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Final Year Project

Does the bilingual experience influence task-switching and inhibition ability in the executive functioning of children?

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Dissertation submitted in partial fulfilment of the requirements of Cardiff Metropolitan University for the degree of Bachelor of Science.
Declaration

I hereby declare that this dissertation is the result of my own independent investigation under the supervision of my tutor. The various sources to which I am indebted are clearly indicated. This dissertation has not been accepted in substance for any other degree, and is not being submitted concurrently for any other degree.
Acknowledgements

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I would like to thank both schools and all the participants for taking the time to participate in my project.

***

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I would not have done it without you!

***

I would also like to thank my buddies [Name] and all the other wonderful people I have met through my time at Cardiff Met – We did it!

***

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Abstract

Previous research suggesting the bilingual experience may enhance a person’s task-switching and inhibition ability within the executive functioning (EF) system are limited and inconsistent. Much of the previous research explores bilingual EF advantages within adult populations, yet it has been argued adults and children learn differently. Therefore, this study explored using an experimental and quantitative mixed design, a Welsh and English version of the Stroop-task to measure task-switching and inhibition abilities to determine if bilingualism enhanced the EF of children aged between nine and eleven years old from a Welsh-medium primary school and an English-medium primary school in South Wales.

Background checks revealed significant socio-economic status (SES) differences within the sample. As SES has been found to influence EF, any effects found could not be attributed to bilingualism alone. Although no significant main effects were found, children from Welsh-English speaking low-SES homes performed faster on the English Stroop-task than those from English-only speaking high-SES homes, despite research supporting those from higher-SES backgrounds having better EF than those from lower-SES backgrounds, arguably due to an enhanced EF ability. Future research replicating this study using a larger sample with no significant SES effects may support a bilingual EF advantage within children.
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Chapter 1: Introduction

1.1 Bilingualism:

Over half of the world’s population is bilingual (Ansaldo, Marcotte, Scherer & Raboyeau, 2008). Bilingualism within the United Kingdom (UK) is less common than other parts of Europe with only 39% of UK citizens taking part in a conversation daily in a language other than their mother tongue, compared to the European average of 54% (Eurobarometer, 2012). In some European countries there are particularly high bilingual rates for example in Luxembourg 99% of the population are functional bilinguals (Eurobarometer, 2012). Worldwide it is estimated that there are just as many bilingual children as there are monolingual children (Paradis, Genesee & Crago, 2011).

In Wales the government wants to increase the number of bilingual Welsh speakers to 1 million by 2050, focusing mainly on education, for example they aim to change the way Welsh is taught so that 70% of Welsh children in English medium schools can speak fluent Welsh by the time they leave school (Welsh Assembly Government, 2017). Since the Education Reform Act (1988) and the introduction of the National Curriculum in Wales, Welsh is taught as a first or second language to almost every pupil in Wales (Jones & Benedictus-van, 2014). Welsh-medium primary schools provide 70% of the teaching through the medium of Welsh (Welsh Assembly Government, 2007) and 19% of primary school aged children attend Welsh-medium primary schools in Wales (Welsh Assembly Government, 2001).

Bilingual speakers have two equivalent words for the same concept and the ability to select words of the intended language and avoid non-target language intrusions, which is argued to enhance executive functioning (EF) (Garbin et al, 2010). In children, there is a relation between EF and academic achievement (Best, Miller, & Naglieri, 2011). In a brain imaging study conducted by Garbin et al (2010) it was found that within a switching-task there were fundamental cortical differences between the bilingual and monolingual brain. With the prevalence of bilingualism worldwide and with the possibility of increasing Welsh-English bilingualism in Wales due to government ambitions, research should have a good understanding of bilingualism in Wales and its possible advantages within the EF of bilingual children.
1.2 Executive control and bilingualism:

Switching between languages is a cognitively demanding skill and it is a skill that monolingual speakers do not develop (Prior and Gollan, 2011). Fluent bilinguals are generally efficient at language switching and at keeping their languages separate (Meuter & Allport, 1999). Due to the ongoing demands of managing two languages, bilingualism is argued to enhance cognitive development, particularly within the EF (Kroll, & Bialystok, 2013). Bilinguals must select the appropriate language depending on the current language spoken, continuously monitoring and controlling the non-target language when conversing which is argued to rely on EF (Philipp & Koch, 2009). Bilinguals are argued to have a higher-order mechanism regulating language activation (Aparicio, Heidlmayr, & Isel, 2017).

The EF system consists of a set of general-purpose control processes which self-regulate thoughts and behaviours which are important to accomplishing goals (Paap, Johnson and Sawi, 2015). These cognitive skills include selective attention, inhibition of attention to misleading information and switching attention in tasks with competing and misleading cues (Bialystok, Craik, Klein & Viswanathan, 2004). The current research focuses on exploring bilingualism within the inhibition and task-switching elements of EF.

1.2.1 Inhibition and task-switching:

As bilinguals successfully inhibit their non-relevant language and can successfully switch between languages (Valian, 2015), bilingualism is argued to influence the development of inhibitory control and task-switching (Martin-Rhee & Bialystok, 2008). Bilinguals are argued to have an advantage in inhibitory control and task-switching as they must prevent intrusions from their non-target language and practice switching between languages (Kirk et al, 2018). The advantages can also be found in nonverbal tasks which test inhibition and task-switching (Yang, Hartanto, & Yang, 2017).

Bilinguals are argued to have an inhibitory control advantage (Hilchey & Klein, 2011), deriving from constant practice in exerting control processes to inhibit the language not currently in use (Von Bastian, Souza, & Gade, 2016). The inhibitory-control model of bilingual lexical activations argues that bilinguals experience interlingual lexical competition and use inhibition to allow selection of the desired lexical item (Green, 1998).

The ability to switch from one task to a completely different task is assumed to require task-switching within the EF, separate from inhibition (Paap & Greenberg, 2013). Bilinguals are argued to have a task-switching advantage (Bialystok, Craik, & Luk, 2008), with faster reaction times (RT’s) compared to monolinguals when switching between two tasks (e.g. Prior & MacWhinney, 2010).
Arguably this advantage is due to the bilingual’s practice of switching between languages (Von Bastian et al, 2016).

