AN ASSESSMENT OF THE EFFECTS OF SES ON THE DEVELOPMENT OF EXECUTIVE

ATTENTION IN SINGAPORE: 4 TO 6-YEAR-OLD ENGLISH-MALAY BILINGUALS

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ABSTRACT

Socioeconomic status (SES) is known to correlate with various aspects of cognitive development in childhood (Gathercole, Thomas, Jones, 2010; Noble, McCandliss, & Farah, 2007). In particular, previously attested advances in executive attention (EA) attributed to bilingualism in childhood (Bialystok, 2011; Yang, Yang, & Lust, 2011) have been argued to be confounded by variations in SES in the populations studied. Hence, results must now be tested for generalizations across cultures and varying levels of SES. Our study tests whether SES variation arrests superior EA in childhood, in a predominantly bilingual Singaporean Malay population. Thirty-four English-Malay bilingual children (19 females, 15 males) from Singapore were tested in this study. This sample had a mean age of 66.91 months (SD = 9.14), with ages ranging from 43 to 101 months.

Although this Malay sample revealed several SES measures below the Singapore mean, their EA rates as tested by the child-Attention Network Test (Rueda et al., 2004) remained high when compared to other populations of monolingual and bilingual children (Yang et al., 2011; Kang, 2009). In addition, EA was strongly correlated with English vocabulary, but not significantly correlated with any of the three SES measures (father's and mother's education, and income). However, income was significantly correlated with English vocabulary scores. Our findings suggest that SES deficits alone are insufficient to diminish high EA rates, as previous literature hypothesized (Mezzacappa, 2004; Morton & Harper, 2007). We conclude that development of bilingualism and SES are partially independent variables (Bialystok, 2011; Gathercole et al., 2010); although SES components can and do modify language development.

BIOGRAPHICAL SKETCH

Carissa Kang Pei Shan was born on September 20, 1986, in Singapore. She received a Bachelor's degree in Social Sciences (*cum Laude*) in 2005 from the Singapore Management University, and went on to complete her Master's in Education (Ed.M.) at the Harvard University Graduate School of Education. She then joined the doctorate program at Cornell University (School of Human Ecology) in 2011.

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CHAPTER 1

INTRODUCTION

Research on the early acquisition of two languages has revealed a bilingual advantage on tasks requiring executive control, in young children between the ages of four and eight (Barac & Bialystok, 2012; Bialystok, 1997, 1999; Bialystok & Viswanathan, 2009; Carlson & Meltzoff, 2008; Yang et al., 2011). Executive control, or executive function (EF), comprises inhibiting attention to misleading information, selective attention, and switching (or shifting) attention in tasks with distracting and competing cues (Bialystok & Martin, 2004). Bilinguals outperformed their monolingual counterparts on tasks requiring attentional control in ignoring certain perceptual features of stimulus or tasks requiring behavioral inhibition (Bialystok, 1999).

Despite positive evidence from studies that reveal a bilingual cognitive advantage, other studies have argued that the supposed advantage might be confounded with several variables like culture and socioeconomic status (SES). For example, with regards to SES, some have argued that the bilingual advantage on EF tasks is due to bilinguals in previous studies being recruited from higher SES families, compared to monolinguals from lower SES homes (Mezzacappa, 2004; Morton et al., 2007). In line with earlier research, SES has been found to correlate with various aspects of cognitive development in childhood, and children from low SES families tend to perform poorly on executive control tasks, compared to their wealthier counterparts (Gathercole et al., 2010; Noble et al., 2005). Hence, Mezzacappa (2004) urged researchers to be cautious when measuring cognitive functions in children, because of the independent and considerable influences of SES on the outcome.

In confronting the issue of SES as a confounder in the bilingual cognitive advantage, we will necessarily confront several research challenges. In general, studying bilinguals is

undeniably a complex and challenging task. Several issues have to be considered, including

theoretical models in bilingual language development, bilingual competence, conceptual

definitions (i.e., how to define bilingualism) and methodological concerns (i.e., characterizing

participants) (Grosjean, 1998, 2004). An important issue to be highlighted is that of assessment

tools −what type of cognitive effects the researcher wants to focus on, and what assessment

methods to employ. Due to the broad definition of ″Executive Function″ (EF), many studies use

a wide variety of EF tasks to measure this concept. For example, the Dimensional Change Card

Sort' (DCCS) task (Zelazo, Frye, & Rapus, 1996) and the Simon task have often been used as a

measure of EF. However, these two tasks involve different aspects of EF that may not be inter-

related, which led to conflicting results across studies (Yang & Lust, 2005). To resolve this

problem, the present study will look at a specific aspect of EF – Executive Attention (EA, a sub-

set of EF) as a focused cognitive measure. In this thesis, EA will be measured using the child-

Attention Network Test (child-ANT) (Rueda et al., 2004), which measures three attentional

components quickly and efficiently (Posner & Fan, 2004; Posner & Petersen, 1990; Posner &

Rothbart, 2007).

Another methodological issue that commonly arises pertains to population characteristics.

Often, researchers do not agree on the characteristics that define a bilingual, as well as the

diverse factors that have been used to recruit participants (Grosjean, 1998, 2004). In this thesis,

we address this by recruiting a sample of simultaneous bilingual children who grew up in

Singapore, and were exposed to two languages before the age of 4. Malays are a minority ethnic

group representing 13.4% of the 4-million population (Singapore Department of Statistics,

2011). Compared to the other major ethnic groups in Singapore, an overwhelmingly large

proportion of Malays − 82.7% - speak their mother tongue (Malay) at home (Singapore

Department of Statistics, 2010), while education in schools is primarily in English. This would make this sample an ideal natural bilingual group.

Importantly, due to the difficulty in dissociating socio-cultural demographics like the influences of culture and SES from bilingualism per se, a researcher has to be cautious about who to choose as the target population. According to some, the bilingual cognitive advantage may be confounded with the influences of the East Asian culture (Carlson, 2008; Lewis et al., 2009; Oh & Lewis, 2008; Sabbagh et al., 2006). One reason why researchers believed that Asian children had higher cognitive control (compared to their Western counterparts) is related to Asian parenting practices that emphasize self-regulation (Lewis et al., 2009). For example, Chinese preschools place greater emphasis on impulse control as compared to U.S. preschools (Tobin, Wu, & Davidson, 1989). Moreover, Chinese parents also expect their child to be adept at self-regulation and controlling impulses as early as two years of age, compared to Canadian parents who expect their children to be able to do so only after they attend preschool (Chen et al., 1998). Consequently, the cultural norms in Chinese societies provide Chinese children with more opportunities to hone their executive function skills, and this could explain why they often outperform their European-American counterparts on these tasks.

Singapore is a multilingual, multi-racial island in Southeast Asia known for its mandatory bilingual education policy since 1966 (Dixon, 2005). Therefore, it would be an ideal place for bilingualism research. Importantly, Singapore's multi-ethnic environment makes the studying of cultural and language contrasts more salient. The Malay culture has been specifically chosen because it has not been studied previously in the literature (e.g., African America, Hispanic, Koreans, and French-Canadians are some examples of groups that have been studied). Results should now be tested for generalizations across cultures and corresponding SES types, and

further analyses should be conducted to investigate the mechanisms by which SES may exert its influence on the bilingual cognitive advantage. The present study tests whether SES variation and bilingualism are related in childhood in a predominantly bilingual Singaporean Malay population. Related to this, previous work in Singapore recruited 50 English-Chinese bilingual preschoolers assessed within-group difference in literacy levels and its relationship with the bilingual advantage on executive attention (measured via the child-ANT) (Kang, 2009). Our study adopted a similar methodology in measuring SES, executive attention and vocabulary.

With respect to the SES issue, Singapore's competitive culture has made it such that the socio-economic progression of the Malays still falls far behind that of the Chinese and Indians (Mutalib, 2005). Statistics revealed that the average monthly household income of the Malays are the lowest of the three main ethnic groups (Chinese & Indians), standing at S$4,575 per month, compared to the Chinese and Indians (S$7,326 and S$7,664 respectively) (Singapore Department of Statistics, 2010). This implies that the Malay population would be an ideal group of 'low-SES' sample to study. Through comparisons of the two bilingual samples in Singapore (i.e., Malay and Chinese), this thesis sets out to examine the role of SES in influencing the within-group bilingual outcome on executive attention.

