

https://dspace.org/

An investigation into the relationship between bilingualism and attentional networks with a focus on linguistic distance and language proficiency.

Wierzbicki, Sylwia

2014-01-09
http://hdl.handle.net10539/13400

Downloaded from a DSpace repository. https://dspace.org/

MASTERS RESEARCH DISSERTATION

An investigation into the relationship between bilingualism and attentional networks with a focus on linguistic distance and language proficiency

By

Sylwia Wierzbicki

Submitted in partial fulfilment for the degree

Masters in Research Psychology by Coursework and Dissertation

in the

Department of Psychology

at the

University of the Witwatersrand

Supervisor: Mrs Aline Ferreira Correia

Table of Contents

Introduction 2

Literature Review 2

Bilingualism and the Attentional Network 3

Bilingualism and Language Proficiency 7

Bilingualism and Linguistic Distance 9

Rationale 11

Research Questions 12

Aims 12

Methodology 13

Hypotheses 13

Variables 14
- Bilingualism 14
- Monolingualism 14
- Attention 14
- Linguistic Distance 15
- Self-Rated Language Proficiency 15
- Extraneous Variables 16

Study Design 17

Procedure 17
- Pre-assessment Stage 17
- Assessment Stage 18
- Post-assessment Stage 19

Sample and sampling 19

Assessment Instruments 21
- Demographic Questionnaire 21
- The Language Experience and Proficiency Questionnaire (LEAP-Q) 22
- Simon Task 23
- The Attentional Network Task (ANT) 23

Ethical Considerations 24

Results 25
Data analysis 25
General analysis 26
The Simon Task 27
The Attentional Network Task 30

Discussion 31
Attentional Functioning 31
Linguistic Distance 35
Language Proficiency 37

Conclusion 38

Limitations and Recommendations 38

Acknowledgements 40

Reference List 41

Appendices 44

Appendix A: Demographic Questionnaire 44

Appendix B: Language Experience and Proficiency Questionnaire (LEAP-Q) 45

Appendix C: Online Introductory Page (Participant Information Form) 48

Appendix D: Schematic Representations of the Attentional Network Task (ANT) 50

Appendix E: Email correspondence for ethical approval on methodological change 51
**

Introduction

Numerous investigations within the linguistic, cognitive, and neuropsychological fields have focused their intentions on understanding bilingualism and have thus far produced a considerable body of literature. Nevertheless, further research is necessary as the various associated complexities of this phenomenon are not yet clear. In order to address this issue the current investigation attempts to elucidate the relationship between bilingualism and attentional functioning, which has previously 'revealed' what has been termed the 'bilingual advantage' (Bialystok, Craik, Green & Gollan, 2009). This notion suggests that bilinguals demonstrate enhanced nonverbal cognitive processing when compared to monolinguals, as a result of having to constantly manage and switch between their two languages. Empirical evidence in support of this hypothesis, although increasing, is not consistent across all studies- perhaps as a result of differences in sample selection or experimental methodology (Hakuta & Diaz, 1985; Morton & Harper, 2007). In essence, the precise nature of this relationship is unclear, thus leading the present study to explore the influence language proficiency and linguistic distance may have on the proposed association.

Literature Review

Both bilingualism and cognition have existed as topics of interest within the field of psychology for many decades, however investigation into the various relationships between them has yielded unsystematic findings. An overview of early exploration concerned with bilingual advantages and disadvantages reflects an interesting perspective which understands bilingual consequences as detrimental to the individual, suggesting that a 'language handicap' may arise and compromise personal standards in grammar, articulation, vocabulary and written composition (Hakuta & Diaz, 1985).These concerns were taken as crucial to the development and administration of psychometric testing, and rightly so, as comparison between monolinguals and bilinguals across the same norms could be problematic. Further investigation did however reveal that the initial differences found were likely to reflect methodological flaws, particularly as the subjects were not appropriately matched on crucial influential factors such as socioeconomic status and language proficiency (Hakuta & Diaz, 1985). Having taken these issues into account, Peal and Lambert (1962) demonstrated that bilinguals may in fact exhibit a general intellectual advantage by outperforming monolinguals on nonverbal cognitive tasks. On the basis of this outcome, similar results have been found by numerous investigations across a wide variety of contexts (Bialystok, Craik, Grady, Chau,

Ishii, Gunji & Pantev, 2005; Bialystok, Crain, Klein & Viswanathan, 2004; Costa, Hernández & Sebastián-Gallés, 2008; Luk et al., 2011).

General cognition is however, a highly sophisticated and complex process which cannot be conceptualized and investigated within a single research study. The current investigation consequently chooses to focus on attentional functioning- a cognitive skill which in itself represents a multifaceted phenomenon. Previous research has revealed results which suggest that bilingualism may exert an influence over the attentional network- such that bilinguals demonstrate enhanced performance on non-verbal attentional tasks when compared to monolingual individuals (Bialystok, Craik, Green & Gollan, 2009).

Bilingualism and The Attentional Network

The theoretical underpinnings of the observed effects have in themselves generated a number of propositions as neuropsychologists, cognitive psychologists and linguists attempt to understand the organization of the underlying processes. The principal assumption building the theoretical framework is the idea that bilingual individuals are constantly faced with the problem of selecting between alternate responses, as both languages are activated even when only one is being used (Bialystok et al., 2005; Brysbaert, 1998; Green, 1998). The mechanism by which this joint activation is attended to and resolved has been addressed by various frameworks, most notably by the Inhibitory Control (IC) model developed by David Green (1998). The primary premises of this theory are based on the problem of competition between both tasks and responses, and consequently suggest that the activation of competing schemas is controlled by a supervisory attention system (SAS) (Bialystok et al., 2005; Green, 1998). Although this system is rather complex and includes multiple levels of control, the application of this work to bilingual research is quite clear in that it emphasizes the role of a selection mechanism based on inhibition. The activation of language schemas in bilinguals is managed through the constant exercise of inhibitory control- which guides responses at the lemma level, or at the 'locus of word selection' (Green, 1998). It is particularly important to note that the processes associated with the IC model are specific to bilingualism (and may be extended to multilingualism) but are not applied to monolingual functioning. In other words, the 'attention problem' introduced by the competition of two active languages is not present in monolingual minds (Bialystok, 2011). Whether or not this is also evident in non-proficient bilingual individuals remains to be seen.

The framework proposed by Green (1998) is pertinent to bilingual research as it has implications for cognitive functioning beyond verbal tasks. Empirical evidence has suggested that the attentive mechanisms described in the IC model are part of the same general-purpose executive control system that is "well known to be involved in situations where selection or conflict resolution is required" (Bialystok, 2011, p.229). One could consequently question whether the constant practice and engagement of these mechanisms could strengthen the system in such a way that improved performance on other, non-verbal attentional tasks utilizing the same processes may be observed. This intriguing notion has been the focus of intense research over the years, and although favourable results have been found, the precise nature of the relationship requires a more insightful understanding (Segalowitz & Frenkiel-Fishman, 2005).

In light of the current status of the available literature, the proposed study aims to focus on the attentional network, particularly as the IC model highlights this component as crucial to bilingual functioning. Broadbent's initial conceptualizations of attentional mechanisms introduced by the filter or 'bottleneck' model inform the modern contextualization of attention as "both a form of alertness and as an index to resource allocation" (Raz & Buhle, 2006, p. 367). In essence, attention is viewed as a mechanism for "providing priority for motor acts, consciousness and certain types of memory" (Raz & Buhle, 2006, p.367). The precise nature of this system has been the focus of rigorous research for more than a century amongst cognitive and neuroscientific disciplines. Several technological and methodological developments have yielded converging data which suggests that attention functions as a set of independent control networks and should not be viewed as a 'uniform concept' as previously suggested (Raz & Buhle, 2006). Research conducted with normal and pathological patients (in states of typical or atypical attention) using behavioural, imaging and electrical scalp recording techniques as well as developmental and genetic assay data, provides evidence for the existence of separate modules of attention (). These modules are functionally and anatomically distinct however the degree of independence between them remains a key focus of research across disciplines (Raz & Buhle, 2006).

William James was perhaps the first to advocate the 'multiplicity' of attention, however Posner (1971) suggested that each component has distinct neurobiological underpinnings. Various methodological developments including the introduction of neuroimaging have informed the development of this theory which has become more refined over the years. Three key attentional networks have been identified, and although the terms of these

networks (initially termed selection, capacity and alertness) have changed under several theorists, these are now known as the executive, orienting and alerting components (Segalowitz & Frenkiel-Fishman, 2005). These networks are thought to be largely independent (Raz & Buhle, 2006).

The alerting network refers to the "ability to increase and maintain response readiness in preparation for an impending stimulus" and is the foundation for other attentional functions (Raz & Buhle, 2006). The performance of this network is typically measured by contrasting response times to tasks where alerting cues are present or absent. Neuoroimaging data suggests that activity associated with this function takes place in the frontal and parietal regions, particularly within the right hemisphere (Raz, 2004). The orienting network, otherwise known as scanning or selection refers to the ability to select specific information amongst multiple sensory stimuli (Raz & Buhle, 2006). This component can also be measured using reaction time tasks and has been associated with activity in the pulvinar, superior colliculus, superior parietal lobe, temporoparietal junction, superior temporal lobe and frontal eye fields. These regions are however activated at various stages in the orienting process. While numerous studies have focused on the alerting and orienting components, executive control has been explored considerably more, and theoretical assumptions suggest that this network is more likely to be affected by bilingualism (particularly as it involves inhibitory control) (Costa et al., 2008).

Executive control or executive attention involves the process of monitoring and resolving conflict through decision making, error detection, regulation of thoughts and feelings and the overcoming of habitual actions (Costa et al., 2008; Raz & Buhle, 2006). The relationship between the executive, alerting and orienting networks remains unclear, however fMRI images suggest that activity associated with the executive component occurs in the anterior cingulated cortex. Past investigations have utilized various cognitive tasks (such as the Simon Task, ANT Task and Stroop task) which require conflict processing in order to assess whether the executive network is superior in bilingual minds when compared to executive network functioning amongst monolinguals (Costa et al., 2008).

Although several theorists have opposed Posner's attentional model with various perceptions on the understanding of the attentional network, the converging data supporting the existence of different attentional networks remain strong, despite the need for clarification on the precise nature and independence of these components. Other attentional models include

Desimone's (1995) neural competition theory which focuses on basic phenomena such as the brain's limited capacity for processing information, where giving attention to any one target leaves less available for others (Desimone & Duncan, 1995). This theory suggests that attention is a much slower mechanism to that proposed by Posner and is primarily mediated by the prefrontal cortex. Nevertheless, this model still differentiates between attentional networks and includes components such as selectivity, and supports the notion of attention as a process of multiplicity.