These bilingual advantages have been reported in several different wide-ranging bilingual language types, for example bilingual inhibition and task-switching advantages have been found in a bilingual English-Gaelic population (Lauchlan, Parisi, & Fadda, 2013), in a Spanish-Catalan population (Costa, Hernández & Sebastián-Gallés, 2008), in a Welsh-English population (Gathercole et al, 2010) and also in an English-Hebrew population (Bialystok & Barac, 2011).

1.2.2
Stroop-task:

The inhibition and task-switching elements of EF are often measured using a Stroop-task (Stroop, 1935). The Stroop-task requires switching goals, resolving conflict between two incompatible responses and withholding preponderant responses (Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010). The Stroop-task presents the participant with two mental representations (ink colour and name of colour word), participant’s are required to only pay attention to one relevant cue (ink colour) ignoring the other cue (name of colour word) (Bialystok, Craik & Ryan, 2006).

A mixture of congruent (colour word matching ink colour e.g. the word RED, in red ink) and incongruent trials (colour word not matching ink colour e.g. the word RED, in blue ink) are presented to participants (Heidlmayr et al, 2014). EF is required in the Stroop-task to override the tendency to respond on the basis of the word rather than the ink colour (Heidlmayr et al, 2014). Faster RT’s are considered to reflect higher inhibitory control and task-switch abilities (Heidlmayr et al, 2013). Incongruent trials cause conflict as word reading is considered to be automatic therefore the participant must ignore the word they read attending only to the colour of the word requiring the use of their inhibition and task-switching EF systems (Augustinova & Ferrand, 2014).

Interference scores are a standard marker for inhibitory control, they are the mean RT’s between trials that require conflict resolution (incongruent) to those that do not (congruent) (Paap & Greenberg, 2013). Smaller interference scores are argued to indicate enhanced inhibition abilities (Paap et al, 2015). Task-switching is measured as the difference in accuracy between switch trials (incongruent) and repeat trials (congruent) in a block where task is randomly varied and cued on each trial (Paap et al, 2015). The Stroop-task demonstrates the inhibition and task-switching elements of EF (Bialystok, 2009).

Both monolinguals and bilinguals respond faster to congruent trials compared to incongruent trials (Monsell, 2003). However, bilinguals have been argued to be faster (Bialystok, 2006) and more accurate (Baker, Kovelman, Bialystok & Petitto, 2003) than monolinguals on congruent and incongruent trials measuring inhibitory control and task-switching (e.g. Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009).
1.3
Childhood Bilingualism and Executive control

1.3.1
Background

Bilingual language production requires the constant involvement of EF to manage attention towards the target language, therefore it is argued that bilingualism has an advantageous effect on EF (Bialystok, 2009). For bilingual children, both languages are active during normal language use (Francis, 1999), therefore in order to speak fluently and avoid unwanted intrusions, bilingual children need to inhibit their non-target language (Blair, Zelazo, & Greenberg, 2005). Fluent bilingual children exercise language switching through monitoring the situation and selecting the appropriate language, whilst inhibiting the other language (Paap & Greenberg, 2013). Bilingual children acquire considerable practice with selection and inhibition, and over time become more efficient at exercising control (Morton & Harper, 2007).

Badzakova-Trajkov, Kirk & Waldie (2008) conducted a study comparing monolinguals and bilinguals through using a Stroop-task in a sample of 30 participants, which found bilinguals had an advantage in EF with faster RT’s and better accuracy. However these findings were not consistent with the findings of Von Bastian et al (2016) who found no bilingual advantage within inhibition or task-switching also using a Stroop-task in a larger study of 118 participants, therefore it was concluded that benefits may not be broad and robust, and benefits found in other studies may be due to task-specific effects and small sample sizes. Von Bastian et al (2016) argue much of the larger scale studies fail to detect bilingual advantages (e.g. Duñabeitia et al, 2014 or Luo, Craik, Moeno & Bialystok, 2013).

Research conducted on a sample of undergraduate students suggests inhibition is important in overcoming interference during the early stages of second-language acquisition (Levy, McVeigh, Marful & Anderson, 2007). A criticism of previous research is that much of it focuses on adults (e.g. Bialystok et al, 2008 or Paap & Greenberg, 2013). Research comparing language acquisition of adults and children (aged 5-7) found children and adults do not learn language in the same way (Hudson & Newport, 2005). Therefore, further research is needed to understand the role of inhibition and task-switching in the second language acquisition of children as research conducted on adults is not valid for understanding how bilingualism influences EF in children.

1.3.2
Evaluation of previous research using children

Bialystok (2001) argues there is growing evidence that bilingual children outperform monolingual children in tasks that require inhibition and task-switching (e.g. Bialystok, 1999). However, recent
research on children has found conflicting findings towards a bilingual advantage in EF. It has been argued that research finding a bilingual advantage in inhibitory control or task-switching is rarely displayed in children (Hilchey & Klein, 2011). There are inconsistencies and limitations within the research conducted, therefore further research is needed to understand whether bilingualism in children is advantageous for EF.

Paap et al (2015) argue that more than 80% of research reporting bilingual advantages in EF after 2011 yield null results and those resulting in significant bilingual advantages tend to have small sample sizes. For example Gathercole et al (2010) found a bilingual EF advantage in a sample of 193 children, whereas Gathercole et al (2014) did not find an advantage in a larger sample of 493 children. In both studies children were matched on socio-economic status (SES) and language proficiency. Much of the evidence conducted has not had consistency within its findings.

It is difficult to rely on previous research as a publication bias towards cognitive advantages in bilingualism is argued. Research looked at the fate of 104 conference abstracts presented at 52 different national and international conferences (De Bruin, Treccani & Della salla, 2015). Research presenting a bilingual advantage was more likely to be published (68%), whereas those who challenged the hypothesis had less chance of being published (29%). (De Bruin, Treccani & Della salla, 2015) Previous research around bilingualism and EF should be explored cautiously.