CHAPTER 2

BACKGROUND

2.1: Brief History of Bilingualism Research

Until the 1960s, bilingual education in young children was discouraged due to a plethora of findings from studies revealing that learning two languages resulted in the retardation of mental growth in children (Saer, 1924; Goodenough, 1926). The turning point occurred in 1962 when Peal & Lambert's research findings challenged the commonly held notion that bilingual education would produce 'retarded' children who were incapable of functioning in both languages (Arsenian, 1937; Darcy, 1953, 1963; Tucker & D'Anglejan, 1971). Unlike previous studies, Peal et al.'s (1962) controlled for group differences in socioeconomic status, age, and sex. They found that bilinguals significantly outperformed monolinguals on verbal and non-verbal tests requiring symbolic flexibility and concept formation. Peal et al. (1962) exercised great caution in differentiating between balanced bilinguals and pseudo-bilinguals; the former ones being proficient in both their first and second languages (L1, L2), while the latter not having attained age-appropriate proficiency in their L2. Thus, their sample only had balanced bilinguals who had almost equal proficiency in both languages. The careful selection of their sample raised the importance of selecting the appropriate bilingual samples as comparison to monolingual counterparts in this field of research.

After Peal et al.'s (1962) revolutionary study changed the world's view on the effects bilingualism, several other researchers began studying bilingualism and its positive cognitive effects. Majority of the studies revealed that balanced bilinguals were advantaged in several cognitive abilities, like metalinguistic awareness (Cummins, 1978) and concept formation (Liedtke & Nelson, 1968). Ben-Zeev (1997) also found that bilinguals were better able to assign

structure to perceptual information presented to them, and had greater ability to reorganize their perceptual world. She postulated that knowing two languages forces the bilingual child to develop coping strategies to minimize interference from each language and this in turn speeds up the child's cognitive development (Ben-Zeev, 1997).

Several reasons have been proposed to explain the bilingual cognitive advantage – one of which is related to the concept of "inhibition". A high level of cognitive control is required to perform executive control tasks, in order for one to inhibit unrelated cues, or to isolate linguistic form and meaning (Bialystok & Ryan, 1985). To successfully complete EF tasks, one has to ignore distracting or contradictory information. Bilinguals are often better at these tasks because of their constant practice with controlling two languages in their minds – suppressing the non-target language when it is not being used (Bialystok, 1993, 1999, 2001; Green, 1998). The practice that bilinguals get in controlling two languages results in a more advanced EF, which plays a role in enhancing performance on non-linguistic cognitive control tasks.

More recently, results from bilingual infant studies revealed that the bilingual cognitive advantage is not necessarily primarily attributed to suppression or inhibition of irrelevant stimuli (Sebastián-Gallés et al., 2012; Kovács & Mehler, 2009). Results from eye-tracking studies showed that preverbal 7-month-old bilingual infants (raised as simultaneous bilinguals from birth) exhibited superior cognitive control abilities in comparison to their matched monolingual counterparts (Kovács et al., 2009). This implies that inhibiting one language while speaking the target language is not necessarily required for EF advancements. Processing two languages and managing both languages' representations well before speech onset is sufficient in explaining the advanced domain-general EF abilities in bilingual infants (Kovács et al., 2009). Thus, the authors argued that bilinguals' well-developed EF skills aid them in separating and monitoring the

linguistic representations of two languages, and this result in the efficient acquisition of both languages.

2.2: Executive Function/Executive Control

The bilingual advantage in attention has been found specifically in executive function, or executive control. These two terms have often been used interchangeably in the literature, but the term "executive function" (EF) will be used in this paper. Executive function comprises inter-related high-level cognitive abilities (Diamond, 2012; Rose, Feldman, & Jankowski, 2012). It is required for academic achievement as well as behavioral and social competence (Jurado & Rosselli, 2007). These include planning, decision-making, overcoming habitual actions, problem solving, thinking flexibly and detecting errors or novel responses (Posner & Fan, 2004; Rose et al., 2012). The development of EF is extended over a long time period, but a child's self-control over his or her thoughts, emotions and behaviors increases considerably during the preschool period (Carlson & Meltzoff, 2008).

The prefrontal cortex has a critical role to play in developing EF skills (Bialystok, Craik & Ryan, 2005). In general, EF consists of 3 primary components – Inhibition (inhibitory control), Updating (working memory), and Shifting (cognitive flexibility) (Miyake et al., 2000). Inhibition involves how one controls his/her behavior, emotions, and attention, while Updating is defined by how an individual holds information in the mind and mentally work with it. Lastly, shifting is the ability to switch flexibly between tasks, mental sets, or strategies (Miyake et al., 2000). Studies of adults and school-aged children proposed that the developmental changes in EFs are foundational abilities in information processing like *memory, speed, and attention* – and these factors explain the significant individual differences in EFs (Rose et al., 2012). For children, developmental improvements in attention efficiency (as measured by the ability to

disregard irrelevant information) are related to similar developmental improvements in working memory (Cowan, 2011).

2.3: Tasks Measuring Executive Function

The bilingual advantage on EF tasks is highlighted in several nonverbal tasks with perceptually distracting cues, like the **'Dimensional Change Card Sort' (DCCS) task** (Zelazo et al., 1996). In the DCCS task, two target cards are first presented – for example, a blue circle, and a red square. Then, other cards with circles and squares are presented, but these shapes have the opposite color (i.e., red circle and blue square). In the pre-switch trials, children have to sort cards presented to them first according to one dimension (like color). After a few trials, the rules would change in the post-switch trials, and the card sorting would have to be done according to another dimension (i.e., shape). In the pre-switch trials, monolingual and bilingual children perform equally well. However, the bilingual advantage is most evident in the post-switch trials, when children are required to sort the cards based on another dimension. On these trials, bilingual children show more accurate and faster performance (Bialystok, 1999).

The **Simon task** is another example of a cognitive control task that highlights the cognitive processes characterizing the bilingual cognitive advantage (Bialystok et al., 2004). This moderately content-free task measures stimulus-response compatibility, or the extent of how irrelevant spatial information influences response time to the task-relevant non-spatial information. Colored stimuli are presented on the right or left side of a computer screen and each of the two colors correspond to a response key on the right or left side of the keyboard, in line with the positions of the stimulus. A congruent trial involves pressing the correct response key for the color that is on the same side as the stimulus, while an incongruent trial occurs when the stimulus and the correct key appear on opposite sides. The increased time required to respond to

incongruent trials is termed the *'Simon effect'*; a smaller Simon effect implies that the

incongruent items are less disruptive for the participant. 4-year-old bilinguals demonstrated a

smaller Simon effect on incongruent trials, compared to their monolingual counterparts

(Bialystok et al., 2004). Thus, the bilinguals' lower inhibition cost (i.e., smaller Simon effect)

indicated more efficient inhibitory control.

Bilinguals show this advantage because both languages are activated when either one

language is being used. Thus, EF – specifically, **interference suppression** – is required to direct

attention to the representational system that corresponds to the target language, while ignoring

the system associated with the non-target language. In the course of bilingual language

production, bilinguals frequently employ interference suppression, and this regular practice with

suppressing irrelevant stimulus results in better performance on tasks requiring interference

suppression (Bialystok et al., 2008).

2.4: Executive Attention: A More Specific Measure

Executive attention (EA) is a more precise and measurable subset of executive function.

EA defined as a conscious process that directs our thoughts and actions and provides us with the

necessary resources to pick out essential information in a sea of environmental stimuli (Posner &

Fan, 2004). It emphasizes the role of attention for use in monitoring and resolving conflict in

different brain areas (Posner & Fan, 2004). EA comprises a set of cognitive processes including

the control of impulse, structured search, planning, and strategy utilization (Oh et al., 2008). On

the other hand, as EF comprises several components, different aspects of EFs contribute

differently to the various executive control tasks that have been employed. This is also known as

the "task impurity problem", an issue that is especially problematic in EF studies (Miyake et al.,

2000). For example, in the DCCS task, apart from measuring EF, other cognitive processes are

involved as well. A child's successful performance on this task is contingent upon his/her ability to switch between two incompatible rules visually presented together in one card. In addition to the child's ability to inhibit conflicting rules, h/she also has to hierarchically represent a structured rule system – and this does not necessarily bear on the definition of EF.

Due to the task impurity issue, inter-correlations among different EF tasks are very low (r=0.4 or less) (Miyake et al., 2000). Several studies investigating EF development in preschoolers approach the concept of EF differently because of varying EF definitions and the different components of EF that scholars have not been able to agree upon (Miyake et al., 2000). Consequently, there is less agreement on the components of EF that is affected by bilingualism (Bialystok et al., 2009). Past research examining cognitive advantages in bilingual children used a diverse range of tasks and methodologies, which oftentimes led to conflicting results across studies (Bialystok, 1999; Bialystok & Viswanathan, 2009; Morton & Harper, 2007; Yang, 2004; Yang, Yang, & Lust, 2011). This explains why the present paper has decided to focus on a more specific sub-set of EF – Executive Attention.