Following a review of attentional theory, the assumptions of this study are aligned with Posner's framework that considers attention as a multidimensional construct involving numerous cognitive functions that can be fractioned into subcomponents underpinned by various neurobiological substrates (Segalowitz & Frenkiel-Fishman, 2005). These functions, and their relation to bilingualism and monolingualism, can be investigated and understood by respondent performance on various cognitive tasks that require efficient functioning of these mechanisms.

The Simon task is one such experimental paradigm which has been administered repeatedly after first being published in the late 1960s. The test is in essence, a response selection task during which a subject is placed in front of a computer screen and asked to complete a number of trials. These trials require an individual to press a button which corresponds to the colour of a square appearing on the screen- regardless of its location. The task involves both congruent and incongruent trials which differ in that throughout the incongruent trial, the location of the square does not correspond with the positioning of the correct button. Although seemingly simple, the design of this experiment allows researchers to investigate the innate tendency subjects have to respond to the source of stimulation, and the effectiveness of the inhibitory control mechanisms which are thought to manage such tendencies (for review, see Lu & Proctor, 1995). The interference caused by the location of the stimulus presents competition within the attentional network that may be compared to the problem experienced by bilinguals who need to manage the constant activation of two languages. Previous investigations involving the assessment of bilingualism and attention using the Simon task have generally revealed results which suggest that bilinguals exhibit faster reaction times and differential brain activation patterns on both congruent and incongruent trials (Bailystok, 2005; Bialystok et al., 2004). Interestingly enough however, a study by Morton and Harper (2007) did not find evidence in support of this hypothesis after

controlling for ethnicity and socioeconomic status, suggesting that previous findings are not without controversy and should be engaged with cautiously.

Although the Simon Task assesses the functioning of inhibitory mechanisms, the design of the experiment engages working memory processes, as the individual is required to remember the stimulus-response rule throughout the procedure (Costa et al., 2008). Therefore, in order to reaffirm the findings revealed by the Simon task, the present study will also include the attentional network task (ANT) as a measure of executive functioning, as well as alerting and orienting mechanisms. The ANT is a combination cue reaction time and flanker assessment which also involves inhibitory control in a measure of congruent and incongruent trials. The process is however somewhat different to that in the Simon Task, as participants are asked to indicate the direction of a central arrow amongst two flanker arrows while considering the presentation of target cues. Nevertheless, both the Simon Task and ANT experiments are expected to reveal faster reaction times for bilinguals when compared to monolinguals- thus indicating superior attentional control supported by a fortified inhibitory control mechanism which has been developed through the use of two languages.

While previous research has primarily focused on the functioning of the executive network, evidence for the effect that bilingualism has on alerting and orienting remains somewhat deficient (Costa et al., 2008). Yet it has been suggested that bilingualism may prove beneficial to other attentional components, as bilingual groups seem to gain more value from the alerting cues and are therefore more prepared for monitoring and conflict resolution (Costa et al., 2008). This finding could explain why reaction-time differences between monolingual and bilingual participants are evident even in congruent trials where stimulus interference is not present. Further investigation within this domain by administration of the ANT will add to existing literature on the topic and further explicate the effects bilingualism has on attentional mechanisms, as well as elucidate the attentional processes themselves.

Bilingualism and Language Proficiency

An overview of the existing literature on bilingualism and the associated advantages indicates that, although well documented, the degree or nature of bilingualism requires more attention if its effects are to be adequately understood. The previously observed attentional benefits should be explored further so as to identify which specific aspects of bilingualism may lead to these particular outcomes. Yet the potential for such insight is sometimes limited as typically, researchers include a sample of bilingual participants who are fluent in two

languages (Luk et al., 2011). Although the comparison of these individuals to a matched group of monolinguals is certainly valuable, it does not allow for any exploration into how the degree of linguistic experience affects an observed relationship. It is therefore important to include both fully balanced bilinguals, as well as bilinguals who are not equally proficient in both languages in future investigations.

Despite the lack of research in this area, language proficiency as it relates to second language mastery has represented a topic of interest across various disciplines for a long period of time. Crucial inquiries and debates have however, also focused on first language (L1) acquisition. Although this issue lies beyond the scope of the current study, it is worth mentioning that the championed view on language acquisition proposes a 'Universal Grammar' or an innate endowment which is somehow represented in the brain itself (Chomsky, 2002). This perspective certainly has implications for bilingual research, as it highlights the importance of considering actual neurobiological changes which may occur as a consequence of second language (L2) acquisition. Research has shown that bilingualism has been found to alter brain structures, and that this change is associated with longer and more proficient L2 use (Luk et al., 2011; Mechelli, Crinion, Noppeney, O'Doherty, Ashburner, Frackowiak & Price, 2004). Interestingly enough, a study by Mechelli and colleagues (2004) which demonstrates this effect found that brain modifications occurred in that area of the brain which is involved in executive functioning. Hypothetically speaking, these changes would influence performance on cognitive tasks involving attentional processing and other executive mechanisms. It is therefore of crucial importance to consider L2 proficiency in bilingual research, particularly when focusing on cognition.

Language proficiency itself may be understood as the level of linguistic skill, or more specifically, as the individual ability to "handle attention-directing aspects inherent in the language and to do so quickly and accurately" (Segalowitz & Frenkiel-Fishman, 2005, p.645). Ultimately, the language processes associated with grammar demonstrated by a proficient speaker are automatic, effortless and predominantly unconscious (Segalowitz & Frenkiel-Fishman, 2005). Although seemingly simple, this distinction is not uncomplicated as language proficiency may be influenced by a variety of environmental and biological factors. The age of L2 acquisition and active bilingual experience or 'immersion', are two such significant factors- both which have been investigated in relation to cognitive functioning (Luk et al., 2011; Perani et al., 1998). A study by Perani and colleagues (1998) assessed differences in cerebral activation associated with the auditory processing of both bilingual

languages and found that the attained proficiency determined cortical representation- not the age of L2 acquisition. This demonstrates the notable influence that language proficiency has on neural processes and therefore emphasizes its value as a topic for inquiry.

Despite its significance, literature on the effect of L2 proficiency on the relationship between bilingualism and attentional functioning is somewhat limited, particularly as controlling for this variable is somewhat difficult. Nevertheless, the existing studies have revealed evidence to support the hypothesis which postulates that a higher level of L2 language proficiency is associated with greater attentional benefits (Luk et al., 2011). The current investigation therefore expected to find results similar to these findings, particularly as they are supported by theory which proposes that the general-purpose executive control system recruited for linguistic processing is fortified through bilingual practice, and consequently affects performance on other cognitive tasks (Bialystok, 2011).

Bilingualism and Linguistic Distance

The majority of studies involved in bilingual research include only one bilingual sample which is generally matched to and compared with a monolingual group. There may however, be considerable value in comparing two bilingual populations that are fluent in different languages. In doing so, the researcher is able to gain more insight into the relationship between bilingualism and attentional functioning so as to better understand how other factors may influence the association. Although languages may be similar to each other, no two languages are exactly the same and it is precisely this degree of similarity that is referred to as ‘linguistic distance’.

The present study includes a bilingual sample of both English-German and Chinese-English speakers, as well as monolingual English-speaking individuals. While both English and German languages belong to the West Germanic branch of the Indo-European language family, the Chinese language is classed within the family of Sino-Tibetan languages. In other words, the linguistic distance between Chinese and English is greater than that between German and English. This is further exemplified by the morphosyllabic script used in Chinese writing and understanding that is markedly different from both the English and German alphabetical system. The key issue to be addressed revolves around whether the magnitude of cognitive benefits previously observed in bilingual participants is affected by the linguistic distance between the two bilingual languages.

An experiment conducted in 2005 investigated the effects of bilingualism on cognitive control using the Simon Task and magneto-encephalography (MEG), and included bilingual Cantonese-English as well as bilingual French-English comparison groups (Bialystok et al., 2005). The linguistic distance between Cantonese and English is greater than that between French and English. Interestingly, behavioural measures of reaction-times on the Simon task were only faster for the Cantonese group, while the French and English monolingual samples did not differ from each other in this respect. This seems to contradict previous findings which do not discriminate between bilingual language families. It is however, crucial to note that the pattern of cortical activity activated during the task was similar for the two bilingual groups but different for the monolinguals, suggesting that there is in fact a difference in attentional processing as a result of bilingualism. In light of these findings the authors claim the observed results are consistent with the theoretical assumptions of the IC model, and state that they "have no explanation for the faster reaction times of the Cantonese-English bilinguals" which could perhaps be the result of sampling variability (Bailystok et al., 2005, p.45).

Admittedly, this result is difficult to explain particularly as research on the topic is somewhat limited. At this point in time researchers can only hypothesize and test assumptions based on the existing empirical and theoretical literature. It is however, possible that the constant competition experienced by bilinguals between the two activated languages is greater if the linguistic distance is large, and so the executive mechanism becomes more efficient. Alternatively, having two languages which are similar to each other may create a greater need for conflict resolution, as simultaneously activated languages may be more difficult to distinguish when linguistic distance is smaller. Neuroimaging evidence has also suggested that different cognitive resources may be utilized in the processing of two distinct languages (that are not relatively similar in terms of lexical and grammatical structure), and that this could result in lesser conflict and a lesser need for conflict resolution (Tan et al., 2003). Consequently, individuals speaking two languages which are similar to each other would demonstrate enhanced attentional functioning when compared to individuals who speak two grammatically distinct languages.

Another study comparing two high-proficiency bilingual samples was carried out by Perani and colleagues in 1998, where Italian-English and Spanish-Catalan speakers were assessed on auditory processing using functional imaging methods. The patterns of activation were found to be similar across the two groups, perhaps suggesting that linguistic distance does not

appear to play a major role in determining the associated neuronal activity (Perani et al., 1998). It is however, important to recognize that all these languages use the same alphabet, and the differences in linguistic distance may not have been great enough to exert any significant effect.

Furthermore, although this study did not administer cognitive tests of executive functioning and did not include a monolingual sample, its results complement those found by Bailystok et al., (2005) which suggest that certain neuronal networks associated with bilingualism are different from those associated with monolingualism. The present investigation did not monitor neurobiological processes but did instead; assess attentional differences or similarities as demonstrated by performance on the Simon and ANT tasks across two distinct bilingual groups and one monolingual group. Although cognitive benefits were expected to be observed in both the bilingual samples, these advantages were expected to be larger for the English-German population as a result of the grammatical and lexical similarity between the two languages.

Rationale

An overview of the available literature reveals a corpus of significant, yet unsystematic findings which fail to clearly demonstrate how the qualitative aspects of bilingual experience influence the previously observed attentional benefits (Luk, De Sa & Bialystok). The precise nature of the relationship between attentional functioning (specific to the alerting, orienting and executive networks) and bilingualism requires elucidation, and the majority of previous investigations have not observed the impact linguistic distance may have on the proposed association. The present study acknowledges the importance of including both second language proficiency and linguistic distance as potentially influential variables in the relationship between bilingualism and attentional functioning. The outcomes of such studies may contribute towards existing literature on cognitive processing, brain plasticity, and neurological structuring.