In a study conducted by Calvo & Bialystok (2014) it was concluded that bilingual children aged 7 and 8 had bilingual advantages in EF. However there was only a significant main effect for bilinguals that they were more accurate than monolinguals in a flanker test of EF; there were no significant effects across congruent and incongruent trials, language groups did not interact with the flanker task, neither was there a main significant effect of RT's nor any significant interactions found (Paap et al, 2015). Therefore arguably, some of the supporting research provides data which does not fully support a bilingual advantage in EF with much of the supporting evidence overestimating the size of any genuine bilingual advantage (De bruin et al, 2015).

On the other hand it could be argued that much of the data was not found to be significant within Calvo & Bialystok’s (2014) study because children within the bilingual groups came from different cultural backgrounds and were included in the study as one ‘Non-English’ group. Culture differences within the ‘Non-English’ group could be why the research did not strongly support that bilingualism enhances EF in children as culture has been found to influence EF (Carlson and Choi, 2009). Specific language combinations from different languages may be why there is an advantage within some studies and not in others. For example a task-switching advantage was found in Spanish-English bilinguals, however not in the Mandarin-English bilinguals (Prior & Gollan, 2011).

Research conducted by Ross & Melinger (2017) found children aged between 6 and 9 years old showed no bilingual advantage, yet a limitation of this research was that although the majority of the bilingual sample spoke Gaelic as a second language, some of the participants spoke other languages (Arabic, Czech, Chinese, Malay, Russian, Japanese, Zulu, Greek, or French) as a second language. Again a limitation of this research comparing bilingual and monolingual EF is limited as these varying languages deriving from diverse cultures could influence EF (Carlson and Choi, 2009). Therefore, only highly proficient Welsh-English bilinguals and lowly proficient English-Welsh bilinguals will be used in this study as previous research exploring bilingual children’s EF such as Ross
& Melinger (2017) and Calvo & Bialystok (2014) is limited as it has not considered cultural differences of those participants speaking different languages within the bilingual sample.

Research supporting a bilingual advantage in children is found in studies whose bilingual groups speak the same language. For example, Gathercole et al (2010) found a bilingual advantage in a sample of Welsh-English bilingual children, compared to monolingual English speaking children. Also, Chen, Zhou, Uchikoshi and Bunge (2014) found a bilingual advantage in a sample of Chinese-English bilingual children compared with monolingual English speaking children. Supporting further those specific language combinations could influence results and the importance of having one bilingual language combination sample (Welsh-English only).

Gathercole et al (2010) found a bilingual advantage in children with a mean age of 8 when using a Stroop-task, measuring inhibition and task-switching. Poarch and Hell (2012) supported this finding showing 7 year olds displayed a smaller increase in response time for incongruent items than monolinguals. However Ross & Melinger (2017) argue these advantages are marginal. However, Gathercole et al (2014) found no bilingual advantage when comparing inhibition and task-switching in children. A limitation of this study is that age groups were limited (ages 3-5, 7-8 and 15-16), missing some vital age groups which may be important. Therefore this study will explore one of the missing age groups of children aged between nine and eleven.

Research conducted by the National Assembly for Wales (2001) found that only 17% of the 19% of children in mainstream Welsh-medium schools were classed by the head teachers as fluent in both Welsh and English language by the age of 7, therefore an older sample of children will be used in this study who should be more proficient in both languages. However, Welsh is also taught as a subject as part of the curriculum for students in English primary schools in Wales, therefore pupils from English-medium primary schools in Wales may also experience bilingualism in a much lower proficiency from those fluent in Welsh within Welsh-medium education (Jones, 2016).

Comparing results from a separate Welsh and English Stroop-task conducted on pupils from both a Welsh-medium and an English-medium primary school will allow for inhibition and task-switching abilities to be compared among highly proficient bilinguals and lowly proficient bilinguals with a key stage 2 curriculum knowledge of Welsh language as either a first or second language (Welsh Assembly Government, 2016).

Valian (2015) argues there are inconsistencies across and within studies. Previous research has been argued to have problems with reliability and replicability (Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010). For example, Duñabeitia et al (2014) did not find a bilingual advantage in children using a Stroop-task. Yet Gathercole et al (2010) using a Stroop-task on children did find a bilingual advantage. Further research is needed to fully understand if bilingualism influences children’s task-switching and inhibition abilities.

A bilingual advantage in EF due to early bilinguals managing multiple languages is very attractive (Paap & Greenberg, 2013), especially for Wales as the government aims to increase the number of Welsh speaking bilingual children (Shipton, 2017). Although some studies such as Chen et al (2014) find a bilingual advantage within children, there is a lack of coherent evidence favouring a bilingual advantage (Paap & Greenberg, 2013). There is a lack of research exploring childhood bilingualism
and its possible effects on EF, therefore it cannot be concluded yet that there is a bilingual advantage within the EF of bilingual children compared to monolingual children.

1.4 Other factors to consider

As bilingualism co-varies with other factors that could affect EF (Paap et al, 2015), such as SES and home language use, these should be controlled for. It is important to group participants on the basis of their SES and their language proficiency so that if there is a significant effect it is more likely due to the bilingualism as opposed to the individual differences of participants SES and home-language use. Participant’s ages were also controlled for as previous research supports that performance on the Stroop-task improves with age (Duell et al, 2018).

1.4.1 Socio-economic status and cultural differences

A widespread criticism for research on bilingualism and EF is a failure to sufficiently control for SES (Hilchey & Klein, 2011). Gathercole et al (2010) argue early studies had mixed results concerning whether bilingualism was seen to have negative or positive effects on cognition because many studies were limited as they did not control for SES or cultural differences (e.g., Bialystok et al, 2004; Bialystok et al, 2008; Cummins, 1992). Research suggests SES could account for differences found in bilingual and monolingual task-switching and inhibition abilities and not bilingualism (Mezzacappa, 2004), as research has reported that the effects of bilingualism may be more pronounced at some SES levels than at other levels (Woodard & Rodman, 2007).