Posner & Peterson (1990) first showed that attention sources could be broken down into three networks that carry out the alerting, orienting and executive control (conflict) functions. Later, neuroimaging studies revealed different anatomies of the three networks (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). The Alerting network correlated with thalamic activations, the Orienting network with parietal activations, and the Conflict network with Anterior Cingulate Cortex activations (Fan et al., 2005). Building on this, Fan et al. (2002) developed the computerized Attention Network Test (ANT), a behavioral task that involved all three networks. The ANT allows researchers to obtain efficiency scores of each network (as calculated by the computer), and is easy to administer in older children and adults (MacLeod et

al., 2010). Rueda et al. (2004) later created a child-friendly version of the ANT, the child-ANT, which will be employed in the measurement of EA in this thesis. This task will be described in greater detail in Section 4.3.2.

Aside from the issues with EF measurements, socioeconomic status (SES) is also another pressing problem that has been raised as a confounding variable in bilingualism studies.

2.5: Socioeconomic Status (SES) as a Confounding Variable

Controlling (or not controlling) for SES is an important issue that played a large role in inconsistent research findings in the bilingual cognitive advantage (Woodard & Rodman, 2007). For example, some authors argued that the bilingual advantage in EF can be attributed to higher socioeconomic status (SES) rather than bilingualism per se, and that SES differences between the monolingual and bilingual groups is a confounding factor (Morton & Harper, 2007). Morton et al. (2007) explained that the bilingual advantage is observed because bilingual populations tend to come from families of higher SES, who are often second language (L2) immigrants seeking higher education. Monolinguals, on the other hand, are from the general local population, who often tend to be of lower SES. Due to mismatch in SES across bilingual and monolingual groups, the unequal opportunities enjoyed by the higher SES bilingual children could have contributed to their better performance on EF tasks, rather than bilingualism per se.

Before delving further into how SES could be a confounding variable in this research area, we first discuss how SES is typically measured, and the general effects of SES.

2.5.1: SES measurements & General effects of SES

A common and stable measure comprises occupation, income, and education, because these three factors together are a better representation of SES than any one of them alone (Ensminger & Fothergill, 2003; McCloyd, 1998; White, 1982). However, there are several other

factors that play a role in influencing the effects of SES on cognitive development – home environment, physical health, neighborhood characteristics, and early education (Noble et al., 2005). Despite the general consensus of what should be measured to determine one's SES level, several arguments remain unresolved. For example, some arguments involve how to composite the three indicators into one SES measure, and how to most accurately measure each component (Krieger et al., 1997). Thus, the measurement of SES still remains open. However, an important point to note is that SES indicators vary across different cultures (Bradley, 1994; Bronfenbrenner, 1995).

In general, SES has been strongly associated with a wide variety of cognitive, health, and socioemotional outcomes in children, with effects beginning prior to birth and lasting through adulthood (Bradly & Corwyn, 2002; Hackman & Farah, 2008; Noble, Norman, & Farah, 2005). Many mechanisms associating SES and child well-being have been postulated and differential access to social and material resources is one of the most common reasons (Bradly et al., 2002). SES influences multiple levels of children's well-being, encompassing both the family and neighborhood. However, its effects can be moderated by a child's personal and family characteristics, as well as the support systems of the child and family (Bradly et al., 2002). Typically, children from high SES families have greater access to material goods, services, social connections and parental actions, compared to those from low SES families who are less privileged in terms of these resources (Bradly et al., 2002). Thus, low SES children are at risk for several developmental problems (Brooks-Gunn & Duncan, 1997).

Several outcome measures can be predicted with SES, some of which include IQ and academic achievement (Bradley et al., 2002; Duncan et al., 1994; Smith, Brooks-Gunn & Klebanov, 1997) and functional literacy (Baydar, Brooks-Gunn & Furstenberg, 1993). In one

study, SES accounted for almost 20% of the variance in childhood IQ (Gottfried, Bathurst, Guerin & Parramore, 2003). With regards to language development, phonological awareness, speech complexity, and receptive and expressive vocabularies have been consistently shown to vary across SES levels (Whitehurst, 1997). In a classic study of language ability and SES, the average vocabulary size of 3-year-olds from welfare families was less than half of those from professional families (Hart & Risely, 1995).

In line with the aim of the present thesis to investigate the role of SES on EF, the next sub-section narrows in on the effects of SES on cognitive development.

2.5.2: SES & Executive Function

Several studies have demonstrated that children from low SES backgrounds perform poorer on EF tasks, compared to their wealthier counterparts (Ardila, Rosselli, Matute, & Guajardo, 2005; Howse et al., 2003; Hughes & Ensor, 2005; Lipina et al., 2004; Mezzacappa, 2004; Noble et al., 2005). In Noble et al.'s (2005) study, 30 middle SES and 30 low SES African-American kindergarteners from various Philadelphia public schools were assessed for their neurocognitive functioning, to evaluate the impact of childhood SES on different neurocognitive systems. Of the five neurocognitive systems that were examined (visual, spatial, memory, language, and executive system), the language and executive systems were disproportionately associated with SES. Low SES children performed worse than their middle SES counterparts on most measures of these two systems, with a moderately large effect size for the executive system, and a large effect size for the language system (Noble et al., 2005).

The authors argued that the associations between SES, language and executive function revealed a possible causal pathway. While SES and EF predict language ability independently, SES did not statistically account for variance in EF, above what was predicted by language.

Thus, SES might have an effect on language, which subsequently drives EF performance independently (Noble et al., 2005). Another explanation could be that an external variable correlated with SES was influencing both language and EF, but this variable has a stronger association with language than EF abilities. The authors explained that the associations between cognitive ability and SES are disproportionate for language and EF could be due to environmental influences. The extended maturation period of the language and EF systems leads to higher susceptibility to environmental influences which may mediate outcome. Alternatively, the different systems may be differentially associated to enculturation processes that differ across SES levels. That is, SES differences are correlated to distinct differences in literacy environment at home, and these differences have been related to development in language skills (Whitehurst, 1997). The present thesis incorporates a simple language skill test to examine the relationship between SES, language development, and EA.

Numerous studies have investigated various aspects of attention in children from varying SES backgrounds (Farah et al., 2006; Lipina et al., 2005; Mezzacappa, 2004; Noble et al., 2007; Noble et al., 2005). In these studies, children from low SES backgrounds encounter difficulties with attention as early as their first year (Lipina et al., 2005), persisting into early adolescence (Farah et al., 2006). One study examined Argentinian 6- to 14-month-old infants (Lipina et al., 2005) on the 'A-not-B' task that measures inhibitory control and working memory. Infants from lower SES families performed worse on the task, compared to the higher SES infants. The authors highlighted that early differences in attentional abilities could be a predictor for attention and EF abilities later on in life. This is because attention deficits influence the early stages of perceptual processing, and might have cascading consequences on other skills development (Stevens, Lauinger, & Neville, 2009). Furthermore, attention deficits in lower SES children later

on in life were also found in Mezzacappa's study (2004), where SES disparities in the 'executive attention' measure of the Attention Network Task (Rueda et al., 2004) in 249 5- to 7-year-olds were seen. Lower SES children showed a decreased ability in ignoring distracting information, and were less influenced by alerting cues that were crucial in improving accuracy and reaction times.

All of the above studies in this section involved monolingual samples. The next section discusses the influences of SES on attention in bilingual populations.

2.5.3: SES, Bilingualism & Attention

Morton et al. (2007) argued that monolingual and bilingual samples come from distinct SES groups, and the higher SES of the bilinguals may be an important factor that explains bilinguals' superior performance on EF tasks. A recent study focused on the effects of linguistic knowledge, language dominance, SES and general cognitive abilities on the cognitive effects of bilingualism (Gathercole et al., 2010). Two major areas were explored, (i) extent to which the bilingual advantage is observed in EF tasks across children with different language dominance levels, and (ii) extent to which linguistic abilities, language use, general cognitive knowledge, and SES influences performance.

English monolingual and Welsh-English bilingual primary school and teenage children were tested on a Stroop task, a tapping task, and two EF tasks. They were also administered tests on vocabulary (English & Welsh), receptive grammatical knowledge (English & Welsh), and general cognitive ability. The bilingual children's homes were either only-Welsh speaking, only-English speaking, or Welsh and English speaking. Subjects were divided into two age groups – 7-8 and 13-15 years of age. SES was measured using parental education and occupations.

For the Stroop task, the bilingual advantage was only observed for younger children from English and Welsh homes (when tested in English). Additionally, performance differed according to cognitive abilities, SES level, use of two languages, and vocabulary levels. For the tapping task, bilingual children from "only-Welsh" families performed best, followed by the other two bilingual groups, and the monolinguals. Performance on this task correlated with age (older children had better performance), more balanced use of the bilingual's two languages, and general cognitive abilities (pertaining to pattern and number discrimination). The authors concluded that although some bilingual advantage was observed in certain tasks, not all bilinguals showed this advantage, and this advantage was not present across all conditions, SES levels, linguistic, and general cognitive factors (Gathercole et al., 2010). Therefore, despite the evident bilingual advantage demonstrated in this study, the authors noted that this advantage is influenced by several other factors. Importantly, beyond the linguistic and cognitive factors, SES level was especially influential in the Stroop task. Once again, this highlights the importance of considering SES as a potentially influential factor in the bilingual literature.