Although theoretically interesting, this also has practical implications for public policy issues, particularly with regard to the formulation and enforcement of education programs. A clearer understanding allows for informed decision-making and may settle disputes surrounding immersion programs and second-language acquisition. This is particularly relevant to South Africa and other similar contexts where a variety of official languages are actively used on a daily basis. Language in the education system has always been a contested issue in South

Africa, particularly with regards to the oppressive history and recent move toward racial and cultural equality. Current national language policies promote multilingualism and the development of official languages; however the drive toward mother-tongue instruction vs. the need for competency in international languages such as English presents a complex and sensitive issue that needs to be addressed by competent and informed government policy. Understanding the influence bilingualism/multilingualism may have on cognitive performance and the mechanics of attentional functioning therefore has practical implications in such contexts.

Health care systems may also benefit from research in the area as bilingualism has been associated with improvements in age-related cognitive decline, and may also shed light on the processes involved in neuropsychological abnormalities such as aphasic disorders (Bialystok et al., 2009). Cognitive and neuroscientific research should therefore continue to focus on the effects bilingualism may have on cognitive functioning, as both the theoretical and practical implications of such findings are relevant to several industries and may drive developments in both the health and educational sector.

Aims

In essence, this research aimed to elucidate the processes associated with attentional control, and chose to observe the relationship between bilingualism and specific attentional processes (alerting, orienting and executive networks). Furthermore, the study aimed to understand how this relationship may be influenced by language proficiency and linguistic distance.

More specifically, the current study hoped to explore and describe differences and similarities in the alerting, orienting and executive attentional networks by assessing the performance of English monolinguals, English-German bilinguals, and English-Chinese bilinguals on non-verbal cognitive tasks (the Simon Task and ANT). The findings of this investigation may add to existing literature within the linguistic and psychological fields, and may potentially provide insight and greater understanding into the relationship between bilingualism and cognitive functioning.

Research Questions

Having considered the ‘gaps’ which may be observed within the existing literature, the present investigation hoped to address three primary research questions:

R1: Is there a relationship between bilingualism and performance on non-verbal tasks requiring attentional mechanisms? (Applies to alerting; orienting; executive attentional networks)

R2: Is this relationship influenced by the linguistic distance of the two bilingual languages?
R3: Is this relationship influenced by the level of L2 proficiency?

Methodology

Hypotheses:

Based on the existing literature, the following predictions regarding the relationship between bilingualism and functioning of the alerting, orienting and executive attentional networks was assessed:

The Simon Task

H1: Bilingual individuals will show faster reaction times and make fewer errors for both congruent and incongruent trials relative to monolinguals

H2: The reaction time measurements observed on the differences between congruent and incongruent response latencies (the Simon effect) are expected to be smaller for bilinguals relative to monolinguals

The Attentional Network Task (ANT)

H3: Bilingual individuals will show faster reaction times and make fewer errors for both congruent and incongruent trials relative to monolinguals.

H4: The interference produced by incongruent flankers in comparison to congruent ones (the conflict effect) will be more pronounced for monolinguals than for bilinguals.

H5: Reaction times will be faster on trials where an alerting cue is presented than where it is not, for both bilinguals and monolinguals, however the magnitude of this effect is expected to be greater in bilingual individuals

H6: Reaction times will be fastest on trails which display an alerting cue indicating the position on the screen where the target will appear, for both bilinguals and monolinguals, however the magnitude of this effect is expected to be greater in bilingual individuals

The Simon Task and The Attentional Network Task (ANT)

H7: English-German bilinguals will show faster reaction times than the English-Chinese bilinguals and the English monolinguals.

H8: Proficient bilinguals will show faster reaction times than less proficient bilinguals

Variables

Bilingualism

Conceptual Definition: this study aligns itself with Hamers and Blanc (2000) who conceptualize bilingualism as "the psychological state of an individual who has access to more than one linguistic code as a means of social communication" (pp. 6) and acknowledge that this degree of access may vary greatly. Bilingualism, as opposed to multilingualism, was therefore be defined by an individual having access to two linguistic systems.

Operationalization: Bilingualism represents the independent variable within the current investigation and was determined by response to the self-report Language Experience and Proficiency Questionnaire (LEAP-Q), which aimed to construct a 'bilingual profile'. Self-report L2 proficiency scores on the speaking dimension differentiated bilinguals from monolinguals, where bilingual individuals indicated an L2 proficiency level between '2' (low) and '10' (perfect).

Monolingualism

Conceptual Definition: Subsequently, monolingualism is defined as the 'absence' of bilingualism, where an individual does not have access to more than one linguistic code as a means for social communication.

Operationalization: Two particular items within the Language Experience and Proficiency Questionnaire (LEAP-Q) were used to identify monolingualism. These items included: Indication by the respondent as 'knowing' only one language, or, self-report L2 proficiency scores on the speaking dimension of '1' (very low) or '0' (none).

Attention

Conceptual Defnition: the current study aligns itself with the attentional network suggested by Posner and Peterson (1990), which proposes that alerting (achieving and maintaining an

alert state), orienting (selecting information from sensory input) and executive control (monitoring and resolving conflict) represent the three primary attentional networks. These components may be understood at both a cognitive operational and neuronal level, and were investigated in this study as the variables influenced by bilingual or monolingual functioning.

Operationalization: Alerting, orienting, and executive control were assessed using the Simon Task and the Attentional Network Task (ANT). These two computer-based cognitive assessments require attentional processes and measure reaction times and associated response errors. These scores were treated as representations of attentional performance where faster reaction times and fewer errors demonstrated enhanced attentional mechanisms.

Linguistic Distance

Conceptual Definition: 'Linguistic distance' exists predominantly within the field of linguistics as a term which loosely describes the extent to which two languages differ from each other (Chiswick & Miller, 2004). Characteristics surrounding vocabulary, grammar, written form, syntax, semantics, and phonetic similarity all contribute significantly towards determining the degree of similarity between two languages. The current investigation therefore treated the variable as a factor which moderates the relationship between bilingualism and attentional performance.

Operationalization: The prevailing view adapted by many linguists is one which suggests that linguistic distance cannot be quantified, as no scalar measure for the 'structural closeness' of languages can be developed (Chiswick & Miller, 2005). This study therefore utilized language trees which trace the evolution of languages as references for 'measuring' the linguistic distance between English and German, and English and Chinese.

In accordance with this perspective, the current investigation perceived the linguistic distance between English and Chinese as greater than that between English and German, as both English and German belong to the West Germanic branch of the Indo-European language family, while the Chinese language is classed within the Sibo-Tibetan family. This 'distance' is further exemplified by the morphosyllabic script used in understanding and reading Chinese that is markedly different from both the English and German alphabetical systems.

Self-Rated Language Proficiency

Conceptual Definition: Language proficiency is a measurement of how well an individual has mastered a language. Proficiency is measured in terms of receptive and expressive language skills, syntax, vocabulary, semantics, and other areas that demonstrate language abilities. Language proficiency is measured for an individual by each language, such that the individual may be proficient in English and not proficient in another language. The proposed research investigation included second language proficiency as an important characteristic in describing the final sample.

Operationalization: Language proficiency was assessed using a modified version of the Language Experience and Proficiency Questionnaire (LEAP-Q), where self-reported scores on the speaking dimension represented L1 and L2 proficiency levels. The measure utilized a likert-type scale which ranged from 0-10 (none- perfect), however only scores between '2' (low) and '10' (perfect) were used to differentiate bilingual individuals with 'high' and 'low' L2 proficiency. These respondents were dichotomized into two 'proficient' and 'non-proficient' groups using a cut-off score of '6' (slightly more than adequate).

Extraneous Variables

As the current investigation required the completion of two attentional assessment tasks, various extraneous variables which may have influence performance were considered. These included numerous physical, psychological or situational factors.

Controlled extraneous variables: Impairments in hearing or vision (such that are not corrected by eye glasses or hearing apparatus), disabilities in language or learning, and neurological disorders such as meningitis, traumatic brain injury, epilepsy or encephalopathy- are all conditions which may exert an influence over attentional performance. In an effort to control such effects, the demographic questionnaire utilized in the current study asked respondents to indicate the presence of any such problems. It also allowed individuals to report information on treatments, medication, or on other issues which they may have felt to be relevant (which were not included in the checklist). Responses from participants who specified problems which could have influenced attentional performance were excluded from the study.

Non-controlled extraneous variables: Numerous situational factors which may alter performance on attentional tasks are difficult to control, as the present study did not allow the researcher access to the testing environment. Various distractions and interruptions which

may have occurred throughout the procedure were therefore largely uncontrollable. Such occurrences may have resulted in longer or more reckless responses on the attentional tasks- a result which could have undermined the findings of the investigation. The introductory page of the online assessment did however, include a brief checklist which asked respondents to ensure that they remain alone and free of distraction throughout the procedure. This could not however, be fully controlled by either the researcher or the participant himself/herself. Furthermore, personality, fatigue, motivation, and socio-economic factors may have influenced attentional performance, however these 'issues' could not be controlled within the current investigation.

Study Design

The proposed research investigation aimed to assess the relationship between bilingualism and attention as moderated by linguistic distance, and was therefore non-experimental and correlational in nature. This study was both confirmatory and exploratory as results were expected to replicate those found in previous research and could provide further insight into the proposed associations.

Procedure

Pre-assessment Stage

Once the ethical clearance for the proposed study had been granted, the data collection procedures commenced and continued over a two month period. Initial procedures which aimed to assess performance on the Simon and ANT tasks within a controlled computer laboratory setting were abandoned due to low response rates amongst high school respondents. As a result, the initially proposed methodology was changed and responses were collected using a global online database of individuals who subscribe to complete online surveys and assessments. The ethical committee was consulted and notified of the change (see appendix E).

The process then began with the development of a web-based assessment as facilitated by a reliable online software and questionnaire tool. Inquisit 3.0 was utilized for this purpose, as millisecond precision timing offered by the software allowed for administration of reaction time experiments necessary to the investigation. By creating a web-based psychological assessment, respondents were free to perform the test at a time and location of their convenience. The data collection process did not however, begin immediately, as several

practicalities were addressed prior to the investigation. The researcher adapted the Language Experience and Proficiency Questionnaire (LEAP-Q) and created a shorter, more condensed version which did not include several questions found in the original assessment. Lengthy questions which were not particularly relevant to the current investigation were excluded (e.g. Please name the cultures with which you identify and rate to what extent you identify with these cultures).

Once the entire assessment had been constructed and established, convenient and purposive sampling methods were utilized in order to attain the required sample. English-German and English-Chinese young adults who are willing to complete a somewhat lengthy and arguably frustrating questionnaire are difficult to access. Consequently, an advisor at the 'Global Survey Market' (an online market research community) was contacted electronically and briefed on the sampling requirements relevant to the current investigation. Following discussion, a payment was made to the Global Survey Market team (by the researcher) for assistance with the data collection process. Electronic links to the online assessment were sent out to English, Chinese and German speaking individuals who were part of the Global Survey Market database. Respondents who completed the assessment in its entirety were rewarded with monetary incentive (of an amount which remains undisclosed to the researcher).

