–13.

Weissberger, G. H., Gollan, T. H., Bondi, M. W., Clark, L. R., & Wierenga, C. E. (2015). Language and task switching in the bilingual brain: Bilinguals are staying, not switching, experts. *Neuropsychologia, 66,* 193–203.

Welsh, M. C., & Pennington, B. F. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental Neuropsychology, 4,* 199-230.

Wöstmann, N. M., Aichert, D. S., Costa, A., Rubia, K., Möller, H.-J., & Ettinger, U. (2013). Reliability and plasticity of response inhibition and interference control. *Brain and Cognition, 81*(1), 82–94.

Woumans, E., Santens, P., Sieben, A., Versijpt, J., Stevens, M., & Duyck, W. (2015). Bilingualism delays clinical manifestation of Alzheimer's disease. *Bilingualism: Language and Cognition, 18*, 568–574.

Yang, H., & Yang, S. (2017). Are all interferences bad? Bilingual advantages in working memory are modulated by varying demands for controlled processing. *Bilingualism: Language and Cognition, 20*, 184–196.

Yow, W. Q., & Li, X. (2015). Balanced bilingualism and early age of second language acquisition as the underlying mechanisms of a bilingual executive control advantage: why variations in bilingual experiences matter. *Frontiers in Psychology, 6.*

Zahodne, L. B., Schofield, P. W., Farrell, M. T., Stern, Y., & Manly, J. J. (2014). Bilingualism does not alter cognitive decline or dementia risk among Spanish speaking immigrants. *Neuropsychology, 28*, 238–246.

Appendices

Appendix A: Information Sheet

Information Sheet

My name is Elfrieda Wheeler and I am a master's student from the School of Human and Community Development at the University of the Witwatersrand. As part of the requirements for my degree, I am conducting a research study entitled: *The relationship between multilingual language proficiency and executive function*. I have contacted you because you are an individual aged 65 years or older and is capable of independent living, thus, you meet the inclusion criteria for this research study. Therefore, I would like to invite you to participate in this study.

Aim of the Study

This study aims to investigate the relationship between proficiency in multiple languages and executive function in older adults. The study will also look at the potential effects of multilingual language proficiency on age-related cognitive decline.

Requirements

If you are interested in participating in this study, you will be required to sign a consent form before any data collection can begin. Thereafter, you will be asked to complete a demographic questionnaire and perform a battery of cognitive tests that involve answering questions, solving problems and completing certain tasks. You will also be asked to complete a questionnaire that asks questions surrounding your proficiency in multiple languages. This procedure is expected to last approximately 50-60 minutes.

Risks and Benefits of the Study

You may withdraw from the study at any time without any negative consequences. There are no anticipated risks involved in participating in this study. However, you may feel distressed or frustrated when completing the cognitive tests as they involve tasks that may be perceived as difficult. You may also feel fatigue due to the time constraints of the data collection, but you may ask for breaks as you require. With your consent, if any cognitive anomalies are detected during the screening process, you will be referred to a neuropsychologist. After completion, you will be reimbursed with R300 to cover any costs you had for participating, such as travel, food, or any other costs

Any personal information provided by you on the questionnaires and tests will be kept confidential and will only be accessible by myself and my supervisor. Your personal information will also be made anonymous through assigning a participant number to your collected data. You will also not be identifiable in the final write-up of the research report.

Contact Details of the Human Research Ethics Committee (Medical) Chairperson and Administrator

A principal function of this committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research. If you have any complaints or concerns over the way the study is being conducted, please contact the Chairperson of this Committee or the Committee secretariat. The contact details are provided below:

HREC Chairperson: Prof Clement Penny
Telephone Number: 011 717 2301
Email Address: Clement.Penny@wits.ac.za

HREC Secretariat
Telephone Number: 011 717 2700/1234
Email Address: Zanele.Ndlovu@wits.ac.za
and Rhulani.Mukansi@wits.ac.za

If you have any enquiries about participation in this study, feel free to contact me or my supervisor using the contact details provided below:

Researcher: Elfrieda Wheeler
Telephone Number: 071 332 8402
Email Address: 1725133@students.wits.ac.za

Supervisor: Kate Cockcroft
Telephone Number: 011 717 4511
Email Address: Kate.Cockcroft@wits.ac.za

Appendix B: Informed Consent Form

Informed Consent Form

I confirm that I am an adult aged 65 or above who is capable of independent living. I also confirm that I do not have a history of head injury and mental illness. I have read the provided information sheet and have been informed about the study's protocols. I understand what is required of me and have been given sufficient time to decide whether or not to participate in this study. By signing this form, I also understand the following:

Participation in this study is voluntary.

I may withdraw from this study at any time without any negative consequences.

There are no risks associated with participation.

All information provided will remain confidential.

My identity will not be known except through a participant number by the researcher.

I will be reimbursed with R300 to cover any travel or other costs associated with participating in this study.

There will be no feedback of individual results.

I am aware that the results of the study will be reported in the form of a research report.

I have received the contact details of the researcher Elfrieda Wheeler and her supervisor Professor Kate Cockcroft

By signing this form, I consent to participate in this research study

Participant: ___________________ Researcher: _________________

Signature: ____________________ Date: ______________________

Appendix C: Demographic Questionnaire

Demographic Questionnaire

Participant No.: | | | | |

Gender: M F

Age:__________________

Home Language: ____________________________

What is your highest level of education?_________________________________

Did you attend a public or private school?_______________________________

Living Standards Measure:

Please answer the following questions according to your current circumstances.