On the other hand, however, other studies have also revealed positive effects of bilingualism for low-SES Spanish-English bilingual children on EF (Carlson & Meltzoff, 2008; Engel de Abreu, Cruz-Santos, Martin, & Bialystok, 2012; Mezzacappa, 2004). In Mezzacappa's (2004) study, the child-Attention Network Task (ANT) (Rueda et al., 2002) was administered to a diverse sample of 249 children. The child-ANT measures alerting (effortful processing), orienting (responding to orienting cues) and executive attention (conflict response). Overall, although the socially advantaged children performed better on the executive attention task, interestingly, results also revealed that exposure to two languages (which may be loosely

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translated as being bilingual) aided some Hispanic children in performing more proficiently on the task (Mezzacappa, 2004).

The most recent study documenting how bilingualism improves cognitive control in low-income children tested matched Portuguese monolingual and Portuguese-Luxembourgish bilingual children from low-income immigrant families in Luxembourg (Engel de Abreu et al., 2012). The sample was matched based on ethnicity, gender, age, and the International Socio-Economic Index of occupational status (Ganzeboom, 2010). Participants were tested on selective attention, interference suppression, abstract reasoning, and visuospatial working memory. SES was measured using several indices, some of which include parental education, child's body mass index, and household size and possessions. Importantly, the bilingual group was disadvantaged based on household possessions, household size, and parental education. All bilinguals were from low-income households, with 18% falling below the poverty line.

The authors investigated two components of EF, (i) "Representation" (i.e., working memory and abstract reasoning) and (ii) "Control" (i.e., selective attention and interference suppression) (Engel de Abreu et al., 2012). No group differences emerged for "Representation" tasks, but bilinguals performed significantly better for the "control" tasks, compared to the monolinguals. The authors concluded that SES and cultural factors were neither confounding nor limiting variables in the bilingual advantage in executive function. The bilingual control advantage was seen in children from low-income families, and this had a large effect size. To rule out previous claims that bilingual advantages are confounded by SES or cultural differences (Morton et al., 2007; Oh & Lewis, 2008), precise matching of children was done across bilingual and monolingual groups. Overall, the results were consistent with the general idea that bilinguals' constant use of their executive control system to resolve conflict between their two

languages enhances their control processes. Consequently, bilinguals become more proficient at EF tasks (compared to monolinguals) that require focusing on relevant aspects of a problem, managing attention, and overcome distracting or irrelevant information in the environment (Bialystok, 2001).

Although adverse early childhood experiences has been overwhelmingly and conclusively shown to negatively influence children's cognitive development, Engel de Abreu et al.'s (2012) study demonstrated that low SES bilingual children significantly outperformed monolinguals in executive control, despite growing up in environmental circumstances that would usually impede cognitive performance. This is an example of how cognitive reserve enables the brain to maintain normal or enhanced functioning despite being in adverse conditions (Stern, 2003). Lifelong bilingualism has shown to increase the elderly's cognitive reserve through reducing the negative effects of dementia (Craik, Bialystok, & Freedman, 2010). In line with this, Engel de Abreu et al.'s (2012) study raised the idea that bilingualism might also serve as a buffer against the adverse effects of poverty on cognitive processes. Constantly using more than one language stimulates the mind and offers more opportunity to enhance executive control mechanisms, subsequently buffering against the negative effects of poverty on cognitive development. Lastly, another prominent finding was that despite the bilingual children's poor performance on the vocabulary tests, cognitive benefits were still observed. Hence, the bilingual cognitive advantage is still possible despite a bilingual having low degrees of proficiency in both their languages (Engel de Abreu et al., 2012).

In light of the existing results, this study sets forth to explore if SES variation affects EF performance similarly within bilingual groups.

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CHAPTER 3

RATIONALE FOR PRESENT STUDY

The present thesis addresses how SES influences EA in young bilingual children in Singapore. The next section provides a brief review of the findings from previous studies.

3.1 Review of previous studies, issues with findings

In terms of SES, Engel de Abreu et al.'s (2012) study was one of the first studies that proposed the idea of bilingualism acting as a 'buffer' (i.e., cognitive reserve) against the negative effects of poverty on cognitive development in children. Although the Portuguese-Luxembourgish bilingual children came from low SES immigrant families in Luxembourg and performed significantly worse than their matched monolingual peers on vocabulary tests, they outperformed the monolinguals on executive control tasks. However, as this was one of the earlier studies that studied low SES bilingual immigrant children in Europe, the buffering effects of bilingualism against poverty's negative influence on cognitive development should be tested in other cultures. Aside from this, as the mean age of the population was approximately 8 years old, we do not know if the buffering effects of bilingualism holds for younger children who have had less years of experience with both languages. Thus, there is a need to test a younger sample (i.e., preschool age) of low SES bilingual children to examine if the buffering effects of bilingualism against the negative effects of poverty hold for younger bilinguals. If superior performances on EF tasks are exhibited by low SES bilingual preschoolers, this would imply that (i) bilingualism buffers against negative effects of poverty even in younger children who have had fewer years of experience with learning two languages (and most possibly have poorer vocabulary proficiencies in both languages) and that (ii) low vocabulary proficiencies in a bilingual's two languages does not exclude young bilinguals from experiencing the buffering

effects of bilingualism on the negative impact of poverty. That is, the mere experience of constantly using more than one language leads to enhancement in EF mechanisms, and this has practical implications for language education policies – especially so for low SES neighborhoods.

To make conclusions about the bilingual advantage, it is necessary to compare monolinguals and bilinguals. In this thesis, comparisons will be drawn with Yang et al.'s (2011) study which employed the same methodology. In their study, Yang et al. (2011) attempted to dissociate the bilingual advantage from possible cultural effects. Monolingual (Korean, English) and bilingual (Korean-English) children were recruited from U.S. and Korea, and compared on the child-ANT (Yang et al., 2011). The authors postulated the bilingualism stimulates cognitive advancement over and above the influence of culture, and that the Korean-English bilinguals (in both U.S. and Korea) would outperform both monolingual groups. Results revealed that the Korean-English bilingual group residing in U.S. outperformed their monolingual counterparts (English and Korean monolinguals in U.S., and Korean monolinguals in Korea). Despite living in the U.S. where the cultural norms differ from the typical Asian cultural norms, the Korean-English bilinguals (U.S.) outperformed the Korean monolinguals in Korea. This implies that the early and efficient use of executive functioning in young bilinguals transcends potential Asian cultural benefits. On the other hand, results also revealed cultural effects that exist independently of bilingualism. The monolingual Korean children in Korea outperformed the monolingual Korean children in the U.S. on the child-ANT, showing greater accuracy (Yang et al., 2011).

However, a fourth sample of Korean-English bilinguals residing in Korea should have been included in this study as well. If no differences are found between matched bilinguals in different cultures (Korea and America), a more persuasive argument for the bilingual advantage

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transcending the effects of culture would have been made. In addition, there might have been other confounding variables that made cultural contrasts less convincing, for example, the level of acculturation to the U.S. culture of the U.S. Korean-English bilinguals. As acculturation was not measured, concrete conclusions cannot be made about whether the Korean-English bilinguals living in the U.S. had been sufficiently acculturated into the U.S. culture, or if they still practiced values from their Asian Korean culture. If parents of the Korean-English bilinguals in U.S. were not assimilated into the U.S. culture, then it could very well be that their Asian cultural roots was still playing a role in influencing the executive functioning of their bilingual children. Therefore, the role of culture as a confounding variable in the bilingual cognitive advantage remains open to some degree.

Finally, unlike Yang et al.'s (2011) study where most of the Korean-English bilinguals were born in Korea and subsequently moved to the U.S., the present study will recruit subjects born and raised in Singapore. As such, confounding variables like acculturation and its effects on the bilingual's child executive functioning will be eliminated.

3.2 Motivation for present study

As data had already been collected from 50 English-Chinese bilingual preschoolers in Singapore using similar methodology (Kang, 2009), we decided to compare the effects of bilingualism on EA using a within-bilinguals approach – with SES differences as a means for comparison between both Malay and Chinese groups. As the majority of the English-Chinese preschool sample was recruited from private kindergartens in Singapore, this group had a range of moderate to high SES level. On the other hand, statistics on the average household income of the Malays revealed that they have the lowest income level in Singapore, compared to the Chinese and the Indians (Singapore Department of Statistics, 2010). The competitive nature of

the Singaporean society has also made it such that the socio-economic progression of the Malays still falls far behind that of the Chinese and Indians (Mutalib, 2005). Thus, the Malay bilinguals are most likely to come from lower SES families; to further ensure this, we recruited the Malay sample from a public kindergarten.