Assessment Stage

If the individual chose to follow the web-link and continue with the testing procedure, he/she was sequentially routed to a demographic questionnaire, a Language Experience and Proficiency Questionnaire (LEAP-Q), and to the Simon and ANT tasks following navigation through an introductory page. The introductory page included and online participant information sheet which emphasized that involvement in the study was strictly voluntary and confidential in nature. Complete anonymity could be undermined as the Global Survey Market team managed the data collection process; however respondents were made aware of the fact that it was not possible for the researcher to directly link any single assessment response to any particular participant. The introductory page also asked individuals to ensure that they remain alone and undisrupted throughout the testing procedure. These particulars needed to be checked off before continuation with the subsequent questionnaire could commence.

The entire assessment should not have taken any longer than an hour to complete, and respondents were able to do so in a time and location of their convenience. Participants could also take breaks at regular intervals throughout the procedure and once the testing had been completed in its entirety, the respondent was thanked for participation in the study.

Post-assessment Stage

Results from the assessment were stored within an Inquisit 3.0 account to which only the researcher had access. However, once the data collection period was concluded, the raw data was downloaded and exported into an excel spreadsheet before being statistically analyzed using SPSS.

Sample and sampling

The sampling strategy employed in the present inquiry was non-probabilistic and purposive in nature as the final sample of 123 individuals (72 males) included 64 monolingual participants (40 males), 29 English-German participants (17 males) and 30 English-Chinese participants (15 males) from several countries around the world (see Table 2). All respondents were between the ages of 18 and 32, and individuals older than 35 as well as those who failed to complete the Simon and ANT tasks were excluded from analysis. Any indication of learning and language disabilities, hearing impairments or neurological disorders also lead to participant exclusion. Furthermore, respondents who scored more than two standard deviations outside the mean on the ANT or Simon task were not included in the final sample (outlier responses that could heavily skew the data could not be interpreted as accurate representations of attentional functioning, particularly as the researcher had no control over the testing environment).

Responses to the brief demographic questionnaire and the LEAP-Q which investigated the characteristics of participants have been summarized in Table 1. The average reported age at which second language learning began was 10.76 and ranged from 3-20 for the English-German group, with 72.41% of the sample having begun learning at an age lower than 10. The average age at which second language learning began for English-Chinese participants was 10.32 and ranged from 0-20. 73.33% of these individuals began L2 learning below the age of 10. A large proportion (72.9%) of the participants in this study may therefore be classified as ‘early’ bilinguals, or individuals who learnt their two languages relatively early in life and would consequently benefit from any bilingual advantages which may exist.

Of the bilingual speakers, 81.8% reported using both English and their second language at an 'adequate' to 'perfect' level of proficiency in both speaking and writing, while 86.4% of the bilingual group reported an 'adequate' to 'perfect' level of proficiency in second language reading (see Table 1). The English-German and English-Chinese samples did not differ significantly on these factors; however the English-German group was found to be significantly older when compared to the monolingual group. Details regarding which factors had contributed toward second language learning, as well as the extent to which participants have been exposed to their second language in various contexts were excluded from analysis, as over 50% of bilingual participants did not complete these sections in their entirety.

Table 1.

Means and standard deviations of participant characteristics

	Monolinguals *N*= 64 (40 males)		English-German *N*= 29 (17 males)		English-Chinese *N*=30 (15 males)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	24.2[a]	5.9	27.6[b]	5.6	25.7	6.6
% Exposure to L2	N/A		29.9[a]	18.7	27.9[a]	19.6
Age began L2 (yrs)	N/A		10.8[a]	7.1	10.32[a]	6.5
Age began reading L2 (yrs)	N/A		11.7[a]	6.8	11.6[a]	5.8
Self-rated L2 speaking proficiency (0-10)	N/A		7.4[a]	2.1	6.5[a]	2.2
Self-rated L2 reading proficiency (0-10)	N/A		7.5[a]	2.1	7.0[a]	2.3
Self-rated L2 understanding proficiency (0-10)	N/A		7.4[a]	2.3	6.5[a]	2.4
Foreign accent as perceived by self (0-10)	N/A		4.0[a]	3.2	5.0[a]	3.5
Self-rated foreign accent as perceived by others (0-10)	N/A		4.8[a]	4.0	6.5[a]	4.7

Means in the same row with different superscript letters differ from each other significantly at $p<.05$.

Table 2.
Summary of Immigration information

Country	Monolinguals *N*= 64 (40 males)		English-German *N*= 29 (17 males)		English-Chinese *N*=30 (15 males)	
	f	%	*f*	%	*f*	%
(a) Current country						
United Kingdom	19	29.7	5	17.2	8	26.7
America	17	26.6	7	24.1	7	23.3
China	3	4.7	0	0	9	30
Germany	2	3.1	12	41.3	0	0
Other*	23	35.9	5	19.9	6	20
(b) immigrants	17	26.6	18	62.1	22	73.3

*other countries include Hawaii, Norway, Switzerland, Finland, Estonia, Belgium, Taiwan, Poland, New Zealand, Japan, Canada, Iceland, Denmark and South Africa

Assessment Instruments

Subjects completed an online assessment which included the following testing tools: a demographic questionnaire, The Language Experience and Proficiency Questionnaire (LEAP-Q), The Simon Task and The Attentional Network Task (ANT).

Demographic Questionnaire

A demographic questionnaire was developed for the purposes of this study in order to obtain important participant information. Requested details included particulars regarding respondent age, gender, employment, as well as immigration data if applicable (see Appendix A). Subjects were asked to report any personal problems by indicating whether they ever had or were currently experiencing any language disabilities, hearing impairments, vision problems, learning disabilities (including ADHD) or neurological disorders such as meningitis, traumatic brain injury, epilepsy or encephalopathy. This section allowed individuals to elaborate further on the selected 'impairment', and provided opportunity for respondents to report any other deficits which may have been omitted by the researcher in the questionnaire. The information gathered here is hugely significant as such problems could influence attentional performance on cognitive tasks and consequently undermine the validity of results. The researcher therefore needed to assess the situation and determine whether a participant should be excluded from the study. The final section asked individuals whether they considered themselves to be bilingual or not, and allowed for a 'yes', 'no', or 'uncertain' response. If the 'no' response was selected, the student was directly linked to the Simon Task

and proceeded with the assessment. If however, a participant selected either of the alternate choices, he/she was required to complete the LEAP-Q before continuing with the cognitive evaluation.

The Language Experience and Proficiency Questionnaire (LEAP-Q)

Both the English-Chinese and English-German respondents were required to complete The Language Experience and Proficiency Questionnaire (LEAP-Q). This is a self-report measure developed by Marian, Blumenfeld and Kaushanskaya (2007) as a reliable and valid tool for constructing an informative bilingual profile and assessing language proficiency. Although the use of self-report questionnaires has been criticized within the research field, investigation into the validity of the LEAP-Q has revealed results which suggest that self-report measures are indicative of bilingual performance on standardized linguistic tests (Marian et al., 2007). The internal validity of the assessment has been established and replicated, suggesting that the LEAP-Q may be used as an efficient and reliable measure of bilingual language status (Marian et al., 2007).

It is however, important to consider that the LEAP-Q was edited and condensed for online administration within the current investigation. The updated questionnaire did not include questions on basic demographic details, immigration data or various problems and impairments, as these sections were covered in a demographic questionnaire completed by participants prior to presentation of the LEAP-Q. In doing so, important descriptive information could be gathered for both the monolingual and bilingual groups, and monolingual participants did not need to fill out the Language Experience and Proficiency Questionnaire.

The questionnaire itself should have taken approximately 10 minutes to complete and included a combination of open-ended, forced-choice, and likert-type scale responses. In an attempt to gain comprehensive understanding and insight into the bilingual profile, the tool focused on acquisition history, context of acquisition, present language use, language preference, and proficiency ratings across domains of speaking, understanding, and reading (see Appendix B). The present study used the speaking proficiency rating scale- which ranged from 0-10 (none-perfect) - to divide respondents into monolingual and high and low L2 proficiency bilingual groups using a cut off score of 6 (slightly more than adequate). The decision to use this particular measure reflects evidence which suggested that self-reported

L2 proficiency is the best predictor of performance on standardized L2 tests (Marian et al., 2007).

Simon Task

The Simon Task was administered to both bilingual groups as well as the monolingual group in order to assess inhibitory mechanisms as measured by stimulus-response times. The online introductory page which appeared as participants began the task included a set of instructions regarding the testing procedure. The respondent was instructed to place each index finger on a left and right shift key. It was made clear to the participant that the left key corresponds to a blue square while the right key corresponds to a red square, and that the appropriate key should be pressed as the visual presentations appear onscreen. The task then commenced when a fixation cross in the centre of the screen came into view, thus signalling the start of a trial. A blank interval followed this warning cue after which the timing measure began and either a blue or red square was presented on the left or right side of the screen. The participant needed to inhibit the natural tendency he/she had to respond to the stimulus location by ignoring the square positioning, thus paying attention to the colour alone. Once the response had been made the stimulus was terminated and the timing measure ceased- marking the end of a trial. The present study included eight practice trials (which need to be completed without error) and twenty-eight experimental trials in accordance with the experimental procedures carried out by Bailystok and colleagues in 2004. These trials were however randomized so that patterns of congruency (where the square was presented on the same side as the corresponding response key) and incongruency (where the square was presented on the side opposite to the corresponding key) remained inconsistent. The reaction time (RT) measurements observed on the differences between congruent and incongruent response latencies should reveal what has been termed the 'Simon effect', and were expected to be smaller for the English-German and English-Chinese samples- thus demonstrating a bilingual advantage (Bialystok et al., 2009). Bilingual participants were also expected to make fewer mistakes and demonstrate faster mean RT score when compared to monolingual participants.

The Attentional Network Task (ANT)

The Attentional Network Task (ANT) was developed and published by Fan, McCandliss, Sommer, Raz and Posner in 2002 as an evaluation of alerting, orienting, and executive functioning. This combination reaction cue and flanker task was administered to participants

of the current study as a computer-based experiment and should not have taken any longer than 30min to complete. The design of the experiment itself followed the procedures carried out by Fan and colleagues (2002) which have also been replicated by Costa et al. (2008). The stimuli presented to the respondents included a row of black arrows which, depending on the condition, faced right or left directions. While testing executive control, the central arrow would have pointed either in the same direction as the four flanker arrows (congruent trial) or in the opposite direction of the four flanker arrows (incongruent trial). Individual reaction times were recorded automatically, and were expected to be slower for the incongruent conditions as interference from the flankers becomes difficult to ignore- resulting in what has been termed a 'conflict effect'. The conflict effect was expected to be smaller in the bilingual groups as the inhibitory mechanisms needed to manage such interference were presumed to be more efficient (Costa et al., 2008). Throughout these trials, the participant was expected to identify the direction of the central arrow (target stimulus) by pressing the corresponding button on the keyboard as quickly as possible.