Question	Answer	
1. I have the following in my household:		
TV set	TRUE	FALSE
VCR	TRUE	FALSE
DVD player	TRUE	FALSE
M-Net/DStv subscription	TRUE	FALSE
Hi-fi/music centre	TRUE	FALSE
Computer / Laptop	TRUE	FALSE
Vacuum cleaner/floor polisher	TRUE	FALSE
Dishwashing machine	TRUE	FALSE
Washing machine	TRUE	FALSE

Tumble dryer	TRUE	FALSE
Home telephone (excluding a cell)	TRUE	FALSE
Deep freezer	TRUE	FALSE
Fridge/freezer (combination)	TRUE	FALSE
Electric stove	TRUE	FALSE
Microwave oven	TRUE	FALSE
Built-in kitchen sink	TRUE	FALSE
Home security service	TRUE	FALSE
3 or more cell phones in household	TRUE	FALSE
2 cell phones in household	TRUE	FALSE
Home theatre system	TRUE	FALSE
2. I have the following amenities in my home or on the plot:		
Tap water in house/on plot	TRUE	FALSE
Hot running water from a geyser	TRUE	FALSE
Flush toilet in/outside house	TRUE	FALSE
3. There is a motor vehicle in our household	TRUE	FALSE
4. I am a city dweller	TRUE	FALSE
5. I live in a house, cluster or town house	TRUE	FALSE
6. I live in a rural area outside Gauteng	TRUE	FALSE
7. There are no radios, or only one radio (excluding car radios) in my household	TRUE	FALSE
8. There is no domestic workers or household helpers in household (both live-in & part time)	TRUE	FALSE

Appendix D: Shortened Version of Language Experience and Proficiency Questionnaire (LEAP-Q-SV)

Participant No.________________

The Language Experience and Proficiency Questionnaire (LEAP-Q)

1. What languages do you know?

Language A: ______________________________

Language B: ______________________________

Language C: ______________________________

Language D: ______________________________

Language E: ______________________________

2. Language A:

This is my _______________ (First, second, third etc.) language. All questions below refer to your knowledge of language A.

(1) Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: _________

(2) Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding spoken language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

3. Language B:

This is my _______________ (First, second, third etc.) language. All questions below refer to your knowledge of language B.

(1) Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: _________

(2) Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding spoken language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

4. Language C:

This is my _______________ (First, second, third etc.) language. All questions below refer to your knowledge of language C.

(1) Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: _________

(2) Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding spoken language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

5. Language D:

This is my _______________ (First, second, third etc.) language. All questions below refer to your knowledge of language D.

(1) Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: _________

(2) Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding spoken language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

6. Language E:

This is my _______________ (First, second, third etc.) language. All questions below refer to your knowledge of language E.

(1) Age when you...

Began acquiring this language: ____________

Became fluent in this language: ____________

Began reading in this language: ____________

Became fluent reading in this language: _________

(2) Please circle your level of proficiency in speaking, understanding, and reading in this language:

Speaking

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Understanding spoken language

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

Reading

0	1	2	3	4	5	6	7	8	9	10
None	Very Low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very Good	Excellent	Perfect

7. Please list what percentage of the time you are *currently* and *on average* exposed to each language. (Your percentages should add up to 100%):

List language here:					
List percentage here					

Appendix E: Shortened Version of the Instrumental Activities of Daily Living Measure (IADL-SV)

Please indicate whether in the past month you experienced difficulty with:

Activity	Answer	
Administering own medication in correct dosages at the correct time	TRUE	FALSE
Grocery shopping	TRUE	FALSE
Preparing meals	TRUE	FALSE
Using the telephone	TRUE	FALSE
Driving or using public transport	TRUE	FALSE
Handling own finances	TRUE	FALSE
Housekeeping	TRUE	FALSE
Laundry	TRUE	FALSE

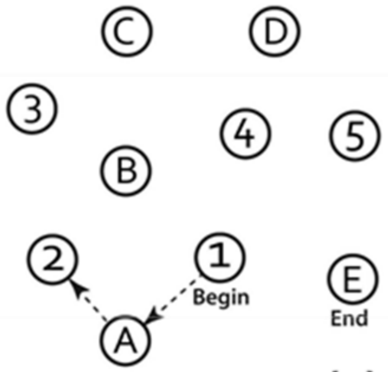
Appendix F: Montreal Cognitive Assessment (MoCA)

Participant No.___________________

MONTREAL COGNITIVE ASSESSMENT (MOCA®)
Version 7.2 Alternative Version

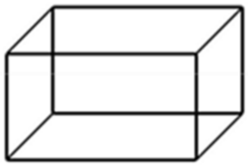
NAME :
Education : Date of birth :
Sex : DATE :

VISUOSPATIAL / EXECUTIVE — POINTS



[ ]

Copy rectangle



[ ]

Draw CLOCK (Five past four)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands

__/5

NAMING


[ ]

[ ]

[ ]

__/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	TRUCK	BANANA	VIOLIN	BARN	GREEN
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).

Subject has to repeat them in the forward order [ ] 3 2 9 6 5
Subject has to repeat them in the backward order [ ] 8 5 2

__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

__/1

Serial 7 subtraction starting at 90 [ ] 83 [ ] 76 [ ] 69 [ ] 62 [ ] 55

4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**

__/3

LANGUAGE Repeat : A bird can fly into closed windows when it's dark and windy. [ ]
The caring grandmother sent groceries over a week ago. [ ]

__/2

Fluency / Name maximum number of words in one minute that begin with the letter S [ ] _____ (N ≥ 11 words)

__/1

ABSTRACTION Similarity between e.g. carrot - potato = vegetable. [ ] diamond - ruby [ ] cannon - rifle

__/2

DELAYED RECALL

		TRUCK	BANANA	VIOLIN	BARN	GREEN	
	Has to recall words **WITH NO CUE**	[ ]	[ ]	[ ]	[ ]	[ ]	Points for UNCUED recall only
Optional	Category cue						
	Multiple choice cue						

__/5

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City

__/6

Adapted by : Z. Nasreddine MD, N. Phillips PhD, H. Chertkow MD
© Z.Nasreddine MD www.mocatest.org
Administered by: ______________________________________

Normal ≥26 / 30

TOTAL __/30

Add 1 point if ≤ 12 yr edu

Appendix G: Reimbursement Document

UNIVERISTY

OF THE

WITWATERSRAN D,

JOHANNESBURG

School of Human and Community Development

Private Bag X3, Wits, 2050, Johannesburg, South Africa

Tel: (011) 717 4500 Fax: (011) 717 4559

Hello,

Thank you very much for participating in my research. This serves as an acknowledgement that you received your R300 reimbursement for participation.

Please sign at the bottom to say you received this reimbursement.