In comparing the Malay and Chinese groups, we acknowledge that culture might also be a confounding variable. However, the main focus of this thesis is to make within-bilingual group comparisons of how SES affects EA development. Before presenting the objectives and hypotheses of this study, the next few sections will first provide a brief overview of Singapore's culture, the Malay race, and the Malay language.

3.2.1 Singapore's ethnic culture & languages

In Singapore, one's ethnic group refers to his or her race, as declared by the individual. There are four ethnic groups in Singapore – the Chinese, Malays, Indians, and "Others" (consisting of Eurasians, and Arabs, etc.). One is classified as Malay if one has a Malay or Indonesian origin (Singapore Department of Statistics, 2010). According to Table 1, the Malays form 13.4% of the entire population of 3.8 million (Singapore Department of Statistics, 2010).

Table 1.

Ethnic Composition of the Resident Population in Singapore (2000 & 2010)

Ethnic Group	Number ('000)		Distribution (%)	
	2000	**2010**	**2000**	**2010**
Total	*3,273.4*	*3,771.7*	*100.0*	*100.0*
Chinese	2,513.8	2,794.0	76.8	74.1
Malays	455.2	503.9	13.9	13.4
Indians	257.9	348.1	7.9	9.2
Others	46.4	125.8	1.4	3.3

Source: Singapore Department of Statistics (2010)

In Singapore, English is the official medium of instruction, and children learn this at the first language level (L1), whereas one's Mother Tongue – assigned based on one's father's ethnicity (Mandarin for Chinese, Malay for Malays, and Tamil for Indians) – is learned at the second language level (L2). Unlike elsewhere in linguistics, the terms "first" and "second language" do not mean the same thing in Singapore. In Singapore, one's Mother Tongue is one's L2, and this may neither be one's native language nor the household language; thus, many students may end up learning two non-native languages at school (Dixon, 2005).

Kindergartens in Singapore have a structured three-year preschool education program for children between four and six years old. This program consists of Nursery, Kindergarten 1 and Kindergarten 2. Children attend kindergarten five times a week, for three to four hours each day. Across all three levels, children participate in activities developing several skills like language and literacy, social skills, basic counting concepts and so on. In kindergarten, children are taught in two languages on a daily basis – English as their L1 and their Mother Tongue (Mandarin, Malay, or Tamil) as their L2.

3.2.2 Why study the Malays?

As Carlson et al. (2008) highlighted, there is a need to replicate the bilingualism advantage in "non-Chinese" samples, to further confirm that the bilingual advantage is independent of supposed Asian cultural advantage on executive function tasks. Although the present sample of Malay children is still considered an Asian sample, they are nevertheless a "non-Chinese" sample of English-Malay bilinguals – a unique group of bilinguals that have never been previously studied in the literature before. According to Table 2, the percentage of

Malays speaking English at home is the lowest in 2010 (17% as compared to 32.6% of Chinese

and 41.6% of Indians who speak English at home).

Table 2.

Resident Population Aged 5 Years and Over by Language Most Frequently Spoken at Home

Ethnic Group/ Languages spoken	2000 (%)	2010(%)
Chinese	*100.0*	*100.0*
English	23.9	32.6
Mandarin	45.1	47.7
Chinese Dialects	30.7	19.2
Others	0.4	0.4
Malays	*100.0*	*100.0*
English	7.9	17.0
Malay	91.6	82.7
Others	0.5	0.3
Indians	100.0	100.0
English	35.6	41.6
Malay	11.6	7.9
Tamil	42.9	36.7
Others	9.9	13.8

Source: Singapore Department of Statistics (2010)

Compared to the other two races, an overwhelmingly large proportion of Malays (82.7%)

speak their mother tongue/L2 (Malay) at home. Critically, the high rate of Malays who speak

their mother tongue (Malay) at home allows us to possibly obtain a group of natural

bilinguals/trilinguals, who are using more than one language on a daily basis (given that they

learn English in school and speak Malay at home with their parents/elderly). This type of

bilingualism would not be as 'forced' as it is in several other cultures in Singapore (i.e. learning

two languages only for academic purposes, for instance); thus, this makes the present group of

subjects even more appealing to investigate.

3.2.3 Brief overview of the Malay language

The Malay language (or "*Bahasa Melayu*") is spoken by approximately 100 million in Southeast Asia (Lee, Liow, & Wee, 2007). "*Bahasa Melayu*" refers to a group of languages in the Malayo-Polynesian branch of the Austronesian language family (Yap et al., 2010). The most prevalent form of written Malay is called the "*Rumi*" (Latin alphabet), while "Jawi" (an adapted Arabic system) is employed for Islamic teaching and cultural purposes (Yap et al., 2010). Both these forms are alphabetic. Malay has a relatively shallow alphabetic orthography as compared to English. In shallow orthographies, the mappings between how the characters are written and read are predictable and transparent. In deep orthographies like English, more complex mappings occur because same graphemes have different sounds across different contexts. For example, the grapheme "-eigh" is pronounced differently in "weight" and "height" (Yap et al., 2010). Phonologically wise, Malay has three pronunciation systems that are mutually comprehensible, and the Standard Malay is used more commonly for writing (Lee et al., 2007).

3.3 Objectives & Hypothesis

The original rationale of this study was to test how monolingualism and bilingualism across different SES levels (i.e., high and low) influences Executive Attention. Other exploratory objectives are to study the relationship between language proficiency and IQ on EA. This is summarized in the figure below.
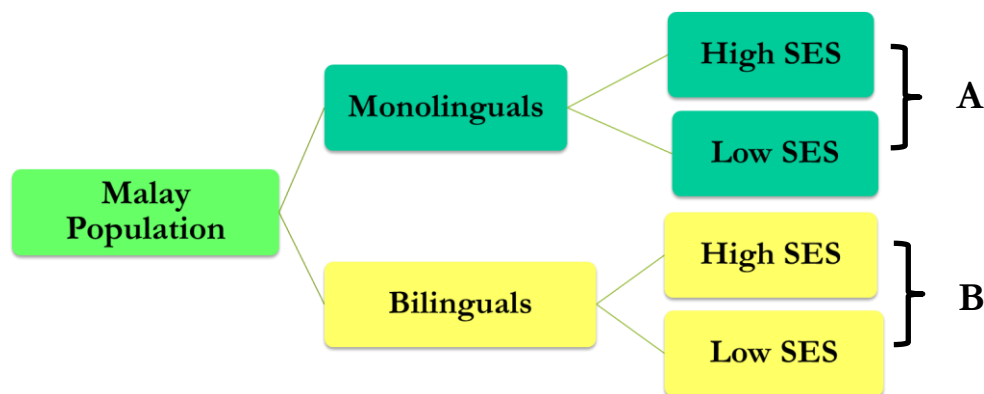
Figure 1. Original Study Design

In Figure 1, the within-group comparison looks at how high and low SES influences EA rates within monolinguals and bilinguals. On the other hand, the between-group comparison investigates if A and B are significantly different – that is, whether SES affects EA differently for monolinguals and bilinguals. However, due to practical constraints, we were only able to recruit Malay bilinguals in Singapore. Additionally, this group of Malay bilinguals were limited in SES range (i.e., low SES), thus, we had to modify the design of the study, based on these limitations. As mentioned earlier, we recruited a group of Chinese bilinguals who were high SES, in comparison with this Malay sample. Consequently, the focus of the thesis was modified to within-bilingual group comparisons (i.e., the "B" portion of Figure 1) – to investigate how SES variations within bilingual groups influence EA rates.

This led us to the **hypothesis** for the present paper – if low SES does not arrest the development of EA in bilinguals, then there will be no significant differences on the EA scores of the low-SES Malay bilingual group and the high-SES Chinese bilingual group (i.e., Null Hypothesis).

CHAPTER 4

METHOD

4.1 Participants

8 children were initially recruited via word-of-mouth and tested in the first batch of this study (1 English-Malay-Chinese trilingual, 1 English-Malay-Finnish trilingual and English-Malay bilinguals). However, because these children were tested in their homes, they were excluded from this analysis due to the difference in testing conditions. In addition, 3 of them failed to complete the child-ANT task, as they were highly distracted in their home environment. Another 39 English-Malay bilingual children were recruited from a Muslim preschool in Singapore, where students attend preschool for 3 hours daily, 5 days a week. Lessons in the preschool are taught in both Malay and English – with English taught from Mondays to Thursdays, and Malay taught on Fridays. Although 39 children were tested, 3 (2 boys and 1 girl) failed to complete the child-ANT. Thus, only data on the remaining 36 bilinguals were analyzed. As diagnostic plots revealed two distinct outliers; hence, only 34 (19 females, 15 males) participants were studied eventually. The remaining sample had a mean age of 66.91 months (SD = 9.14), with ages ranging from 54 to 76 months, and a girl who was 101 months. All the children participated in one session that lasted approximately 50 minutes per child. Some caregiver reports from the Child Multilingualism Questionnaire revealed that 17 English-Malay bilinguals spoke both English and Malay at the preschool, at home, and other places.