Hartanto, Toh, & Yang (2018) argue a child’s SES level can be defined in terms of parent’s educational level, income or occupation. It is important to assess SES as it is argued children from high-SES backgrounds can access material resources, social connections, and positive parenting styles that enhance their social and cognitive development (Bradley & Corwyn, 2002). For example, children from high-SES backgrounds participate in more cognitively stimulating materials and experiences (e.g., reading), whereas low-SES children may have limited or no access to those resources resulting in a deprivation of stimulation and support for cognitive development (Bradley & Corwyn, 2002).

It is argued that children from low-SES backgrounds are at an increased risk of delays in EF development (e.g., Ardila, Rosselli, Matute, & Guajardo, 2005), with empirical research showing how household income and parental education individually affect EF (Hackman et al., 2015). For example, children aged 6-7 from lower SES backgrounds (measured by parental education, occupation, and income) performed poorer than those from higher SES backgrounds on a Stroop-task measuring the inhibition and task-switching elements of EF (Blair, Zelazo, & Greenberg, 2005).
Bialystok (2001, P.220) argue that SES including parental education level correlates with children’s cognitive development. Research conducted by Calvo (2011) on bilingual and monolingual children aged 5, found strong evidence that bilingualism and SES are independent from one another. Morton and Harper (2007) conducted a study measuring children’s task-switching ability in the EF of bilingual and monolingual children matched on SES. On the task-switching test the bilingual and monolingual children performed identically, however children from higher SES families were advantaged in the task compared to the children from lower SES families.

Research examining bilingual and monolingual children’s task-switching and inhibition ability conducted matched on SES found a bilingual advantage within EF (Engel de Abreu et al, 2012). However, the study is criticised as the bilingual children were raised in separate areas (Luxembourg and Portugal) therefore the advantage may be due because of the unaccounted social-experiences unique to each country (Hilchey, Saint-Aubin, & Klein, 2015). Carlson and Choi (2009) also found culture influenced EF ability in a study comparing matched SES samples of Korean and American monolingual and bilingual children.

Therefore, this research will consider SES and cultural differences as these differences between samples, if not accounted for, could influence inhibition and task-switching abilities in the bilingual and monolingual samples. Controlling for SES and cultural differences is important as if any advantageous effect occurs it can be argued that this is due to SES or cultural differences, or if no significant associations are found then it can be argued that any differences on the Stroop-task performance are likely to be due to their bilingual experience of practicing suppressing and switching (Ross & Melinger, 2017).

### 1.4.2 Home language use

The settings in which a second language is learnt and literacy learning in the home are argued to influence bilingual children’s EF development (Bialystok, 2001, P.224). Bilingual groups can vary in how they use their two languages and how frequently they mix and switch languages (Basnight-Brown & Altarriba, 2007), also speakers of two languages vary in proficiency (Costa, & Santesteban, 2004). Gathercole et al (2010) argue further research is needed to understand how language proficiency influences EF as it is yet unclear how important it is.

Research exploring EF abilities in bilingual Chinese American immigrant children aged 7-10 grouped the bilingual children into groups of bilingual language proficiency as the children had varying levels of Chinese and English language proficiencies (Chen et al, 2014). In EF tasks it was found that highly proficient children in both Chinese and English performed best in tasks measuring task-switching and inhibition (Chen et al, 2014). Prior and Gollan (2011) supported this finding, as bilingual advantages were restricted to bilinguals who switch between languages frequently.

Language proficiency is argued to influence the Stroop-task i.e. the greater the proficiency, the more likely the within-language interference (Chen & Ho, 1986). Costa and Santesteban (2004) argue that
inhibition in language switching is required only by lower-fluency speakers. Paap, Johnson & Sawi (2014) argue there is no compelling evidence that bilingual language proficiency ratio predicts any component of EF.

This study accounts for language proficiency and language switching in the form of a language background questionnaire to group children into groups based on their home language use. Although research is inconsistent and further research is needed as it is yet unclear if and how language proficiency and the frequency of language switching influences bilinguals EF, it does not mean that they are not important factors to control for.

However, in research where participants were grouped based on age of acquisition, usage and proficiency as well as matched on SES questions it is unclear whether a bilingual advantage exists as no bilingual advantage was found in inhibition or task-switching (VonBastian et al, 2016). Therefore previous advantageous findings could be due to other factors such as SES, usage and proficiency which have not been accounted for, for example Chen et al (2014) found a bilingual advantage yet language usage and proficiency were not controlled for. A limitation of VonBastian et al (2016) is that the study was conducted on an adult sample, therefore it is unclear whether bilingualism enhances EF of children.

1.5 Summary, Aims and Hypothesis:

Having an in-depth understanding of bilingualism is important as bilingualism is an integral part of society (Ansaldo et al, 2008). It has been argued that bilingual speakers may have an advantage in the inhibition and task-switching elements of EF, as when they use language they must control interference from active representations in the non-target language (Rodriguez-Fornells, Balaguer, & Münte, 2006), while they are able to switch successfully from one language to another (Paap & Greenberg, 2013), more consistent findings are needed.

Further research is needed to explore whether bilingual children are advantaged compared to monolingual children as there is a lack of coherent and consistent research. It is important for children to be matched on SES and language proficiency as research suggests that it may be important (e.g. Mezzacappa, 2004), with previous studies failing to measure this e.g. Cummins (1992).

Due to inconsistent and unreliable research, a lack of research conducted on children and research not controlling for SES and language proficiency, one is led to explore this hypothesis.

Hypothesis: Highly proficient Welsh-English bilingual children should have lower Stroop interference, responding faster on a Stroop-task when compared with matched SES lowly proficient English-Welsh bilinguals due to an enhanced task-switching and inhibition ability within the EF.
Participants:

Participants were recruited from two local primary schools in South Wales, one English medium and one Welsh medium. The sample consisted of thirty-two children aged between nine and eleven years old (in year five and year six), with a mean age of ten years old (St Dev. = 0.66). Sixteen children were from a Welsh medium primary school, whilst the other sixteen children were from an English medium primary school. Three participants who spoke a language other than Welsh or English were excluded from the study.