Thank you very much,

Signed (You can just write your name): ___________________________

Date: ______________________________

Researcher’s Signature: ________________________

Assigned Participant Code: __________________________

Appendix H: Advertisement to Recruit Participants

Seeking Volunteers for Research Study

I am a master's student from the University of the Witwatersrand. As part of my degree, I am conducting a research study about the relationship between proficiency in multiple languages and executive function in older adults

I am looking for research participants who:

- Can speak 2 or more languages (which must include English).
- Are 65 years or older and living independently.
- Have no history of head injury and mental illness

Participation will involve completing a few questionnaires and cognitive tests that will take about 50-60 minutes.

You will be reimbursed with R300 to cover any travel or other costs associated with participating in this study.

If you are interested to participate in this study or require more information please contact Elfrieda using the following details:

- Email:1725133@students.wits.ac.za
- Phone: 0713328402

Appendix I: Ethical Clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Miss Elfrieda Wheeler

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M190717

NAME: (Principal Investigator)	Miss Elfrieda Wheeler
DEPARTMENT:	School of Human and Community Development
PROJECT TITLE:	The relationship between multilingualism and executive function in the elderly
DATE CONSIDERED:	26/07/2019
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Kate Cockcroft
APPROVED BY:	CPenny Dr C Penny, ~~Chairperson~~, HREC (Medical)
DATE OF APPROVAL:	17/10/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed July and will therefore be due in the month of July each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature ______________ Date ______________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix J: Normality tests

Table 9

Normality indicators for key variables used

	Skewness coefficient	Kurtosis coefficient	Kolmogorov-Smirnov test (*p*-value)
L2 AoA	2.41	8.10	.00
L3 AoA	.97	1.30	.108
L2 Frequency	.36	-.39	.040
L3 Frequency	1.81	2.78	.000
L1 Composite	-.74	-.42	.000
L2 Composite	-.67	-.71	.001
L3 Composite	-.17	-.77	.200
English Speak	-.60	-.11	.001
English Under	-.60	-.14	.002
English Read	-.78	-.65	.001
Token Test	-.53	-.29	.014
VST			
Colour-word RT	.50	-.95	.012
Total Errors	2.64	8.74	.000
Interference Score	.38	-.54	.200
Simon Task			
Incongruent RT	.55	-.17	.200
Total Errors	1.69	2.49	.000
Simon Effect	-.47	-.21	.200

Note. L2 AoA = Second language age of acquisition. L3 AoA = Third language age of acquisition. L2 Frequency = Second language frequency. L3 Frequency = Third language frequency. L1 Composite = First language composite score. L2 Composite = Second language composite score. L3 Composite = Third language composite score. English Speak = English speaking. English Under = English understanding. English Read = English Reading. VST = Victoria troop Test. Colour-Word RT = Colour-word response time. Incongruent RT = Incongruent response times.

Appendix K: Spearman's Correlations

Table 10

Spearman's Correlations among covariates, language variables and cognitive variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. SES																			
2. MoCA	**.565****																		
3. L2 AoA	.117	-.083																	
4. L3 AoA	.152	-.319	.300																
5. L2 Freq	-.003	.016	-.198	-.272															
6. L3 Freq	**-.337***	**-.344****	.104	-.284	.237														
7. L1 Composite	-.201	.010	-.091	-.220	-.050	.308													
8. L2 Composite	-.082	.198	**-.323***	-.274	**.357****	-.282	**.398****												
9. L3 Composite	**-.439***	**-.373***	-.003	-.055	.312	**.671****	.317	.138											
10. Eng Speak	.208	**.331****	-.048	-.096	-.056	-.177	**.412****	**.322***	-.028										
11. Eng Under	.193	**.365****	.023	-.074	.034	-.190	**.424****	**.440****	.015	**.899****									
12. Eng Read	.209	**.425****	.067	-.100	.008	-.318	**.426****	**.494****	-.145	**.812****	**.982****								
13. Token Test	**.534****	**.507****	.028	.004	-.004	-.301	-.062	-.025	-.182	**.344****	**.313***	**.306***							
VST																			
14. CW RT	-.138	**-.306***	.147	.152	.005	.157	.047	-.179	-.029	-.136	-.184	-.223	-.148						
15. CW Errors	**-.323***	**-.394****	-.123	-.159	.059	-.130	-.122	-.023	-.238	-.115	-.172	-.242*	-.181	**.390****					
16. Interfere	.227	-.021	.227	.213	-.094	-.259	-.131	**-.248***	**-.420***	-.056	-.104	-.188	.089	**.804****	**.292***				
Simon Task																			
17. Incong RT	.042	.083	.140	-.172	.157	.311	-.102	-.222	-.024	.037	.062	-.011	-.081	**.390****	.119	**.396****			
18. Tot Errors	-.230	-.092	-.145	-.239	-.029	-.015	.088	.224	.159	-.021	-.112	-.030	-.154	-.033	.076	-.114	-.182		
19. Simon Eff	.036	.150	.037	-.187	-.060	.200	-.123	**-.284***	-.046	-.184	-.115	-.214	.093	-.026	-.101	.029	**.361****	.116	

Notes. SES = Socioeconomic status. MoCA = Montreal Cognitive Assessment. L2 AoA = Second Language age of acquisition. L3 AoA = Third language age of acquisition. L2 Freq = Second language frequency of use. L3 Freq = Third language frequency of use. L1 = First language. L2 = Second language. L3 = Third language. Eng Speak = English speaking. Eng Under = English understanding. Eng Read = English reading. CW RT = Colour-Word response time. CW Errors = Colour-Word Errors. Interfere = Interference score. Incong RT = Incongruent response time. Tot Errors = Total errors. Simon Eff = Simon Effect. * = $p < .05$, ** = $p < .01$.