The task did however become slightly more complex with the introduction of a 'cue type' factor, where an alerting cue was presented before the target stimulus and sometimes signalled the position on the screen where the target stimulus would appear. These conditions provided insight into the alerting and orienting networks, however Fan et al. (2002) reported test-retest correlation coefficient scores of only 0.52 and 0.61 respectively. The executive control network measure does however, appear to be reliable yielding a test-retest correlation coefficient of 0.77 (Fan et al., 2002). Nevertheless, the current study explored all three of the networks and therefore required the completion of randomly presented trials across 12 experimental conditions (represented by 8 trials in each block) while individual reaction times and 'correctedness' of responses were recorded by the computer software program.

Ethical Considerations

The procedures utilized in the current investigation adhered to the standards of professional conduct as outlined by the American Psychological Association (APA). Ethical approval for the study was granted by Human Research Ethics Committee (HREC) at the University of the Witwatersrand.

Although the study posed no obvious threat to the participating individual, concern may be raised over subject well-being following completion of the assessment. While unlikely, it was possible that a respondent may have reflected upon personal performance and perceived it as

poor and problematic. Consequently, only individuals over the age of 18 were permitted to participate in the study and those younger than 18 were immediately redirected to a 'thank-you page' which briefly explained the age requirements and thanked the individual for their interest in the assessment. Unfortunately no single link could be provided for distressed individuals to follow upon completion of the tasks as participants resided in various countries around the world. The study did not however, engage respondents with any traumatizing or sensitive material and no adverse effects were expected to emerge.

Furthermore, the online participant information sheet or 'introductory page' (see Appendix C) described the assessment and its processes, thus allowing for informed consent and voluntary participation. It was also made clear to the individual that proceeding with the questionnaire constituted informed consent, and that although respondents could leave the study throughout the testing procedure, withdrawal following completion of the assessment was not permitted due to the anonymity associated with the process. In addition, confidentiality could be assured as the raw data was stored in an online, password-secure Inquisit account to which the researcher alone had access, and no individual tracking information was ever collected.

Although participants could not receive individual feedback regarding their performance on the attentional assessments (due to anonymity and confidentiality), respondents were informed that they could receive general feedback by contacting the researcher if they chose to do so.

Results

Data Analysis

Response times and the number of correct responses on both the ANT and Simon Task were treated as dependent variables throughout statistical procedures and analyzed using SPSS 20. The scores yielded from these tasks were viewed as interval while L2 proficiency levels were treated as nominal. Assumptions of normality were assessed using histograms, and equality of variance (where necessary) was checked using Levene's test. Throughout proceedings, parametric tests were used where possible and if the appropriate assumptions were not met, non-parametric alternatives were utilized.

Initial statistical procedures included the overview of frequency tables and distributions and several outliers were excluded from the subsequent analyses- which focused on comparing

RT scores and number of correct responses between monolingual and bilingual samples. Statistical procedures addressing the various hypotheses first compared the English-German, English-Chinese and monolingual groups, however if no significant differences were found the two bilingual groups were combined into a single sample and similar statistical tests were repeated.

Differences between the RT scores and number of correct responses on both congruent and incongruent trials of the Simon task were evaluated using ANOVAS and t-tests (and the Kruskal Wallis where parametric assumptions were not met). The data yielded by the ANT was analyzed using a variety of procedures. Firstly, where normal distributions of the ANT scores were observed, a two-way ANOVA was conducted with three dependent variables: 'cue type' and 'flanker type' as within subject factors, and 'group of participants' as the between-subject factor. A series of ANOVAs and t-tests were also conducted to contrast RT scores and the number of correct responses across the various cue type and trial conditions.

All these analyses were conducted repeatedly and were run on two sets of data: the first which included non-proficient bilingual participants and the second which did not.

General analyses

Various responses to the brief demographic questionnaire and the LEAP-Q were assessed in order to determine whether the monolingual and bilingual samples were significantly similar to, or different from each other. The findings of these procedures may be found in Table 1 where it is indicated that no significant differences existed between the samples across the following variables: percentage of exposure to L2; age participant began learning L2; age participant began reading L2; self-rated L2 proficiency in speaking, reading and understanding; foreign accent as perceived by self; self-rate foreign accent as perceived by others.

Results did however reveal that although the two bilingual samples did not differ in any way, the English-German (M= 27.63, SD= 5.6) group was significantly older then the monolingual English group (M= 24.22, SD= 5.9); F= -3.42, p= .03. Nevertheless, the mean age of all three samples remained beneath 30 years and within the 'young adult' division, and subsequently, all three samples were compared.

The Simon Task

Reaction Time: Latency scores on both the congruent and incongruent trials were normally distributed for all three groups. Levene's Homogeneity of variance test did however, suggest that variances were unequal and a Kruskal Wallis test was conducted to assess differences in scores between the monolingual, English-German, and English-Chinese groups. Results did not reveal significant difference on either the congruent and incongruent trials, and consequently, the two bilingual groups were combined to form a larger sample for further analysis.

An independent samples t-test was conducted to compare response times between the monolingual and bilingual samples on congruent trials, and results revealed significantly lower means for the bilingual group (M= 428.37, SD= 50.35) when compared to the monolingual group (M= 450.62, SD= 66.95); $t(117)$= -2.11, p= .037, d= .46. A subsequent independent samples t-test compared the same two groups on the incongruent trials of the Simon Task, and results revealed significant difference between the scores. The bilingual sample (M= 451.66, SD= 42.76) performed faster than the monolingual sample (M= 479.16, SD= 69.52); $t(105)$= -2.67, p= .009, thus suggesting a bilingual advantage which may demonstrate a more developed inhibitory control mechanism (see Figure 1 and Table 3 for a summary of the results).

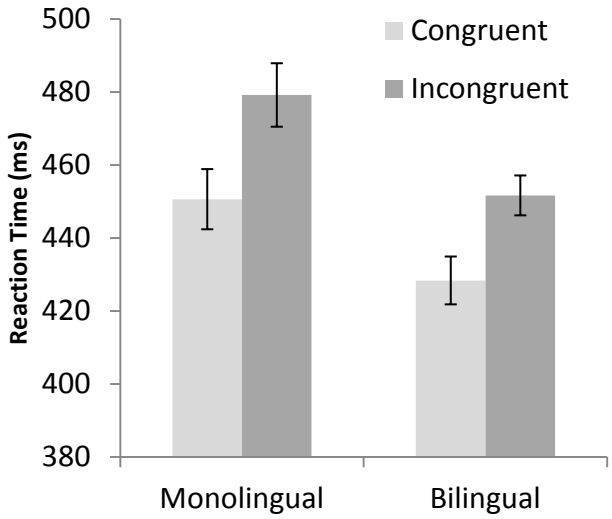


Figure 1. *Mean reaction time (in milliseconds, ms) for bilingual and monolingual participants on both congruent and incongruent trials. Error bars represent standard error.*

The differences between congruent and incongruent response latencies (termed the Simon effect) were calculated for each individual and compared across English-German, English-Chinese, and monolingual English samples. Differences were not found to be significant between any of these groups, and this did not change once the two bilingual samples had been collapsed into a single group (as seen in Table 3).

Table 3.

Mean reaction times (RT) and standard deviations on the Simon Task

	Monolingual (*N*= 64)	Bilingual (*N*= 59)	*t*	*df*
Congruent	450.62	428.37	-2.11*	117
	(66.95)	(50.35)		
Incongruent	479.16	451.66	-2.67**	105
	(69.52)	(42.76)		
Simon Effect	28.46	23.29	-.602	121
	(50.77)	(43.85)		

*Note.**=*p*<.05, **=*P*<.01 Standard deviations appear in parenthesis below means

Correct responses: Significant results were also found for the number of correct responses on incongruent trials, where the English-Chinese participants (*M*= 12.76, *SD*= 1.22) scored higher than the English-German (*M*= 12.17, *SD*= 1.33) and monolingual English participants (*M*= 11.91, *SD*= 1.84) (see Table 4). These results reveal that monolingual and English-German bilingual individuals made more errors where inhibitory control was required (when compared to English-Chinese bilingual individuals). No significant differences were found between the groups on congruent trials, and this remained unchanged despite further comparison which included a single, combined bilingual sample.

Table 4

Mean number of correct responses and standard deviation on Simon Task

Incongruent trials	Monolinguals *N*= 64	English-German *N*= 29	English-Chinese *N*=30	*F*	*df*
Mean	11.91 (1.84)	12.17 (1.33)	12.76 (1.22)	2.851*	2

*Note.**=*p*<.05, Standard deviations appear in parenthesis below means

L2 level of proficiency: The small sample size and lack of variability in the current study did not allow for comparison of attentional functioning between proficient and non-proficient bilinguals. 81.8% of the bilingual sample reported a level of L2 speaking proficiency ranging from and 'adequate' to 'perfect, while only 18.2% reported a level of L2 speaking proficiency ranging from 'low' to 'slightly less than adequate'. Consequently, the subsequent analyses excluded those who were identified as non-proficient and compared attentional functioning between proficient bilinguals and monolinguals. The remaining English-German and English-Chinese participants were combined into a single proficient bilingual group in order to form a sample large enough for statistical comparison.

Reaction Time: Parametric tests were used to compare response latencies as the reaction time scores on both the congruent and incongruent trials were normally distributed. An independent samples t-test revealed significantly faster reaction times for the proficient bilinguals as opposed to the monolinguals on both congruent and incongruent trials. A summary of these results is presented in the table below (Table 5). The Simon effect was however, found to be similar across samples.

Table 5.

Mean reaction times (RT) and standard deviations on the Simon task

	Monolingual (*N*= 64)	Proficient Bilingual (*N*= 48)	*t*	*df*
Congruent	450.62	424.02	-2.09*	121
	(65.88)	(49.24)		
Incongruent	479.08	440.63	-2.62**	121
	(69.52)	(33.04)		
Simon Effect	28.49	16.611	-6.02	121
	(50.78)	(45.39)		

*Note.**=$p<.05$, **=$P<.01$ Standard deviations appear in parenthesis below means

Although the latency scores of the proficient bilingual group were slightly faster than the latency scores of the bilingual group which included the non-proficient bilingual participants, this difference was not found to be statistically significant.

Correct responses: Independent samples tests did not find the number of correct responses to differ significantly between proficient bilingual and monolingual samples on either congruent or incongruent trials, and consequently, the present findings provide only limited support for the 'bilingual advantage' proposed by previous research within the field.

The Attentional Network Task

Response latencies and number of correct responses were normally distributed for all three groups and were treated as dependent variables in several analyses aimed at addressing the considerations put forward in this study. Statistical procedures focused on assessing the three attentional networks (executive, alerting and orienting) independently, and between the monolingual and bilingual samples.