The participants were grouped based upon responses from a questionnaire (Rhys & Thomas, 2013) regarding their home language use and were given a SES score based on household income and if the child received free school meals (FSM) so that any differences would more likely be due to language differences as opposed to SES differences between the participants. Participants were matched on SES as it has been argued that previous research which has not controlled for SES differences yet has found a bilingual inhibition and task-switching advantage is possibly due to SES differences and not language differences (Mezzacappa, 2004). As research has reported that the effects of bilingualism may be more pronounced at some SES levels than at other levels it is therefore important to control for SES differences (Woodard & Rodman, 2007). Participants’ mean SESav score was 3.27 (St Dev. = 1.15). The exact ages of participants were also calculated for an analysis to check that any differences that may be found are less likely to be due to age differences between the participants.

Based upon responses from a questionnaire the participants were also grouped into home language groups. Similarly to Gathercole et al (2010) the participants were allocated into the home language groups of Welsh English homes (WEH), English only homes (EOH) and Welsh only homes (WOH). The participants were classed as WEH if both Welsh and English were reportedly spoken in the home between a ratio of 40% and 60% of the time. The WEH participants were considered to be highly proficient bilinguals. If 80% of the child’s home language use were reported to be English then participants were allocated into the EOH group. Likewise if 80% of the child’s home language use were reported to be Welsh then participants were allocated into the WOH group. Participants within the WOH or EOH were considered to be lowly proficient bilinguals. However, no participants met the criteria for the WOH therefore this category was eliminated.
The table below (Table 2.1) shows the amount of children in each home language group:

<table>
<thead>
<tr>
<th>Homes Type</th>
<th>Welsh/English homes</th>
<th>English only homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 2.1: Table displaying home language groups and participants.

The table below (Table 2.2) displays the amount of participants from each primary school and their home language group:

<table>
<thead>
<tr>
<th>School Type</th>
<th>Welsh-medium school</th>
<th>English-medium school</th>
</tr>
</thead>
<tbody>
<tr>
<td>English only homes</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Welsh/English homes</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2.2: Table displaying participants’ school and home language groups.

### 2.2 Design:

The study compared the EF of highly proficient Welsh-English bilingual children and lowly proficient English-Welsh bilingual children by exploring their task-switching and inhibition abilities through measuring Stroop interference. The study implemented an experimental and quantitative mixed design because there was one between subject independent variable (IV) (home language group, with two levels, WEH and EOH) and two within subject’s IV’s (Stroop language, English and Welsh). The dependant variable (DV) was the Stroop interference scores from congruent conditions and incongruent conditions response times (RT’s) in the Stroop-task which was calculated as the average incongruent RT’s minus the average congruent RT’s.

### 2.3 Materials:

Children were measured on a Stroop-task, whilst parents answered a questionnaire measuring SES and home language use (Rhys & Thomas, 2013). Materials included information sheets and consent forms for head-teachers, parents and pupils, a home-language and SES background questionnaire (Rhys & Thomas, 2013) for parents and a Stroop-task designed for children based on MacLeod’s (1991) colour Stroop-task.

Two Stroop-tasks were created using ‘Open Sesame’ software on a PC, one created in the Welsh language and one created in the English language. Both tests had 48 randomised trials, half of which were congruent conditions whilst the other half where incongruent conditions (See Fig. 2.1, 2.2, 2.3 and 2.4 for examples of congruent and incongruent trials in both the Welsh and English Stroop-task). The Stroop-task measured RTs and accuracy of participants’ responses which were collected using a response box (’Cedrus Response Pad RBS40’) connected to the PC (see Fig. 2.5). The participants had 2000ms to respond before the next trial began.
Data was presented and collected on password protected PC using ‘Open Sesame’ software, and saved in Microsoft Excel. Responses from the Stroop-task were collected using a response pad. A reference number which corresponded with the child’s response on the task and the parent/guardian’s response on the questionnaire were calculated and provided for each participant to anonymize data.
2.4 Procedure:

Teachers, parents/guardians and pupils provided consent for their child/class/school to participate through returning consent forms which were collected prior to data collection. An information sheet attached to the consent forms fully explained the study so a full understanding of the study was attained by participants, parents/guardians and teachers before an informed consent was given. Contact details were presented on the information sheet for parents to call or email if they had any concerns or queries about the research.

Parents were required to complete a home-language and SES background questionnaire, containing questions about what language is spoken at home and what their highest level of education is and their earnings. The questionnaire contained an introduction which provided information about confidentiality and how the questionnaire responses would be used. They were also reminded in the instructions that they were not obliged to answer any questions that they did not feel comfortable answering.

The children from both the English medium and Welsh medium primary school participated in both the Welsh and English Stroop-task, measuring accuracy and RT’s in a classroom setting. The Stroop-task required the participants to name the ink colour of the word rather than name the word itself, with sometimes the ink colour matching the word (congruent condition) and other times the ink colour not matching the word (incongruent conditions). The Stroop-task presented participants with a random mixture of congruent and incongruent conditions which test for task-switching and inhibition abilities within executive functioning. The study lasted approximately ten minutes for each participant and took approximately five minutes per Stroop-task. Pupils completed the study one at a time and then were returned back to class.

A reference number was calculated for each participant that corresponded with the participant’s response on the task and the parent/guardian’s response to the questionnaire. Once this matching was complete, the data became anonymous and only if data needed to be withdrawn was the reference number matched with the participant’s identifying information.

Participants’ responses on the Stroop-task and parents’ responses on the questionnaire were analysed using SPSS. The data extracted and entered into SPSS from the questionnaires and Stroop-tasks included SES average (SESav) scores, FSM, home language groups, age and Stroop interference on both the Welsh and English Stroop-task.

2.5 Method of analysis:

Firstly six χ² were conducted to explore if there were any significant associations between the dependant variable (DV) SES average and the independent variable (IV) home language, the DV FSM and the IV home language, the DV SES average and the IV school language, the DV FSM and the IV school language, the DV SES average and the IV age and the DV FSM and the IV age. These were
conducted in order to establish that any differences found were less likely to be due to the extraneous variables of SES and age differences and that any differences found could support premise that the differences are due to the bilingual experience of the child. Empirical research has shown how household income and parental education individually affect EF (Hackman et al., 2015), for example research comparing bilingual and monolingual children’s task-switching and inhibition ability considering SES found that children from high-SES backgrounds perform significantly better than those from low-SES backgrounds (Morton & Harper, 2004). Therefore, it is important to test for any differences to establish that any differences found cannot be attributed to SES background.