Appendix L: Correlations among Language Proficiency Variables

Table 11

Pearson's Correlations among language proficiency variables

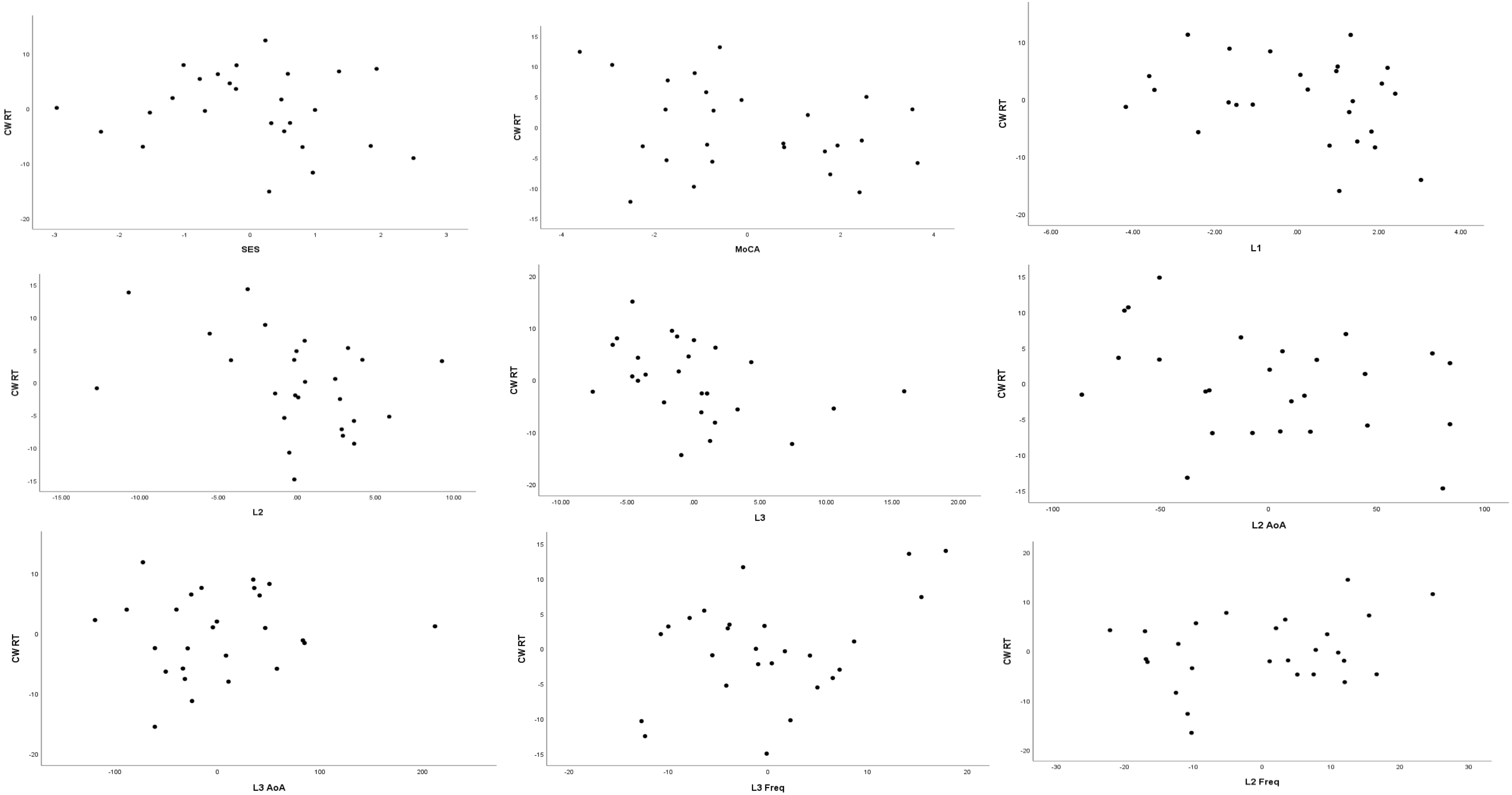
	1	2	3	4	5	6	7	8	9
1. L1 Speaking									
2. L1 Understanding	**.772****								
3. L1 Reading	**.773****	**.794****							
4. L2 Speaking	.275	**.363****	**.394****						
5. L2 Understanding	.211	**.332***	**.392****	**.895****					
6. L2 Reading	.248	**.282***	**.426****	**.819****	**.788****				
7. L3 Speaking	.352	.330	-.001	-.098	-.104	-.256			
8. L3 Understanding	.305	.314	.005	.139	.162	-.034	**.894****		
9. L3 Reading	358	.271	.128	.016	.153	.110	**.754****	**.820****	

Notes. L1 Speaking = First language speaking proficiency. L1 Understanding = First language understanding proficiency. L1 Reading = First language reading proficiency. L2 Speaking = Second language speaking proficiency. L2 Understanding = Second language understanding proficiency. L2 Reading = Second language reading proficiency. L3 Speaking = Third language speaking proficiency. L3 Understanding = Third language understanding proficiency. L3 Reading = Third language reading proficiency.