Analysis of the executive network (as indexed by the 'conflict effect' which compares response latencies to congruent and incongruent trials) revealed results which suggest that the difference between congruent and incongruent trials did not differ significantly between the groups. The alerting effect (no cue vs. double cue trials) and the orienting effect (centre cue vs. spatial cue) were also found to be similar between the samples. No significant results were revealed throughout statistical procedures which compared both reaction time performance and number of correct responses on the cue and flanker conditions between the bilingual and monolingual groups. Although bilingual participants did score slightly better on various trials throughout the task, none of these differences were found to be statistically significant. The lack of findings contradicts expectations which have been put forward in this study upon the considerations of previous literature. Nevertheless, a summary of the response latencies may be found in Table 4.

Table 4.

Mean reaction times (RT), with standard deviations in parenthesis, for bilingual and monolingual participants on the ANT

	Flanker Type		Cue Type			
	Congruent	Incongruent	None	Double	Centre	Spatial
Monolingual	324.73	330.94	336.78	322.2	327.18	319.97
N= 64	(106.33)	(112.58)	(115.5)	(110.38)	(107.35)	(107.48)
Bilingual	305.19	324.64	317.57	309.06	320.79	303.61
N= 59	(78.29)	(89.89)	(85.03)	(87.17)	(85.74)	(77.36)

L2 level of proficiency: Further analysis assessing the differences in performance between the monolingual and bilingual samples included a comparison between monolinguals and bilinguals who were identified as proficient in their second language. No significant findings were revealed through an analysis of either the response latencies or number of correct response for the alerting, orienting and conflict effects. These results suggest that bilingual persons do not demonstrate enhanced inhibitory control even when non-proficient participants are excluded from analysis.

Discussion

The present investigation addressed considerations which suggest that bilingual individuals demonstrate enhanced nonverbal cognitive processing (within the alerting, orienting and executive attentional networks) when compared to monolingual individuals. Previous research has yielded evidence in support of this hypothesis, yet these results remain inconsistent and require elucidation. Linguistic distance and second language proficiency were consequently included within the current study as variables which could potentially influence the relationship between bilingualism and the attentional network. In doing so, it was hoped that details regarding the precise nature of this relationship could be understood to a greater degree, particularly as attention itself was treated as a multidimensional construct and analysis focused on various components within the attentional network. These components included executive, alerting and monitoring mechanisms and were compared across all bilingual and monolingual samples. An overview of the existing literature informed the expectations proposed within the current study and suggested that bilingual participants would demonstrate enhanced attentional functioning across all components, and would therefore outperform monolingual participants on both the Simon and ANT tasks. In addition, it was expected that attentional performance would be stronger in English-German individuals who reported higher levels of second language proficiency. The findings of the present study do not unequivocally support the proposed hypotheses, and provide only limited evidence for the 'bilingual advantage' which has been demonstrated in previous investigations. These results do however, offer several contributions toward both theoretical and methodological concerns within the field of language use and cognitive functioning.

Attentional Functioning

The Simon Task: Green's (1998) model of inhibitory control provides a framework for understanding the findings revealed through both the Simon and ANT tasks. According to

this model, bilingual individuals are constantly required to manage the simultaneous activation of two languages, and consequently utilize the attentive mechanisms which are part of the executive control system to perhaps, a greater degree than monolingual individuals who are not confronted with a similar 'attention problem'. Assumptions supported by the existing body of literature suggest that this phenomenon leads to a strengthened executive control system in bilingual persons, which may manifest in superior performance on non-verbal attentional tasks.

Results of the current investigation should have therefore found faster reaction times, fewer errors, and smaller conflict effects for bilingual participants, and slower reaction times, more errors and larger conflict effects for monolingual participants. The hypotheses proposed in this study suggest that these results would be evident across both congruent and incongruent trails. Significant differences in reaction time scores on both congruent and incongruent trials of the Simon Task were evident between the monolingual and bilingual samples, where bilingual participants performed faster than the monolingual participants (the moderate effect size indicated by Cohen's d suggests that this difference is important). These findings reflect existing literature which suggests that bilingualism is beneficial to attentional functioning particularly within the executive network, and replicate the results of numerous investigations and literary reviews (Adesope et al., 2010; Bialystok et al., 2005; Bialystok et al., 2009; Bialystok et al., 2011).

While superior performance by bilingual persons on incongruent trials of the Simon Task may be understood through the assumptions provided by Green's IC model, it is important to consider the fact that bilingual participants also outperformed monolingual participants on congruent trials. These trials do not engage inhibitory mechanisms, and would therefore be expected to reveal similar reaction times for both monolingual and bilingual persons. Similar results were found in an investigation conducted by Costa and colleagues (2008) who suggest that this observation exists only when incongruent trials are included within the task, and that the effect disappears when congruent trials are presented alone. According to this supposition, the requirement of cognitive control for conflict resolution affects trials even where such resources are not needed (Costa et al., 2008). These insights (as well as the results yielded by the present investigation) suggest that although bilingualism may be beneficial to attentional functioning on tasks which require inhibitory control, this effect may exist beyond such tasks under certain conditions.

Although thus far evidence from these results demonstrates a 'bilingual advantage', it is important to acknowledge that the difference between congruent and incongruent response latencies, or the Simon effect, was not significant when compared across bilingual and monolingual samples. This finding contradicts the results of previous research and suggests that all participants experienced similar levels of conflict and interference. More specifically, because the Simon effect was not smaller for bilingual participants (as expected), this study cannot conclude and report that bilingual persons demonstrate 'more-developed' inhibitory control mechanisms when compared to monolinguals. Perhaps the inclusion of a larger sample would have revealed significant differences, particularly as mean scores for the Simon effect were smaller (although statistically insignificant) in the bilingual group as opposed to the monolingual group. Nevertheless, results revealed by reaction times on the Simon task provide only partial and limited support for the considerations put forward in this study- which suggest that bilingual participants demonstrate superior inhibitory control on non-verbal cognitive tasks.

The 'number of correct responses' on congruent and incongruent trials of the Simon Task were also compared across bilingual and monolingual samples, with fewer errors indicating enhanced inhibitory control. The number of correct responses differed significantly on incongruent trials between the English-Chinese and monolingual English group (where the English-Chinese participants made fewer errors), however no differences were found between the English-German and monolingual English samples. Although these results provide support for the 'bilingual advantage' proposed by previous investigations, this support is limited due to the fact that the attentional benefits displayed by correct responses were only significant for one of the two bilingual groups. Although this may provide insight into the influence linguistic distance may have on the relationship between bilingualism and attentional functioning, it is important to acknowledge that discussion of the previous analyses did not include reflection on differences between the two bilingual groups as none were found to be significant. English-German participants were expected to outperform Chinese-English participants as the English and German languages are more similar to each other and present greater need for conflict resolution. The results do however demonstrate superior executive functioning amongst those respondents who speak grammatically distinct languages, suggesting that the complexity of processing the competition between such languages may enhance inhibitory mechanisms. It is important for future researchers to assess models of attention across bilingual persons who have either distinct or similar L1 and L2

languages. Interestingly, the fact that no differences existed between the English-German and English-Chinese participants on response times implies that the mechanisms that are specific subcomponents of the executive network may be affected by linguistic distance, rather than the entire network itself.

The overall findings revealed by results of the Simon task suggest that bilingual individuals do experience a degree of enhanced executive functioning; yet these results remain somewhat uncertain, and do not wholly reflect the findings of previous research within the field. The inconsistency in these differences does suggest that the differences between bilingual and monolingual executive functioning (specific to inhibitory control) may be more qualitative than quantitative in nature and that superior performance may exist within a subcomponent of inhibitory control.

The current investigation did however; also include the ANT (which participants completed after the Simon Task) with the aim of investigating functioning of the executive, alerting and orienting attentional components. It was hoped that in doing so, the findings presented through the results of the Simon task could be reaffirmed and the independence of the three networks could be tested.

The ANT: Existing literature suggests that the 'bilingual advantage' experienced by bilingual individuals should enhance performance on non-verbal attentional tasks such as the ANT (Costa et al., 2008). Consequently, the executive network (which monitors and resolves conflict and represents a component of the attentional process) should be more efficient in bilingual as opposed to monolingual individuals. The current investigation did not however, find any significant difference in performance between bilingual and monolingual participants as indicated by response latencies or 'number of correct responses'. More specifically, no differences were evident in the assessment of the conflict effect, thus suggesting that bilinguals did not suffer less interference from congruent flankers when compared to monolinguals- contrary to what was predicted. Furthermore, the alerting and orienting network effects were similar between samples, thus indicating that alerting and orienting cues were no more beneficial to the bilingual group than they were to the monolingual group. Ultimately, these results do not suggest that bilingualism enhances functioning of the executive, alerting or orienting networks.

These findings should however, be interpreted with caution. It is important to acknowledge the fact that while no differences of the effects existed between the groups, the effects

themselves were also not found to be significant. In other words, performance on congruent trials was not significantly faster than performance on incongruent trails, and performance on trials preceded by a spatial cue was not significantly faster than for those preceded by a central cue. Similarly, performance on trials preceded by a double cue was not significantly faster than for those preceded by no cue. These results were found for each monolingual and bilingual group, and are contradictory to both previous research, and the expectations proposed in the present study.

Although this issue cannot be addressed with certainty, it is possible that the sampling procedures adapted in the current investigation heavily influenced responses to this particular task. The ANT includes 288 trials across 12 experimental conditions, and completing the task in its entirety may be both frustrating and lengthy. Consequently, the incentivized nature of this study (which included individuals who were not engaged with on a personal level) may have resulted in extremely rushed responses and consequently, extremely fast reaction times. It is also likely that participants may not have completed the task within a distraction free environment, and the nature of this study did not allow the researcher to monitor such situations. Interestingly, an overview of response latency scores revealed in the current investigation and those revealed by another investigation conducted by Costa and colleagues (2008) (which also included a sample of young adults) suggests that the incentivized online nature of this study may have influenced reaction time scores- where participants seemed to be more rushed with their responses.

Linguistic Distance

The linguistic distance between two bilingual languages was included within the current investigation as a variable which could potentially influence the effects bilingualism may have on alerting, orienting and executive components of attentional functioning. Comparisons between the English-German and English-Chinese groups were included throughout statistical procedures, however where no differences were found, the groups were combined to form a single bilingual sample (and subsequently compared to monolingual participants). Following an overview of the existing literature, this study expected to observe enhanced attentional functioning specifically within the executive network responsible for conflict resolution, amongst English-German participants (as the linguistic distance between English and German is smaller than that between English and Chinese). Previous research supported by neuroimaging evidence has suggested that the understanding and reading of Chinese may

require different cognitive processes than those required for the understanding and reading of English and other similar languages (Tan, Spinks, Feng, Siok, Perfetti, Xiong & Gao, 2003). The framework provided by this proposition implies that individuals engaging with two languages which differ from each other greatly will not experience as much cognitive 'competition' as those engaging with two similar languages (and will therefore have a 'smaller' bilingual advantage).