Once these initial analyses were conducted a two way 2 x 2 mixed ANOVA was performed on the data once inputted into SPSS. A two way 2 x 2 mixed ANOVA was used as there were 2 nominal data within subjects IVs Stroop language (with 2 levels – Welsh and English) and a between level of home language use (with 2 levels, EOH, WEH) and the interval data DV was the Stroop interference which is the incongruent RTs minus the congruent RTs. As there were no participants in the WOH language group this group was removed from the analysis.
Chapter 3: Results

3.1 Introduction:

Thirty-two participants completed both Welsh and English versions of the Stroop-task. Participants’ parents completed questionnaires which assessed the extraneous variables (children’s age and their level of SES). Six $\chi^2$ were completed on the extraneous variables in section 3.2 to determine whether the extraneous variables were independent from one another. A two way $2 \times 2$ mixed ANOVA was completed on data from the Stroop-task which is presented in section 3.3.

3.2 Methodological checks:
Socio-economic status average and free school meals analyses

Six $\chi^2$ were conducted to explore if participant’s home language and SESav, home language and FSM, age and SESav, age and FSM and school language and SESav were independent from one another as any significant relationships found could attribute for any significant differences found between bilinguals and monolinguals in the results from the Stroop-task.

Age

A $\chi^2$ was conducted to explore the relationship of participant’s age and SESav, which did not reveal a significant association, $\chi^2 (192) = 202.436, p = 0.289$. Also a $\chi^2$ was conducted to explore the relationship of participant’s age and FSM, which also revealed no significant associations between age and FSM, $\chi^2 (15) = 8.976, p = 0.879$.

Home language

A $\chi^2$ was conducted to explore the relationship of participant’s home language use and SESav, which revealed a significant association, $\chi^2 (12) = 21.6, p = 0.042$. A $\chi^2$ also revealed a significant association between home language use and FSM, $\chi^2 (1) = 4.971, p = 0.026$. Therefore, due to these significant findings any significant differences found on the participants’ Stroop-task performance cannot be attributed to bilingualism or home language use alone.
School language

A $\chi^2$ was conducted to explore the relationship of the participants’ school language and FSM, which did not reveal a significant association, $\chi^2 (1) = 1.275, p = 0.259$. However, a $\chi^2$ was conducted to explore the relationship of the participants’ school language and SESav, which did reveal a significant association, $\chi^2 (12) = 22.533, p = 0.032$. Therefore, due to this significant finding any significant differences found on the participants’ Stroop-task performance cannot be attributed to bilingualism or home language use alone.

The $\chi^2$ analyses revealed significant associations between home language and SESav, home language and FSM and school language and SESav. As these variables were not independent from one another any significant Stroop interference differences found between participants from different home language and school language groups cannot be attributed to language differences alone.

### 3.3 Stroop-task:

A 2 way mixed 2 x 2 ANOVA was used as there were 2 IVs, one within subjects’ IV Stroop language (with 2 levels – Welsh and English) and one between subjects’ IV level of home language use (with 2 levels, EOH and WEH) and the DV was the Stroop interference which is the incongruent RTs minus the congruent RTs.

The table below (Table 3.1) displays the descriptive statistics for the Stroop-task interference comparing those from WEH and EOH.

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<td></td>
<td>Total</td>
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<td>46.21</td>
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</tbody>
</table>

Table 3.1. Table displaying descriptive statistics for Welsh and English Stroop-task interference for those from WEH and EOH.

Figure 3.1 displays that there is higher mean Stroop interference in the WEH language group than in the EOH language group on the Welsh Stroop-task. Figure 3.1 also displays a fairly similar mean Stroop interference on the English Stroop-task within the WEH and EOH language groups, although there was a slightly higher mean Stroop interference for the EOH. Figure 3.1 also displays that participants from WEH had a higher mean Stroop interference on the Welsh Stroop-task in comparison to the English Stroop-task. On the contrary, figure 3.1 displays that participants from EOH had higher Stroop interference on the English Stroop-task than on the Welsh Stroop-task.
Figure 3.1. Displaying descriptive statistics in the form of a bar chart showing mean Stroop interference scores of Welsh and English Stroop-tasks and home language groups. Error bars display standard error.

ANOVA did not find a significant main effect of Stroop language, $F(1, 30) = 0.12, p = 0.914$. ANOVA also revealed there was no significant main effect of home language, $F(1, 30) = 0.311, p = 0.581$. ANOVA did not reveal a significant main effect of both Stroop language and home language, $F(1, 30) = 0.77, p = 0.387$.

Pairwise comparisons found no significant interactions between the home language use (WEH, EOH or WOH) and the type of school that was attended (Welsh medium or English medium) on the Stroop interference scores in either language condition (Welsh or English) of the Stroop-tasks. There was no significant interaction found in participants attending a Welsh medium primary school from WEH, EOH or WOH home language backgrounds, $F(1, 30) = 25.42, p = 0.573$. Also no significant interactions were found in participants attending an English medium primary school from WEH, EOH or WOH home language backgrounds, $F(1, 30) = 14.67, p = 0.448$.

The ANOVA did not reveal significant main effects of Stroop language or home language, nor did it reveal any significant interactions between the home language background or school language used to teach pupils. Although no significant effects were found it is interesting to note that those from WEH responded quicker than those from EOH on the English Stroop-task arguably due to their bilingualism enhancing their task-switching ability. Also the participant’s from EOH responded quicker in the Welsh Stroop-task rather than the English Stroop-task, possibly due to an error.
Chapter 4: Discussion

4.1 Background and predictions:

The introduction put forward the idea that bilingualism has been argued to enhance the EF of children (Bialystok, 2001), specifically within the task-switching and inhibition elements of EF as highly proficient bilingual children must prevent intrusions by inhibiting their non-target language and practice switching between languages (Ross & Melinger, 2017). The current study aimed to replicate the findings of Gathercole et al (2010) who compared highly proficient Welsh-English bilingual children with English lowly proficient bilingual children’s task-switching and inhibition ability through using a Stroop-task finding highly proficient Welsh-English bilingual children performed better with faster RT’s than lowly proficient English-Welsh bilingual children matched on SES.