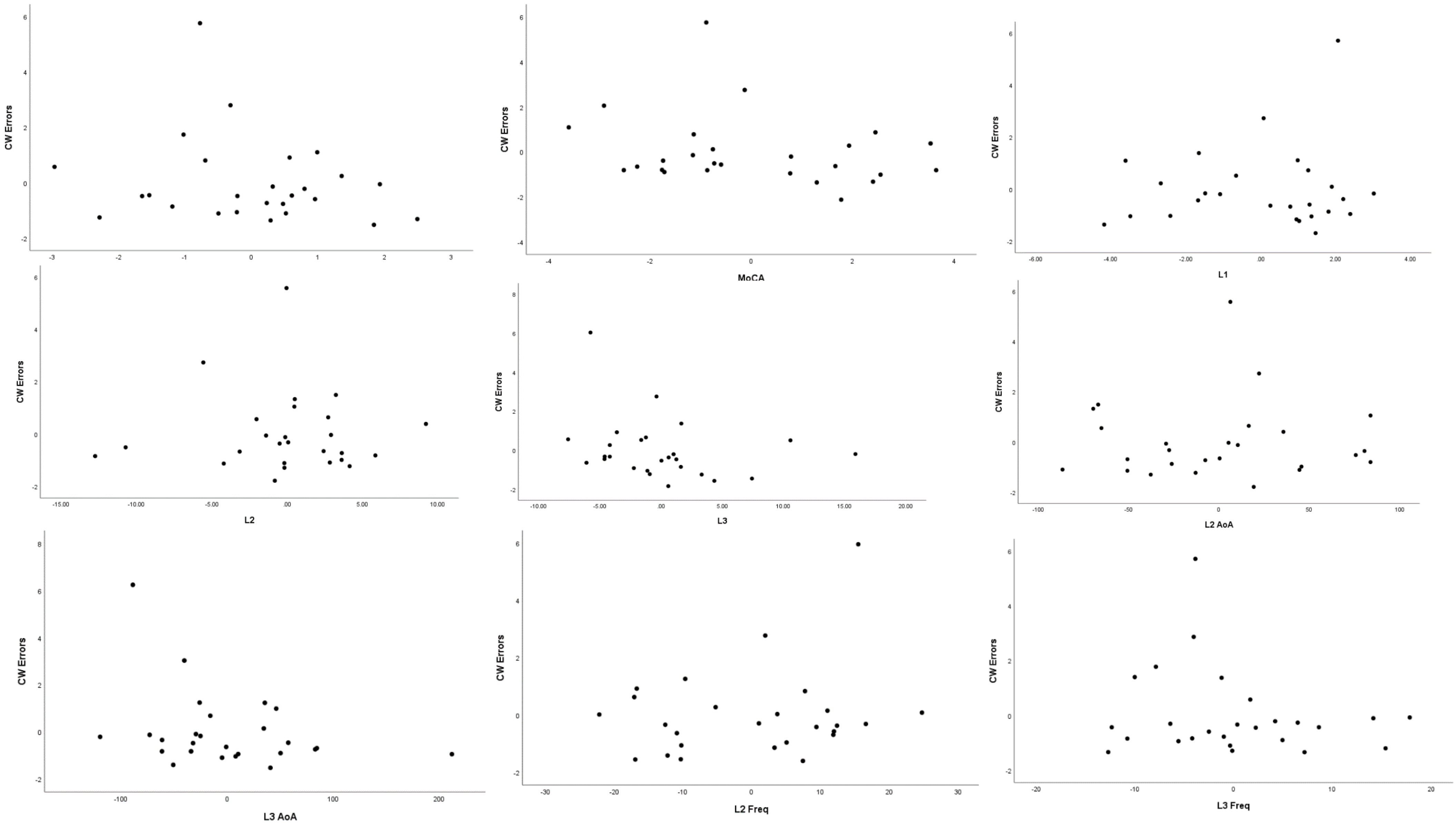
* = p < .05, ** = p < .01.

Appendix M: Scatterplots among key Variables

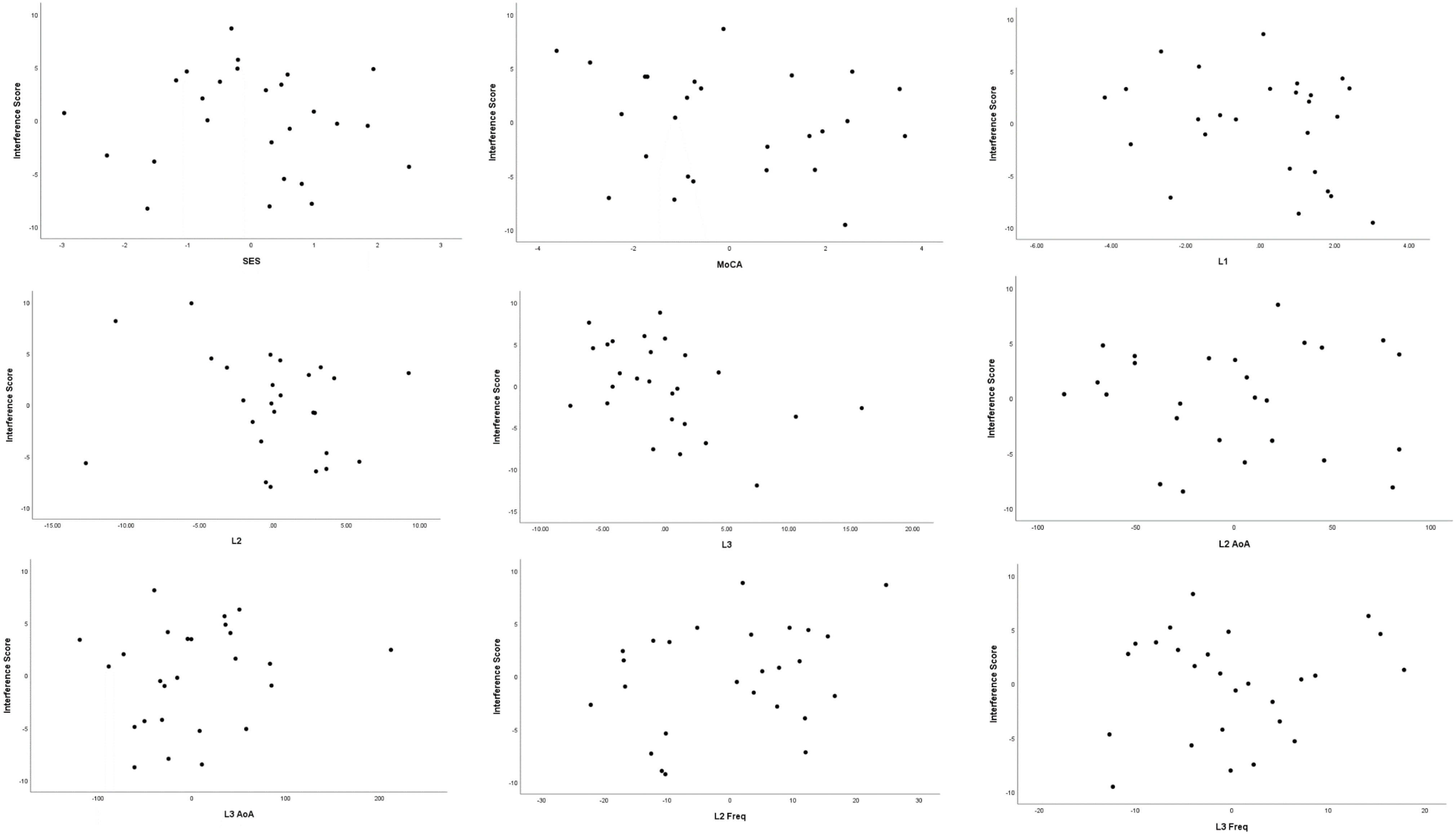
Scatterplots between colour-word response times (CW RT) on the Victoria Stroop Task (VST) and all independent variables