A review of the results revealed by this study does not however, provide evidence in support of the considerations which have been put forward. Linguistic distance was not particularly influential throughout the assessment as the only significant difference found between English-German and English-Chinese groups was that which compared the number of correct responses on the incongruent trials of the Simon Task (where the English-Chinese participants made fewer errors). No differences were found between the English-German and monolingual English samples. Furthermore, no differences were found between reaction time scores when English German and English-Chinese participant performances were compared. Although these results may reflect sampling variability, the English-Chinese and English-German participants did not differ significantly across various factors including: age, age of exposure to L2, age of initial learning/reading of L2, self-rated proficiency levels in speaking, reading and understanding of L2, and self-rated accent perception by self and others. The English-German group was however, slightly older than the monolingual English sample- a characteristic which may or may not have, resulted in slightly higher error rates. Alternatively, this finding may imply that although bilingual individuals demonstrate enhanced inhibitory control in terms of speed, those who speak two grammatically distinct languages are more competent at this process.

Although the evidence provided by the results of the current study is not strong enough to suggest that linguistic distance represents an important influencing variable in the relationship between bilingualism and all the attentional networks proposed by Posner, it does suggest that linguistic distance may affect the competency of a sub-mechanism of the inhibitory control process. The lack of results demonstrated through reaction times is however consistent with several studies which demonstrate that bilingual experiences influence attentional functioning regardless of the linguistic distance between the two languages. In combination with these insights, the results revealed by this investigation propose that differences in cognitive functioning that result from linguistic distance may be qualitative rather than quantitative in nature, and should be explored further in studies which

are able to include neuroimaging data. Furthermore, these studies should focus on comparing neural activity between respondents who speak different languages while they demonstrate correct ad incorrect responses.

Language Proficiency

Although language proficiency has been explored in previous investigations, researchers typically include a sample of bilingual participants who are fluent in both languages (Luk et al., 2011). The current investigation aimed to compare attentional functioning amongst the alerting, orienting and executive networks between individuals who were either proficient or non-proficient in their second language, and expected the proficient bilinguals to demonstrate enhanced performance on both the ANT and Simon Tasks. The final sample did not however include enough non-proficient bilingual participants to allow for such comparisons and consequently, several analyses were conducted which either included or excluded these individuals.

Outcomes of the analytical procedures which included both the proficient (81.8%) and non-proficient (18.2%) participants have already been discussed, and although several significant findings were revealed, these findings do not appear to provide unequivocal support for the considerations proposed in the current study. Consequently, subsequent analyses excluded those participants who were identified as non-proficient in their second language and focused on investigating the relationship between bilingualism and attentional functioning within the proficient bilingual group. As previous research postulates that a higher level of L2 proficiency is associated with greater attentional benefits, performance scores on both the ANT and Simon tasks were expected to be better for the proficient bilingual group (and worse for the monolingual group). The results were however, statistically similar to those revealed by analyses which included both proficient and non-proficient bilingual individuals.

Although these findings suggest that L2 proficiency levels may not influence the relationship between bilingualism and attentional functioning, this conclusion cannot be drawn with any degree of certainty due to the small number of non-proficient bilinguals included in the sample. These results do however; suggest that bilingual participants with high levels of L2 proficiency do not demonstrate enhanced functioning within the alerting and orienting networks when compared to monolingual participants. Furthermore, limited and partial evidence does exist to suggest that participants with high levels of L2 proficiency may

experience a strengthened inhibitory control mechanism which is advantageous to performance on non-verbal attentional tasks that require conflict resolution.

Conclusion

Ultimately, the findings revealed throughout this study provide only limited support toward assumptions suggested by research concerned with language use and attentional functioning. The 'bilingual advantage' that was expected to manifest in superior reaction times and smaller conflict effects was only partially evident in the Simon Task (and not at all evident in the ANT). Although there is some evidence to suggest that young bilingual adults with high levels of L2 proficiency do demonstrate enhanced inhibitory control (on both congruent and incongruent trials of tasks which require conflict resolution), these findings are not supported by results from the ANT or by differences in the Simon effect and remain inconclusive. Furthermore, the results of this study do not replicate previous findings which propose that bilingualism is beneficial to the functioning of alerting and orienting components within the attentional network. It is however, important to acknowledge that the inconsistencies evident in these results may represent the sampling methodology adapted by the current study which incentivized participants who completed the assessment, and did not allow for researcher control over environmental factors which may have been influential throughout the testing process.

Nevertheless, the results of this research suggest that smaller differences between two bilingual languages do not necessarily indicate higher levels of 'cognitive competition', nor do they indicate enhanced attentional functioning- as previously proposed. Alternatively, a larger linguistic distance between two bilingual languages may influence the functioning of the executive network, where more competent and precise performance is demonstrated. Perhaps these effects are more qualitative than quantitative in nature, and it may not be beneficial to focus on linguistic distance as a variable in investigations which do not include insight provided by neuroimaging evidence.

Limitations and Recommendations

Despite the conclusions which have been drawn, several limitations and recommendations surrounding the theoretical and methodological considerations of this study should be addressed:

- The lack of random independent sampling resulting from the purposive and convenient sampling strategy employed in this study may introduce bias into the results. By using Global Survey Market and including individuals who form part of their international database, it is likely that participants differed across a number of important characteristics (such as socio-economic status and level of education). Previous research has revealed that SES may influence the relationship between language use and attentional functioning, and consequently, the current study cannot claim that the results which have been revealed were not subject to such influence. Future researchers should aim to include a more homogenous sample which does not differ on such important factors, and it is important that sufficient participant information is collected and reported within the investigation.
- The incentivization of participation may have introduced bias into the results as unknown significant factors (such as personality characteristics) could have influenced respondent performance and altered findings. Furthermore, it is probable that certain individuals rushed through the assessment in order to obtain the monetary reward. This is evidenced by the relatively fast response latencies on the ANT and the large number of missing data within the LEAP-Q. Future researchers should not incentivize participation in studies which aim to assess attentional functioning, as individuals who are not genuinely interested in the study may complete the attentional tasks in a manner which may not be reflective of their typical performance.
- The lack of control over the testing environment is an important issue characteristic of online research which may influence the nature of the data. Although participants were asked to complete the ANT and Simon Task within a distraction free environment, the researcher could not ensure that this requirement was met. Individuals who were distracted while completing an attentional task may have demonstrated inferior performance when compared to those individuals who did not experience similar distraction. Furthermore, without researcher control there is no guarantee that the person completing the assessment is in fact who they are claiming to be. Researchers who wish to evaluate attentional performance should aim to have some degree of control over the testing environment. Conducting such research in a remote online setting may not be the best method for collecting this type of data, particularly as the authenticity and reliability of results may be undermined.

- It is likely that the lengthy nature of the current assessment introduced a level of fatigue and frustration which ultimately undermined attentional functioning (particularly on the ANT). This is evidenced by the relatively fast response latencies on the ANT and by the large amount of missing data in the LEAP-Q. Furthermore, the LEAP-Q was developed within an American context and may not have been appropriate to various populations across several countries. Future researchers should not include the LEAP-Q together with a lengthy cognitive task within a single assessment. If however, the LEAP-Q is included, it should be piloted and adapted so that it is appropriate to the population which will be included in the investigation.
- Although the findings of this study provide a quantitative contribution toward existing literature, they do not in themselves demonstrate how the effects occur and make no comparisons between varying levels of language experience, use and proficiency (due to sample size limitations). Future research should aim to understand the precise nature of the relationship between bilingualism and attentional functioning by assessing the influence of factors such as L2 language proficiency and daily L2 use. Where possible, researchers should include evidence from MEG data so as to better understand the more qualitative aspects of quantitative effects. This is particularly relevant to studies which choose to investigate linguistic distance and include bilingual groups with different bilingual languages.

Acknowledgements

The research reported in this paper was funded by the researcher (Miss Sylwia Wierzbicki) and supervisor (Mrs Aline Ferreira Correia). I wish to thank Mrs Aline Ferreira Correia for her contribution in funding, discussing and editing. I am grateful to Mr Dean Marais for technical assistance with the study

Reference List

Adesope, O.O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research, 80,* 207-245. doi:10.3102/0034654310368803

Bialystok, E. (2011). Reshaping the mind: The benefits of bilingualism. *Canadian Journal of Experimental Psychology, 65,* 229-235. doi: 10.1037/a0025406

Bialystok, E., Craik, F.I.M., Grady, C., Chau, W., Ishii, R., Gunji, A., & Pantev, C. (2005). Effect of bilingualism on cognitive control in the Simon task: evidence from MEG. *Neuroimage, 24,* 40-49. doi: 10.1016/j.neuroimage.2004.09.044

Bialystok, E., Craik, F.I.M., Green, D.W., & Gollan, T.H. (2009). Bilingual minds. *Psychological Science in the Public Interest, 10,* 89-129. doi: 10.1177/1529100610387084

Bialystok, E., Craik, F.I.M., Klein, R., & Viswanathan, M. (2004). *Psychology and Aging, 19,* 290-303. doi: 10.1037/0882-7974.19.2.290

Chiswick, B.R., & Miller, P.W. (2005). Linguistic distance: A quantitative measure of the distance between English and other languages. *Journal of Multilingual and Multicultural Development, 26,* 1-11. doi: 10.1080/14790710508668395

Chomsky, N. (2002). Language and the Brain. In A. Belletti, & L. Rizzi (Eds.), *On Nature and Language* (pp. 80-85). London, United Kingdom: Cambridge University Press.

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

Desimone, R., & Duncan, J. (1995). Neural Mechansims of Selective Visual Attention. *Annual Review of Neuroscience, 18,* 193-222. doi: 10.1146/annurev.ne.18.030195.001205

Fan, J., McCandliss, B.D., Sommer, T., Raz, A., & Posner, M.I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14,* 340-347. doi: 10.1162/089892902317361886

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

Hakuta, K., & Diaz, R.M (1985). The relationship between degree of bilingualism and cognitive ability: A critical discussion and some new longitudinal data. In K.E. Nelson (Eds.), *Children's Language, Vol.5* (pp.320-344). Hillsdale, NJ: L.Erbleum.

Lu, C.H., & Proctor, R.W. (1995). The influence of irrelevant location information on performance: A review the Simon and spatial Stroop effects. *Psychonomic Bulletin and Review, 2,* 174-207. doi: 10.3758/BF03210959

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,* 1-8. doi: 10.1017/S1366728911000010

Marian, V., Blumenfeld, H.K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire-Q (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research, 50,* 940-967. doi.1092-4388/07/5004-0940

Morton, J.B., & Harper, S.N., (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10,* 719-726. doi: 0.1111/j.1467-7687.2007.00623.x

Okuniewska, H. (2007). Impact of second language proficiency on the bilingual Polish-English stroop task. *Psychology of Language and Communication, 11,* 49-63.