4.2 Experimental Design

The study involved one individual session, conducted in English. Each session involved completing the Peabody Picture Vocabulary Test – Fourth Edition (PPVT-IV), the child-ANT, and the Kaufmann Brief Intelligence Test – Version 2 (KBIT-2). The order of the tasks was

counterbalanced and randomized. Due to the long duration of each session (approximately 50 minutes), children were asked if they wanted to take breaks between each task. However, none of the 34 children requested for a break, and completed all 3 tasks within a single seating. The experimental tasks were manipulated as a within-subjects factor, while SES was a between-subjects factor. In addition to this, parents were required to complete a Family Background Information sheet that allowed us to assess the child's family background (i.e. occupational, educational and income details). Parents were also interviewed over the phone for the VLL Multilingualism Questionnaire (Lust, 2012) that provides descriptive data on children's behavior, and the bilingual language background. As we did not recruit monolinguals, the present study is a within-subjects comparison of bilingual groups.

4.3 Tasks & Procedure

Procedure

Participants were tested individually in a quiet room of the kindergarten. All tasks were administered in English. The battery of tasks comprised the computerized child-ANT, the PPVT-IV, and the KBIT-2. Each session lasted approximately 50 minutes. Children were rewarded one sticker after they completed each task and a small sheet of stickers at the end of the session. Informed consent was obtained from parents before the child's participation.

Tasks

4.3.1 Peabody Picture Vocabulary Test – Fourth Edition (PPVT-IV) (Dunn & Dunn, 2006)

The PPVT-IV (Dunn & Dunn, 2006) is a norm-referenced scale used to assess receptive vocabulary in children and adults, in English. This test consists of two parallel forms – Form A and B, each with four colored pictures as options for response on each page. For every item, the

child will be shown four colored pictures and asked to select the picture that best illustrates the word the experimenter read aloud. From the start, the child's basal performance level will be defined and this is the set whereby he/she commits zero mistakes. This is then continued in sets of twelve increasingly difficult words until the child commits eight or more mistakes in one single set. Finally, standardized tables will be employed to convert raw scores to standard scores. However, for the context of this study, only the raw scores were used, because the standardized scores are based on the scores of American children, which might not be generalizable to the Singaporean population.

4.3.2 Child-ANT

The child-ANT is a computerized cue by flanker task that measures three attentional components (Alerting, Orienting, Executive Attention) in one integrated test (Rueda et al., 2004). Rueda et al., (2004) adapted the integrated Attention Network Test (ANT) into a child version through the replacement of the arrows ($\leftarrow$ $\leftarrow$ $\rightarrow$ $\leftarrow$ $\leftarrow$) with fish that had arrows embedded in them (). On top of this, animation and sound feedback were incorporated into the test, based on children's responses. Children will hear a "Woohoo!" if they accurately pressed the right button to which the face was pointing, and a "Huh?" if they were inaccurate.   The ANT has also been shown to provide reliable single subject estimates in all three dimensions (Fan et al., 2002). The efficiency of the three networks can be measured through observing how alerting cues, spatial cues and flankers influence reaction time (RT) and percentage accuracy (%). The computerized stimuli in the child-ANT were presented visually on a laptop, and children were asked to help the experimenter feed hungry fish. Children had to respond to two input keys on the keyboard with both their index fingers (one on the left and one on the right arrow, while the rest of the keyboard was covered by a cardboard paper to reduce distractions) as quickly as

possible; when they see the fish appear on the screen. These arrows should match the swimming direction of the fish presented on the screen (which are embedded in the fish). The child-ANT comprised 168 trials which are composed of 24 practice trials in one training block, and three experimental blocks with 48 trials each.

To ensure children are familiarized with the use of the computer, they first completed a training block with 24 practice trials. Before the task began, the experimenter used six flash cards that contained pictures of the different combinations of fish they will see on the screen, to further familiarize the child with the rules. The experimenter also reminded the child to proceed with the game even if they hear a "Huh?" sound (i.e, the feedback during inaccurate responses), so that they will be able to feed all the hungry fish in the game. Experimenters provided children with positive feedback and encouragement throughout the session. To combat the issue of fatigue, experimenters offered the children a short break between each block if the need arose.

Each of the 168 trials has a combination of four cue (NO CUE, DOUBLE CUE, CENTRAL CUE, and SPATIAL CUE) and three flanker conditions (NEUTRAL, CONGRUENT, and INCONGRUENT). These conditions test the three attentional networks of alerting, orienting, and executive control. The trials are composed of different combinations of these conditions in a randomized order. The cues function either to direct the child's attention to the location of the target, or to enhance the child's alertness in order to prepare them for the target's impending presentation on the screen. On the other hand, flankers serve to assess attention control capability when faced with flankers that distract one's attention. A neutral condition is composed of a single fish stimulus that swims to the left or right. A congruent condition comprises five fish swimming in the same direction, and an incongruent condition comprise five fish swimming, but with the central target fish swimming in the opposite direction

as its flankers. A diagrammatic explanation on the workings of the child-ANT is shown in the

diagram below.

[INSERT FIGURE 2 ABOUT HERE]

Percentage accuracy is based on the number of times the child accurately responds to the

direction where the target fish swims. Reaction time (RT)-based efficiency scores are computed

for all three components of the network, using subtraction equations. First, the *alerting* function

is described as the achievement and maintenance of a state of readiness for the effortful

processing of information. This can be measured using temporal pre-cues, where a cue is

presented before a target appears. This cue functions both as a warning signal as well as to

supply specific information about the target. The *alerting effect* can be calculated by the

subtraction of the mean reaction time (RT) when double cues are presented from the mean RT

when no cue is presented (Fan et al., 2002). The use of the double cues keeps attention divided

between the two potential target locations, while at the same time alerting one to the impending

appearance of the target.

Second, *orienting* refers to the ability to shift one's focus from one stimulus to another,

and this can be measured using valid spatial pre-cues. A cue presented indicates where in space

one should attend to, providing information as to where one should direct attention to in the cued

location. The *orienting effect* is calculated through the subtraction of the mean RT of a spatial

cue from the mean RT of a center cue. While the center and spatial cues serve as alerting cues,

only the spatial cue gives predictive spatial information prompting subjects to start orienting

their attention to the appropriate location before the target appears. The center cue, like the single

cue, serves as a control because it prompts attention orienting to one location.

Lastly, *executive attention* is made up of processes involved when an individual carries out goal-directed behaviors, and is also related to one's ability to overcome distracting stimuli. Executive attention is often studied using tasks involving conflict, which is introduced by incongruent flankers producing interference. The *conflict or executive attention* effect can be calculated through the subtraction of the mean RT of congruent flanking conditions summed across cue types, from the mean RT of incongruent flanking conditions. Using neutral flankers will give the same results as using congruent flankers because of minimal differences between congruent and neutral flanker conditions. Response times are expected to be longer during incongruent conditions as compared to congruent conditions. Lower efficiency scores reflect higher network efficiency because they represent a small increase in reaction time when conditions become more difficult. On top of these, **inverse efficiency (IE) scores** were also calculated. IE scores are used to analyze both accuracy and RT together, without including speed-accuracy tradeoffs; as such, they provide us with a better understanding of processing efficiency (Townsend & Ashby, 1978; as cited in Yang et al., 2011b). These scores are obtained through dividing the mean RTs during the accurate trials by the proportion of correct responses. A higher inverse efficiency score represents worse performance.

4.3.3 Kaufman Brief Intelligence Test – Second Edition (KBIT-2) (Kaufman & Kaufman, 1990)

The KBIT-2 is a brief intelligence test used as a measure of overall intelligence for individuals aged 4 to 90 years old. It has 2 major components – verbal and nonverbal, and comprises 3 subtests. For the verbal component, the 2 subtests include Verbal Knowledge (general knowledge and receptive vocabulary), and Riddles (vocabulary knowledge, reasoning, comprehension). The non-verbal component has a "Matrices" subtest which tests one's ability to

understand relationships and analyze visual analogies. For this study, only the non-verbal Matrices subtest was used as a brief measure of intelligence, due to time constraint. The KBIT-2 manual has full-color stimulus and administration of the Matrices subtest takes about 5-10 minutes, depending on the individual.