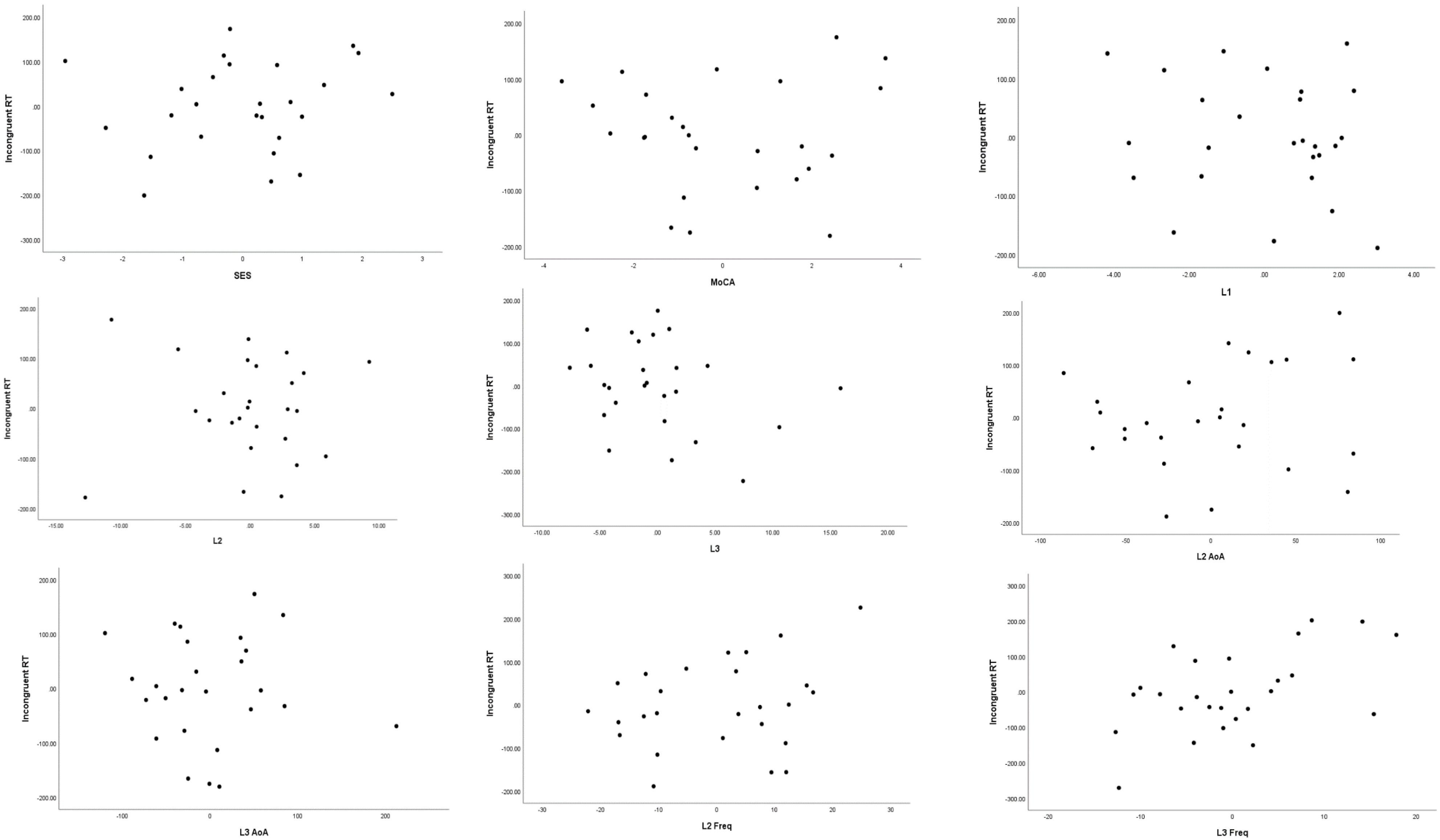
Scatterplots between Errors made on the VST's colour-word condition (CW Errors) and all Independent variables