Perani, D., Paulesu, E., Sebastián-Gallés, N., Dupoux, E., Dehaene, V.B., Cappa, S.F., Fazio, F., & Mehler. (1998). The bilingual brain: Proficiency and age of acquisition of the second language. *Brain, 121,* 1841-1852. doi: 10.1093/brain/121.10.1841

Posner, M.I., & Peterson, S.E., (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* 25-42. doi: 10.1146/annurev.neuro.13.1.25

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. doi: 10.1017/S1355617711000580

Raz, A., & Buhle, J. (2006). Typologies of attentional networks. *Neuroscience Nature Reviews, 7,* 367-379.

Raz, A., (2004). Anatomy of attentional networks. *Anat. Rec, B New.Nat, 281,* 21-36.

Segalowitz, N., & Frenkiel-Fishman, S. (2005). Attention control and ability level in a complex cognitive skill: Attention shifting and second-language proficiency. *Memory & Cognition, 33*, 644-653. doi: 10.3758/BF03195331

Appendix A: Brief Demographic Questionnaire

1. **Please complete the following demographic information:**

Age:_____

Gender:_____

Country of residence: _____

2. If you did not always live in the country you were living in, when did you move there?

_____

3. If you have ever lived in another country, please provide name of country and dates of residence:

_____

_____

_____

4. Have you ever experienced any of the following problems (Check all applicable)

☐ vision problem

☐ hearing impairment

☐ language disability

☐ learning disability (including ADHD)

☐ neurological disorder (such as meningitis, traumatic brain injury, epilepsy, encephalopathy)

☐ If yes, please explain (include any other problems and describe any treatments or medication you are taking)

_____

_____

_____

_____

4. **Do you consider yourself to be bilingual?**

☐ yes

☐ no

☐ uncertain

Appendix B: The Language Experience and Proficiency Questionnaire (Leap-Q)

1. **Please list all the languages you know in order of which you know best to which you know least:**

Language A: _____

Language B: _____

Language C: _____

Language D: _____

Language E: _____

2. **Please list all the languages you know in order of which you learnt first:**

Language A: _____

Language B: _____

Language C: _____

Language D: _____

Language E: _____

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

Language A:_____ _____

Language B:_____ _____

Language C:_____ _____

Language D:_____ _____

Language E:_____ _____

7. **If you had access to writing available in all your languages, in what percentage of cases would you choose to read it in each of your languages? (Your percentages should add up to 100%)**

Language A:_____ _____

Language B:_____ _____

Language C:_____ _____

Language D:_____ _____

Language E:_____ _____

8. **When choosing a language to speak with a person who speaks all your languages well, what percentage of time would you choose to speak each language? (Your percentages should add up to 100%)**

Language A:_____ _____

Language B:_____ _____

Language C:_____ _____

Language D:_____ _____

Language E:_____ _____

10. **Language: Language X**

This is my (please select from scroll down menu: First, second, third etc.) language.

All questions below refer to your knowledge of language X

(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) Please rate to what extent you are currently exposed to this language in the following contexts:

Interacting with friends _____

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

Interacting with family _____

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

Watching tv _____

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

Listening to radio/music _____

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

Reading _____

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

Self-instruction _____

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

Internet _____

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

(4) In your perception, how much of a foreign accent do you have in this language?

_____

0	1	2	3	4	5	6	7	8	9	10
None	Almost None	Very light	Light	Some	Moderate	Considerable	Heavy	Very heavy	Extremely heavy	Pervasive

(5) Please rate how frequently others identify you as a non-native speaker based on your accent in this language:

_____

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

Appendix C: Online Introductory Page (Participant information Form)

School of Human & Community Development
Faculty of Humanities
University of the Witwatersrand
Private Bag 3, WITS, 2050
Tel: (011) 717 4500 Fax: (011) 717 4559

Hello, my name is Sylwia Wierzbicki, and I am currently conducting research for the purpose of obtaining my Masters in Psychology by Coursework and Research Report at the University of the Witwatersrand, South Africa. My research focuses on the relationship between bilingualism, monolingualism and attention. I would like to invite you to participate in this study.

Your participation is strictly voluntary and you will not be advantaged or disadvantaged by choosing to participate or not to participate in this study in any way. You are also free to withdraw from the study at any time during data collection with no negative consequences.

Participation in this study will require you to complete an online survey, consisting of two questionnaires and two cognitive tasks which should take no longer than 40 minutes to complete. Although you may take breaks throughout the assessment, please ensure that you are not distracted in any way while completing the two cognitive tasks. Your confidentiality may be assured as all the raw data will be kept secure and will only be made available to the researcher. Furthermore, your response cannot be matched to your person and no individual results will be reported. Please note that proceeding with the questionnaire constitutes informed consent.

Once the study has been completed, the results will be reported in a research report and will be submitted for publication in an accredited psychological journal. Although no personal feedback will be provided due to the anonymity and confidentiality associated with this study, if you would like a summary of the results, you are welcome to email the researcher at sylwiawits22@gmail.com with the subject “study feedback’. Feedback will then be emailed to you.

Your participation in this study would be greatly appreciated. This research will provide information that may be useful in understanding the important connection between language use and attention.

Kind regards,
Sylwia Wierzbicki

Contact Details:
Sylwia Wierzbicki- email:sylwiawits22@gmail.com
Mrs Aline Ferreira Correia (supervisor) - email: Aline.FerreiraCorreia@wits.ac.za

Before proceeding with the assessment please ensure that the following condition has been met:

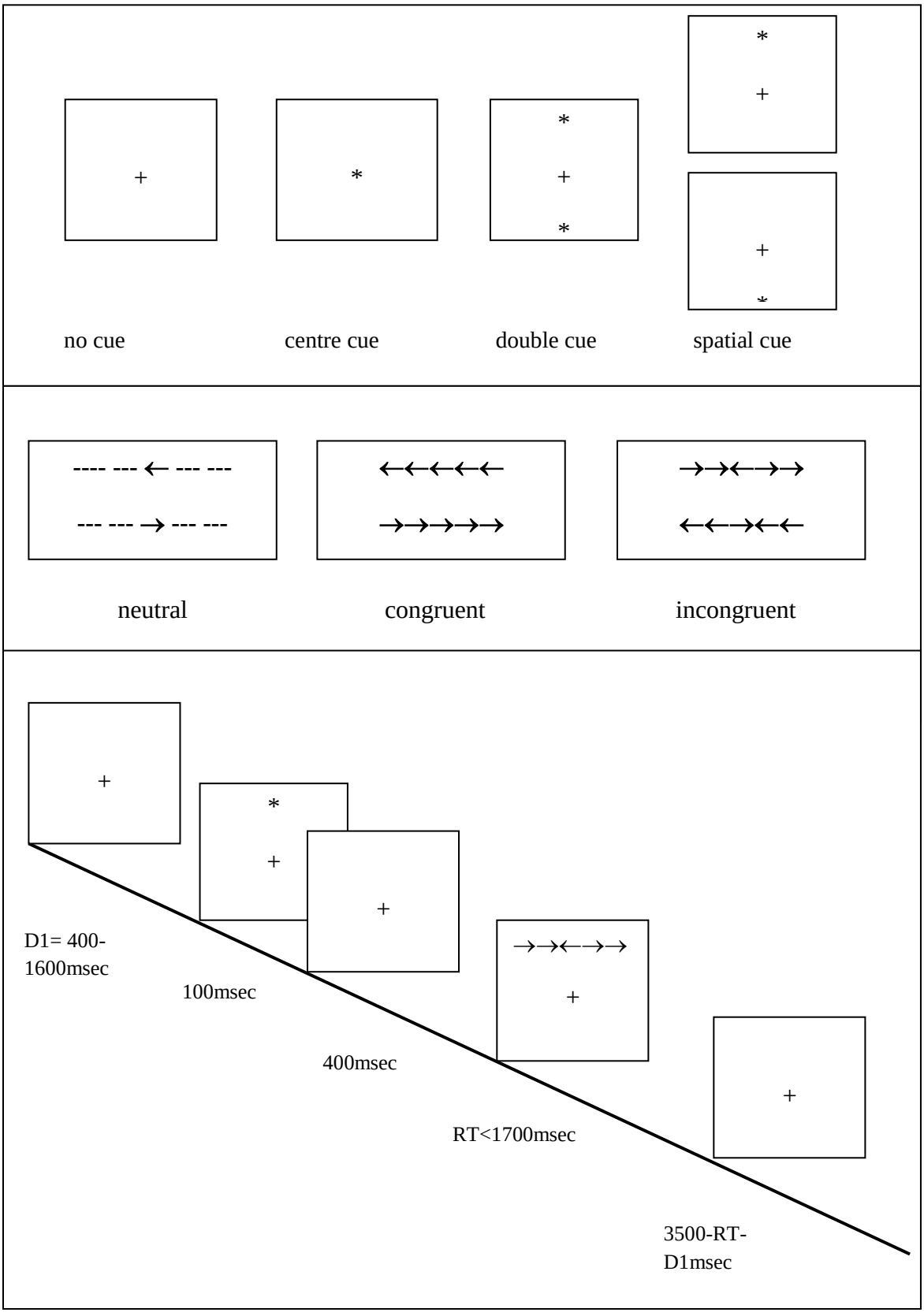
- ☐ I am currently alone and in an environment where I will not be interrupted for the next 40 minutes

Appendix D: Schematic Representation of the ANT

a) The four cue conditions

b) Examples of the stimuli

c) Examples of the procedure



Appendix E: email correspondence for ethical approval on methodological change

Sylwia Wierzbicki <sylwy22@gmail.com>

to Kate.Cockcroft

Dear Dr Cockcroft,

I am busy completing my masters in research psychology and I have received ethical clearance for my study which focuses on bilingualism and cognitive functioning. I am changing my sample and was advised by Gillian that I inform ethics of the changes. I am not sure if you are the person to speak to, if not, could you please direct me to the relevant authority.

Initially I was collecting data through an online survey which was to be completed by high school students. Due to the low response rates I cannot reach my target and my supervisor (Mrs Aline Ferreria Correia) and I have decided to use an online paid survey service (global market survey) to collect the data.

I was told that I would not need to reapply for ethics as I was initially working with children and am now working with adults. As the survey will be sent to individuals from around the world, it will be stated in the introductory page that proceeding with and completing the online survey will constitute informed consent.

Regards,
Sylwia Wierzbicki

Kate Cockcroft
<Kate.Cockcroft@wits.ac.za>

Dear Sylwia

You have reached the right person. I will add this email to your research application – just to indicate that there has been a slight change in method. You can go ahead with your research.

Regards

Kate

From: Sylwia Wierzbicki [mailto:sylwy22@gmail.com]
Sent: 15 October 2012 11:38 AM
To: Kate Cockcroft
Subject: research ethics