As in Gathercole et al’s (2010) study, participants in this study were classed as highly proficient bilinguals if they came from a Welsh-English speaking home, whereas participants were classed as lowly proficient bilinguals if they came from either a Welsh only or an English only speaking home as Welsh is a compulsory part of the curriculum for those in Wales attending English medium schools. Therefore, those from the English medium schools would have had a basic knowledge of Welsh (Jones & Benedictus-van, 2014). The study aimed to replicate the findings within a sample of children aged between nine and eleven years old, unlike Gathercole et al (2010) who conducted their study on children aged between seven and eight years old. The study controlled for participants SES backgrounds as bilingualism and SES are argued to be independent from one another (Calvo, 2011). Also those from higher SES backgrounds are argued to perform better than those from lower SES backgrounds on the Stroop-task (Blair et al, 2005).

It was hypothesised highly proficient Welsh-English bilingual children should have lower Stroop interference responding faster on a Stroop-task when compared with matched SES lowly proficient English-Welsh bilinguals due to an enhanced task-switching and inhibition ability within the EF.

4.2 Main findings and interpretation:

Although the methodological background checks revealed no significant relationships between participant’s age and SESav, age and FSM, school language and FSM, significant relationships were found between participants’ home language use and SESav, home language use and FSM and school language use and SESav. Therefore, as the methodological checks revealed these significant
associations, any significant Stroop interference differences could not be attributed to bilingual or monolingual language differences alone and SESav and FSM could also attribute to any differences found within the Stroop-task.

A strength of this research is that, unlike previous research, which has supported a bilingual advantage (e.g., Bialystok et al, 2004; Bialystok et al, 2008; Cummins, 1992) and has been criticised questioning the validity of their supporting evidence for failing to control for SES differences within their research (e.g. Paap et al, 2015; Hilchey & Klein, 2011), this research controlled for such differences. However, the methodological background checks revealed a significant difference between the sample attending the Welsh medium school from WEH and those attending the English medium schools from EOH, as although both schools were selected from the South Wales area, the location of the Welsh medium school was in a deprived area whereas the location of the English medium school was in a more affluent area. A suggestion for future research would be to use a larger more representative sample and if possible to select schools from similar locations as it is argued that those from high-SES backgrounds have more access to material resources, social connections and positive parenting compared with those from low-SES backgrounds which have been argued to impact on cognitive development (Bradley & Corwyn, 2002).

The study revealed no significant main effects of Stroop language or home language, nor did it reveal any significant interactions between the home language background or school language, supporting previous research which found no bilingual advantage through using a Stroop-task in comparison to their monolingual counterparts in the task-switching or inhibition elements of children’s EF (e.g., Duñabeitia et al, 2014; Gathercole et al, 2014; Ross & Melinger, 2017). Future research should aim to use a larger sample, as a limitation of this study was that due to the small sample size there were no participants within the WOH group and the sample of highly proficient bilingual children was relatively small with only eight participants fitting the criteria of coming from WEH.

Participants from EOH responded faster in the Welsh Stroop-task than they did in the English Stroop-task, also they responded faster in the Welsh Stroop-task than those from WEH. Arguably this finding could be due to an error as they would not have experienced interference from reading the colour word in Welsh in the incongruent conditions as although they were classed as lowly proficient Welsh speakers it is a possibility that they did not understand the colour words written in Welsh. Therefore, without understanding the colour words written they may have experienced little or no interference from reading the word in Welsh and would have been faster at selecting the colour of the word as they experienced no interference.

Those from EOH attending English medium schools were classed as lowly proficient bilinguals and were presented with the Welsh version of the Stroop-task, because between the ages of nine and eleven with a key stage two education knowledge of Welsh second language, the participants should have had an understanding of the colours in Welsh (Welsh Assembly Government, 2015). Therefore, a suggestion for future research is to test participants from English medium schools or EOH on their understanding of the Welsh language, especially testing their understanding of the colours in Welsh prior to the study and group participants into groups of monolinguals, lowly proficient bilinguals and highly proficient bilinguals. A standardized method should be created to determine participants’ degree of bilingualism to ensure the reliability and validity of research, as a limitation of current research is that no such standardized method exists (Prior & Gollan, 2011).
Bilingualism is argued to be a multidimensional and continuous variable (Luk & Bialystok, 2013), therefore a suggestion for future research would be to explore bilingual language proficiency as a continuous variable instead of splitting participants into different categorical language groups. Since participants within this study were split into language groups based on questionnaire responses from parents about their child’s household language use, there may have been a wide-range of different language proficiency abilities within each group.

Future research should create and use a test to determine participants’ language proficiency in both languages as it is possible that the self-report language background questionnaire was not the most reliable way to explore the child’s language proficiency. Participants may have responded in a certain way to a self-report questionnaire due to a social desirability response bias (Fan et al, 2006). For example, the participants may not have spoken as much Welsh in the home as parents reported as the parents may have responded in a way to appear more favourable to the experimenter (Furnham, 1986). Arguably, some of the parents may have viewed speaking more Welsh as a socially desirable behaviour and therefore over-reported it due to this response bias.

It is also interesting to note that although no significant effects arose, participants from WEH responded quicker than those from EOH on the English Stroop-task, arguably due to bilingualism enhancing their task-switching and inhibition ability (Martin-Rhee & Bialystok, 2008). While this research does not strongly support previous research finding a bilingual advantage in children’s inhibition and task-switching ability as no significant effects were found, it does support findings that bilingual children respond faster than monolingual children on the Stroop-task (e.g., Badzakoda-Trajkov et al, 2008; Chen et al, 2014; Gathercole et al, 2010). However, as Ross & Melinger (2017) argued previously much of the supporting evidence presents marginal findings as with the supporting findings from this study only being minor.