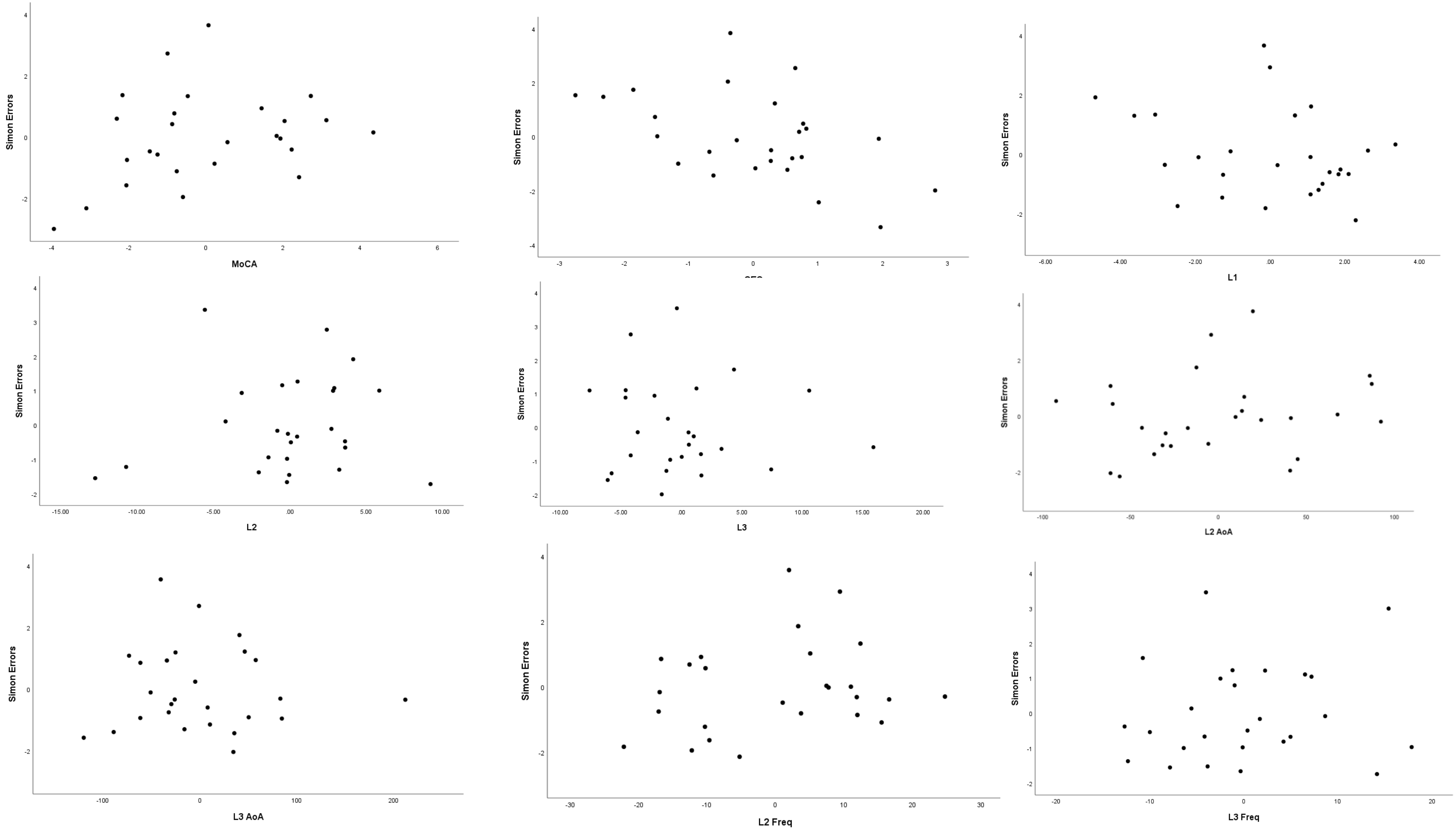
Scatterplots between the VST's interference score and all independent variables



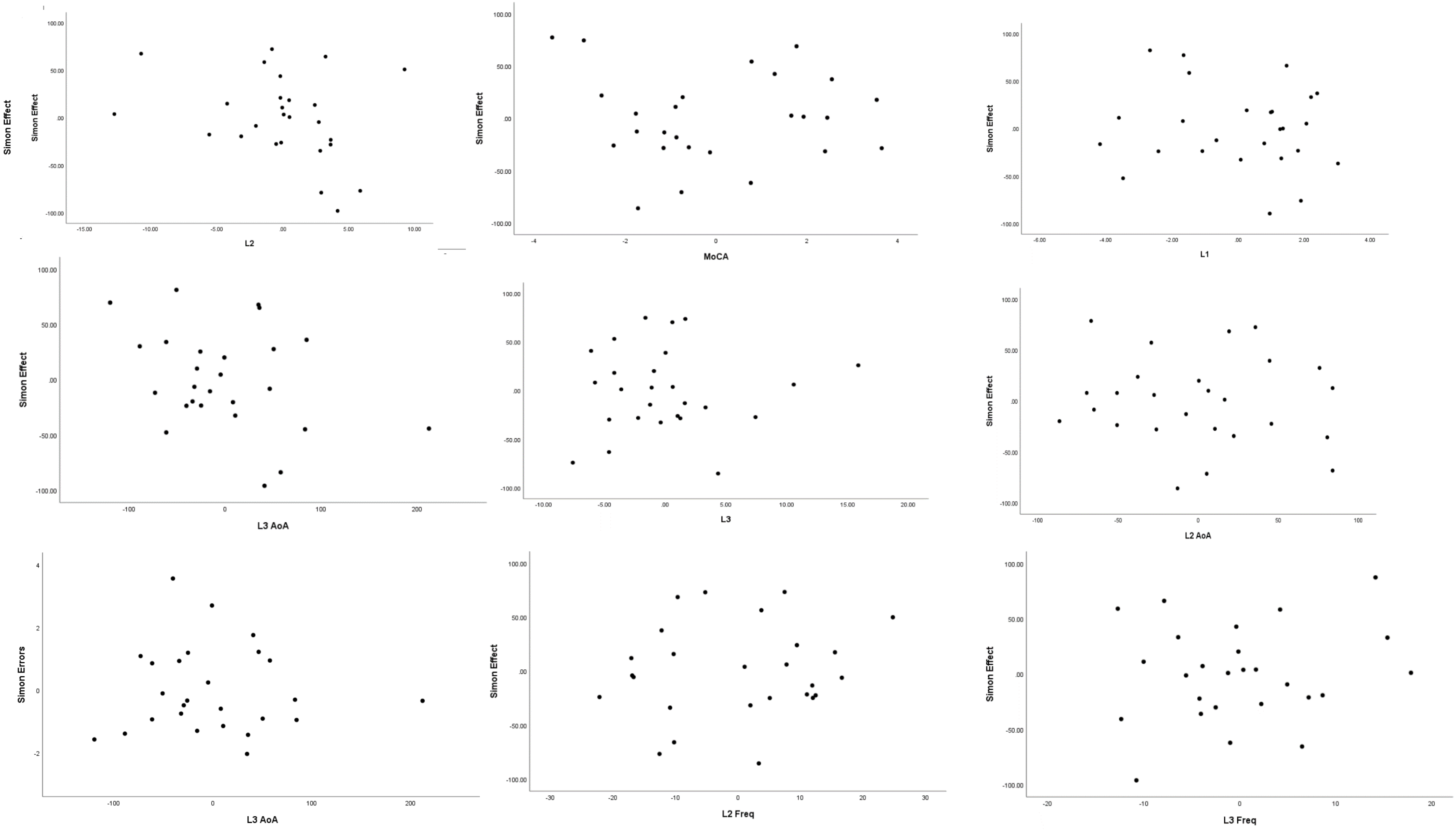
Scatterplots between incongruent response times (Incongruent RT) on the Simon task and all independent variables