The child is presented with the visual stimulus (presented on the middle of the page), and is instructed to respond via pointing to the correct response at the bottom of the page. An example of a visual analogy tested in this section includes a picture pair of a sailboat and the ocean presented next to each other. Below this pair lies another picture pair – a picture of a car, and an empty picture next to it. The child has to pick from 1 of 5 options presented at the bottom of the page. In this example, the answer would be a picture of a road – that is, a sailboat goes with the ocean, just like a car goes with the road. Another example of a test item in this subtest includes picking out patterns or trends from a string of visual stimuli (i.e. dots in circles, where each circle has varying positions of dots). Prior to testing, there are 2 teaching or training items. If errors are made here, the administrator will fully explain to the child his/her mistakes, and prompt him/her to try again.

All subtests include a basal score – passing the first three items based on the entry point of a child's age. The administrator has to drop back to a lower starting point until the child passes the first three items. The test ends when a child makes four consecutive mistakes. The final score for this subtest involves the highest item reached, subtracted by the number of mistakes committed throughout the test. One advantage of the KBIT-2 is that it is a behavioral task that requires little querying, and thus reduces the extent to which one's answer is dependent on verbal ability (e.g., comprehension and production).

4.3.4 CLAL Child Multilingualism Questionnaire (CMQ) for Parents

The majority of studies investigating bilingualism in young children often use measures of receptive vocabulary in English and the child's other language to assess a child's degree of bilingualism. However, receptive vocabulary tests are limited in the information they provide about a bilingual child's language background. Therefore, the CLAL CMQ (Yang, Blume, & Lust, 2006) was included in this study in order to provide us with a more comprehensive background of a child's bilingual environment.

The CLAL CMQ was prepared for the Virtual Center for Language Acquisition at Cornell University, and has been revised several times over the years. The present study employed the use of the most updated version (2012). It measures a child's sociolinguistic background and investigates the nature of their bilingualism/multilingualism. The following aspects are assessed by the questionnaire – the child's demographic information, family language background, child language background, child language use (code-switching), reading/writing ability and an appendix where the parent provided information about the child's daily activities. There is also a section where parents will be asked about their expectations about their child's language acquisition (i.e. whether they think it is important for their child to learn more than one language, the means by which their child acquires different languages through the parents etc.). This questionnaire includes both close- and open-ended question types. Information provided on this questionnaire will reveal the language(s) the child speaks at home, in school, and in other places.

After the completion of the questionnaire, three trained researchers independently evaluated each questionnaire using evaluation criteria formulated by a research group at the Cornell Language Acquisition Lab. This evaluation form summarizes the essential points of the

Multilingualism Questionnaire, and requires each evaluator to objectively the proficiencies of the child's L1 and L2 on Listening Comprehension, Oral Production, and Overall Proficiency, based on the information provided by caretakers on the VLAL CMQ.

4.3.5 Family Background Information Sheet

All parents completed this questionnaire which was used to assess the child's socioeconomic background. An extensive range of variables can predict SES, and SES is most often measured through a combination of 'financial, occupational and educational influences' (Winkleby, Jatulis, Frank and Fortmann, 1992). In this questionnaire, education is measured by the highest academic qualification received by both parents, which is divided into 5 levels: 1-None/Primary, 2- Secondary/Pre-University, 3- Vocational/Technical, 4- Tertiary/University and 5- Postgraduate. In addition, the number of years of schooling for each parent is also taken into consideration. The average monthly household income is divided into 5 categories, with Level 1 being less than $1000, Level 2 being $1000 to <$3000, Level 3 being $3000 to <$6000, Level 4 being $6000 to <$9000 and level 5 being more than $9000 per month. The household size, number of siblings and birth order of the child are also required fields in this questionnaire.

CHAPTER 5

RESULTS

Results in this chapter will be reported in the following order. Background demographics will be presented, followed by bilingual assessments of language (PPVT, CMQ). Results from the cognitive tasks will be analyzed (child-ANT, KBIT), and correlational and regression analyses of the SES and Executive Attention data (i.e., child-ANT) will be presented. Within some of these sections (PPVT, child-ANT), comparisons will be made with samples from Kang (2009) and Yang et al. (2011) in order to provide a benchmark to compare the Malay sample's performance on these tasks. Finally, we conclude this chapter with a summary of the critical findings.

5.1 Background Demographics (Family Background Information)

Data from 34 English-Malay bilingual children (19 females, 15 males) were included in the final analyses. This sample had a mean age of 66.91 months ($SD = 9.14$), with ages ranging from 54 to 101 months. Three SES variables were analyzed in this study – father's and mother's highest educational attainment, and average monthly household income.
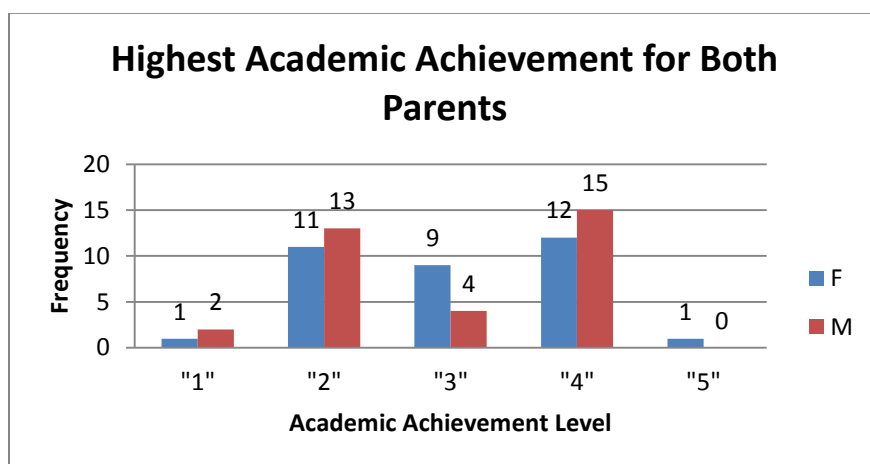
Figure 3. Highest academic achievement for both parents.

Figure 3 summarizes both parents' highest academic achievement. The average highest educational attainment for fathers and mothers was a level 3 (on a scale of 1 to 5, 5 being the highest), which represents a Vocational/Technical education. In general, mothers had higher academic achievement than fathers. Only 1 father had education of "5" (i.e., Postgraduate). The majority of the sample fell under the level "2" (i.e., Secondary/Pre-university) and level "4" (i.e., Tertiary/University) educational attainment category.
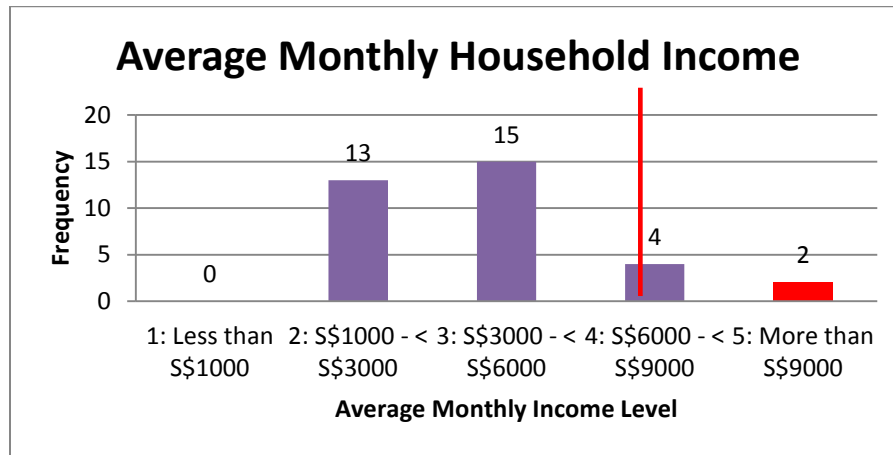
Figure 4. Distribution of average monthly household income in the sample.