In spite of these findings being insignificant and minor, the background methodological checks revealed significant SESav and FSM effects as those from WEH and a Welsh medium school were from lower SES backgrounds than those from EOH and an English medium school. Interestingly, previous research has argued that those from low-SES backgrounds are at risk of delays in EF development, with research showing how household income and parental education negatively affect EF (Hackman et al, 2015). Yet the results from this study displayed that those low-SES highly proficient bilingual children were faster than the high-SES lowly proficient bilingual children on the English version of the Stroop-task. Although they were not significantly faster, future research replicating this study using a larger more representative sample size with no significant SES findings may have discovered a significant advantage in EF in the bilingual sample compared to the monolingual sample.

Research exploring parental incentives for choosing a Welsh-medium education has found many choose this type of education because of elitist ideas that Welsh-medium schools provide a better education and have a better reputation than English-medium schools (Hodges, 2012). Further research found that Welsh-medium schools have a lower proportion of pupils from low-SES backgrounds compared to those from English-medium schools (Jones, 2017). However in this study, participants from the WOH were from lower SES backgrounds than those from EOH, challenging this perception of elitism within the Welsh language.
Further research should explore whether the way a second language is acquired may or may not influence EF differently, as there are many ways to be bilingual. For example, some are born bilingual, some pursue bilingualism and others are forced into bilingualism in later life (Bialystok, Craik, Green, & Gollan, 2009). Research has not yet compared if there are bilingual differences within EF between different types of bilinguals who have learnt a second language differently, yet this may be something important to consider. Also further research should explore if these advantages in EF are exclusive to only some types of languages or if there are universal bilingual language advantages as for example Prior and Gollan (2011) found EF advantages in Spanish bilinguals but not in Mandarin bilinguals.

Although Friedman et al (2008) found evidence which suggests the Stroop-task measures the inhibition component of EF, it is unclear whether the Stroop-task is a reliable measure of inhibition. Research measuring a group of children’s inhibition abilities through using a Stroop-task, a Simon task and a Flanker task found no correlation between the tests, therefore it is unclear whether the Stroop-task is a successful measure of inhibition within children (Stins, Polderman, Boomsma, & de Geus, 2005). Hilchey & Klein (2011) argue that in order to measure inhibition a Stroop-task may not be appropriate as it is noticeably language driven. Further research should explore the possibility of an inhibitory control or task-switching advantage within bilinguals through using other types of tests and not only the Stroop-task. However, little is known about EF and the tasks used to measure its components, questioning the validity of research using tests measuring EF (Valian, 2015).

Future research should also consider other factors which have been argued to influence EF, as differences found may be a result of other experiences. For example, musically trained individuals have been argued to have an advantage within task-switching (Moradzadeh, Blumenthal, & Wiseheart, 2015). Children who are more physically active are also argued to have better EF than those who are less physically active (Best, 2010). Video gaming has also been argued to enhance cognition (Boot, Blakely & Simons, 2011). These factors were not considered within this study, yet could have influenced participant’s performance. Measuring if participants played a musical instrument, played video games or were physically active may be important for future research to assess whether any EF differences found between bilinguals and monolinguals are due to language differences and not other EF enhancing experiences.

Future research could also explore children’s intelligence levels through using an intelligence test as this was not explored within this study. Research has found those with higher intelligence perform better on tests of EF such as the Stroop-task (Arffa, 2007). Reading and arithmetic abilities have also been argued to enhance the EF of children (Gathercole et al, 2014). Arguably, some children may have had better EF skills because of their intelligence levels or their reading and arithmetical abilities and not because of their bilingual experience. Therefore it is important to consider all factors which may enhance a child’s EF before concluding that it is down to a bilingual language advantage alone.
4.3 Conclusion:

Background methodological checks revealed significant relationships between participants’ home language use and SESav, home language use and FSM and school language use and SESav. Therefore, as the methodological checks revealed these significant associations, any Stroop interference differences could not be attributed to bilingual or monolingual language differences alone and SESav and FSM could also attribute to any differences found within the Stroop-task. Those from WEH and from the Welsh-medium primary school were from lower SES backgrounds than those from the EOH and from the English-medium primary school. Future research should use a larger and more representative sample size, as it is possible with a larger sample that no significant relationships would have occurred with participants SES backgrounds and therefore the research would have been a better measure of highly proficient bilingual and lowly proficient bilingual language differences within the inhibition and task-switching elements of EF.

As much of the research is not coherent or consistent this research used a Stroop-task to explore and compare highly proficient Welsh-English bilingual children and lowly proficient English-Welsh monolingual children aged between nine and eleven years old from a Welsh-medium school and English-medium school measuring their task-switching and inhibition ability. No significant bilingual advantages emerged, supporting research which finds no bilingual advantage (e.g. Paap et al, 2015; Hilchey & Klein, 2011).

Arguably due to error, participants from EOH responded faster in the Welsh Stroop-task than they did in the English Stroop-task; also they responded faster in the Welsh Stroop-task than those from WEH. It is a possibility that they did not understand the colour words written in Welsh and therefore were faster in recognising the colour of the word as they did not experience the interference from reading the word in Welsh.

Interestingly although no significant effects arose, participants from WEH responded faster than those from EOH on the English Stroop-task, arguably due to bilingualism enhancing their task-switching and inhibition ability. More interestingly is that previous research argues those from high-SES backgrounds have enhanced EF abilities (Hackman et al, 2015), yet the children from the Welsh-medium school coming from lower-SES backgrounds responded faster than those from the English-medium school from high-SES backgrounds. Although this finding was not significant future research using a larger sample size may find a significant difference.

To conclude, lots of experiences may influence EF but it is still unclear whether bilingualism enhances children’s task-switching and inhibition abilities. This study did not support a bilingual EF advantage however there were many limitations within this study. Future research using a larger sample size should be conducted as research is inconsistent on whether a bilingual EF advantage exists. The bilingual children were faster in the English Stroop-task although not significantly, therefore a bilingual advantage cannot be ruled out completely.
References


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