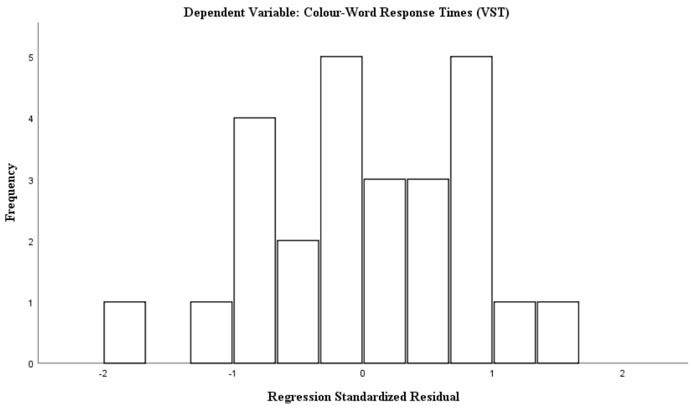
Scatterplots between errors made on the Simon task (Simon Errors) and all independent variables

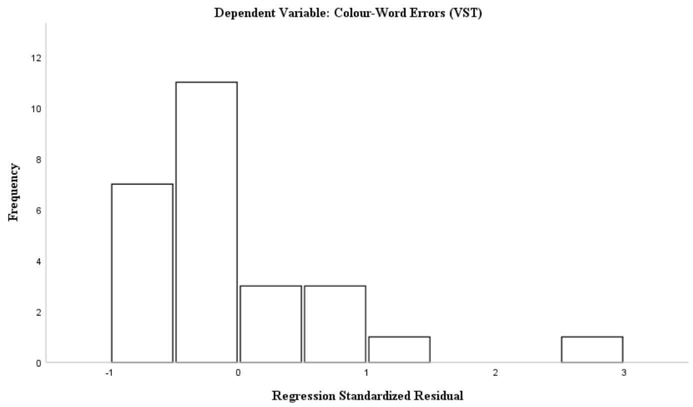


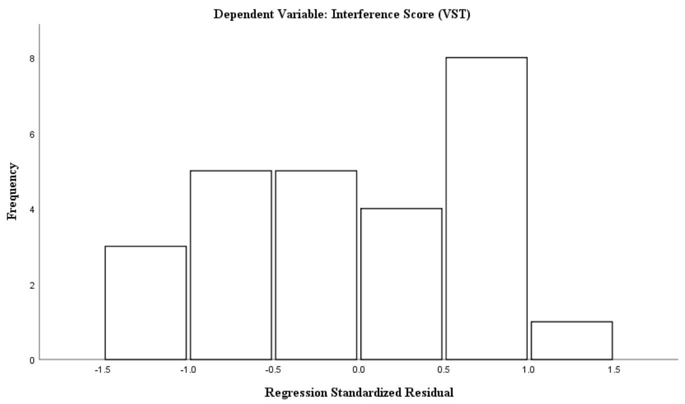
Scatterplots between the Simon Effect and all independent variables

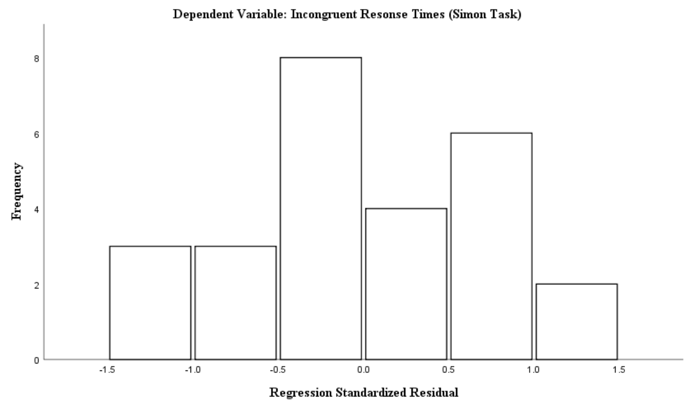


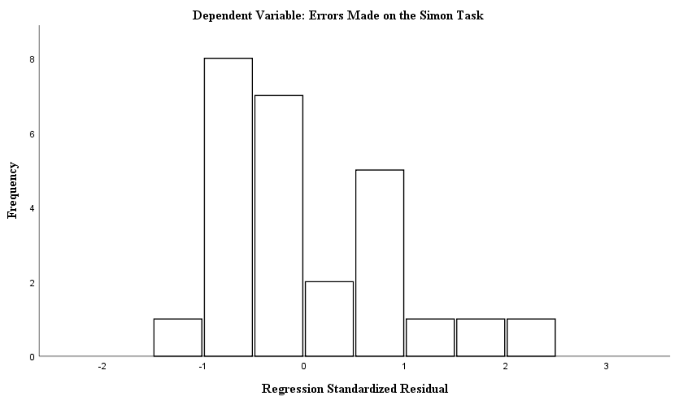
Appendix N: Histograms Assessing Normality of Standardised Residuals

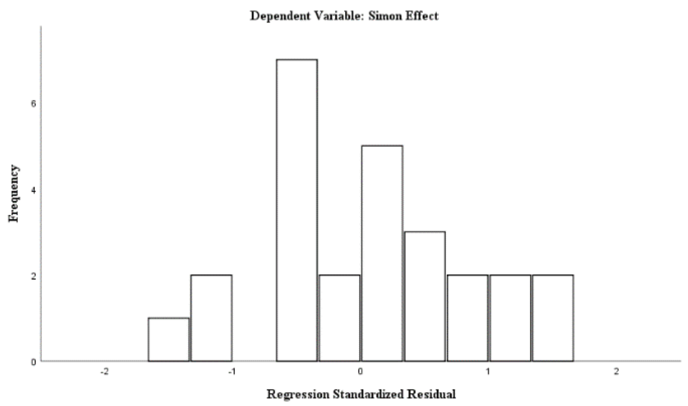












Appendix O: Normal Probability Plots