Figure 4 provides an overview of the distribution of monthly household income in this sample. The average monthly household income was 2.85 on a scale of 1 to 5 (5 being the highest), and this translates to an amount between S$3000 and S$6000. This is considered to be below the median monthly household income in Singapore, which is S$6286 (or a level of 4 on the scale used in this study) (Singapore Department of Statistics, 2011).The majority of this sample (n=28) fell below the median household income in (as indicated by the red vertical line on Figure 4). Only 6 families had moderate to high household income. Figure 4 also reveals the fairly limited SES range (i.e., low) of the sample.
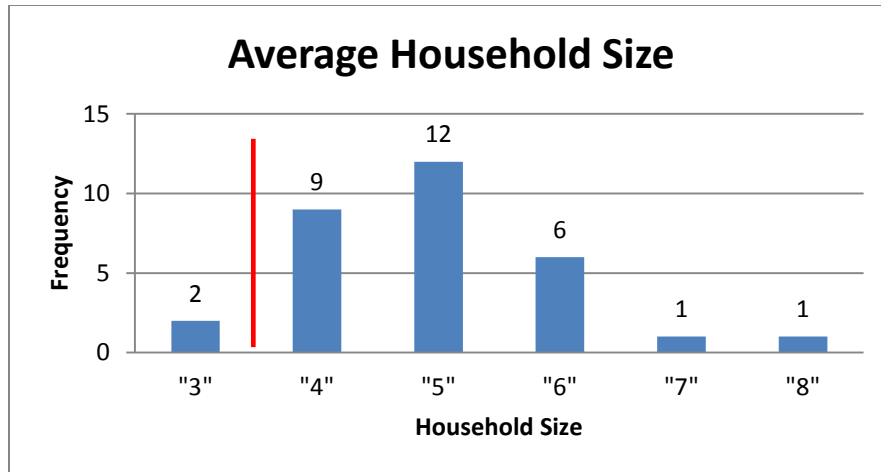
Figure 5. Distribution of average household size in the sample

In terms of household size, three participants did not complete the question on average household size, so Figure 5 provides an overview of the distribution of only 31 participants in this sample. The average household size was 5.90, which translates to approximately 2 more people in the household compared to the Singapore's median household size of 3.5 (as indicated by the red line on the figure). Taking these SES data into consideration, our present sample was considered as low SES in Singapore's terms, especially when measured in terms of income and household size.

Table 3 summarizes the occupation type of both parents (mothers on the left, and fathers on the right). Fifty percent of the mothers were housewives, and this is lower than the average female labor force participation rate of 57.7% for the population aged 15 and over (Singapore Department of Statistics, 2013). For the fathers, the majority held "Government/Uniform group" jobs (i.e., policemen, firemen etc.). As a benchmark for comparison, the gross monthly salary of a police inspector in Singapore is between $2,650 and $3,482 (Singapore Police Force, 2010). This is below the median monthly household income in Singapore which is $6286 (Singapore Department of Statistics, 2011).

Table 3.

Summary of Occupation Types (Both Parents)

Mother's Occupation Type	Frequency	Father's Occupation Type	Frequency
Housewife	17	Technician	3
Teacher	3	Teacher	2
Government/Uniform Group	2	Government/Uniform Group	11
Service	4	Service	4
Construction	1	Construction	1
Banking/Finance	2	Banking/Finance	1
Administrative Assistant	1	Administrative Assistant	1
Public Relations	1	Maintenance	1
Executive	1	Engineering	1
Legal Services	1	Unemployed	1
Unknown	1	Unknown	1
		Self-Employed	2
		Manufacturing	2
		IT-related	2
		Public-listed	1
Total	*34*	*Total*	*34*

As frequent comparisons are made between our English-Malay sample and the English-Chinese sample in Kang's (2009) study, Table 4 presents summarizes the demographics of the Malay and Chinese samples.

Table 4.

Summary of demographics of English-Malay and English-Chinese (Kang, 2009) samples

	English-Malay (*n*=34) (SD)	English-Chinese (*n*=50) (SD)
Age (in months)*	67.15 (9.18)	69.44 (4.82)
Male to Female ratio*	15 : 19	26 : 24
Father's Highest Educational Attainment (Scale of 1-5)	3.03 (0.97)	3.12 (1.24)
Mother's Highest Educational Attainment (Scale of 1-5)	2.94 (1.04)	3.18 (1.10)
Average Monthly Household Income (Scale of 1-5)	2.85 (1.04)	3.42 (1.03)

Note: This refers to the age and Male to Female ratio of the children in the samples

Independent *t*-tests revealed no significant differences in the ages of both groups, as well as father's and mother's highest educational attainment (*ps*>.05). However, there were significant differences in the average monthly household income, with the English-Chinese sample (*M*=3.42, *SD* = 1.03) showing a higher monthly income than the English-Malay sample (*M*=2.85, *SD* = 1.04); *t*(82) = -2.64, *p*=.010.

5.2 Bilingualism Assessments of Language

This section summarizes results from direct assessment and caregiver reports of a child's language proficiency. We first present results from the direct assessment of the English receptive vocabulary test (PPVT-IV), and then review results from the caregiver reports of the child's language proficiency in both languages, as well as our evaluations of these reports.

5.2.1 PPVT-IV

Raw scores of the English PPVT-IV were used for data analysis because standardized norms for the American version of the PPVT-R may not apply to the Singaporean context. Additionally, for the scope of this present thesis, because comparisons were not made with American English monolinguals, using standardized scores may not be essential. Overall, the PPVT scores ranged from 43 to 118, with a mean of 77.94 (*SD* = 19.09). To find out how the English PPVT scores of the Malay children in this sample compares to other age-matched samples, their average scores were compared to Kang (2009)'s study of 50 English-Chinese bilinguals. An independent samples *t*-test revealed no significant difference in the PPVT scores of the English-Chinese sample (*M*= 84.92, *SD* = 18.56) and the English-Malay sample (*M*=77.94, *SD* = 19.09); *p*>.05, with a Cohen's d of 0.38 (i.e., medium effect size). The PPVT score difference is summarized in the Figure 6. Thus, both samples had equal control of English vocabulary.
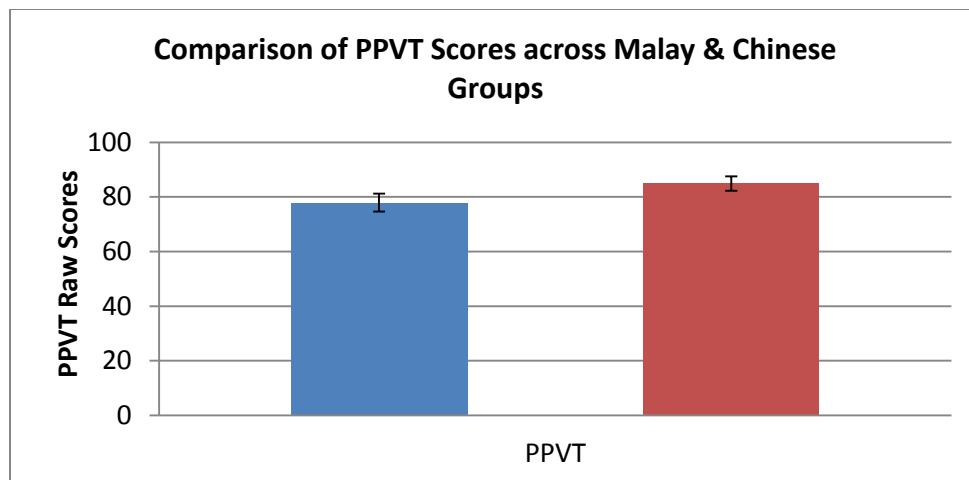
Figure 6. Comparison of PPVT scores across Malay and Chinese Groups

5.2.2 Analysis of Child Multilingualism Questionnaire

Three trained research assistants independently evaluated the MQs based on criteria in the evaluation form. Of the 34 children, only 17 MQs were completed by caregivers. We will take this sample to be representative of the population studied. Of the 17 children, 16 were born and raised in Singapore, while one lived in the United Kingdom for three years before moving back to Singapore (thus only learning Malay at the age of 4). All 17 caregivers reported English as their child's L1 and Malay as their L2. As mentioned earlier, in Singapore, one's Mother Tongue is assigned based on the father's ethnicity (Malay language for the Malay racial group), and this is learned at the second language level. The terms "L1" and "L2" do not hold the same meaning in Singapore unlike elsewhere in linguistics. Thus, although Malay may be technically listed as the child's L2, this might not necessarily mean that Malay is not the household language of this population.

To determine the child's order of bilingualism (i.e., simultaneous or sequential bilinguals), we looked at the age of acquisition of the 17 participants. Although 6 of them were not exposed to both languages – English & Malay, simultaneously during infancy, according to

the definition of simultaneous bilinguals being children exposed to two languages during infancy and early childhood (Patterson, 2002), all 17 children would be classified as simultaneous bilingual learners. All 17 children were exposed to semi-formal education in both languages since nursery school (i.e., 4 years of age). There were 2 children in the sample who had learnt Arabic as a L3 since the age of 3, and attend two hours of religious class in Arabic each week. Another 2 children recently picked up Chinese as their L3 in preschool for over a few months. Based on the information provided on the MQ, the researchers evaluated the overall frequency of exposure to English and Malay (i.e., across different settings) for each child. Table 5 summarizes several central findings from the CMQ and includes standardized PPVT scores. The PPVT scores were standardized to facilitate comparisons across various ages within this sample.

[INSERT TABLE 5 ABOUT HERE]

Based on the ratio of the 17 children's overall exposure and overall use of English to Malay, we see that these children are not only exposed to both languages on a daily basis, but are also using both languages in their daily communications. Out of the sample of 17, 9 were classified as 'balanced bilinguals', while the remaining 8 were classified as either dominant or slightly dominant in English or Malay – 2 dominant in Malay, 2 slightly dominant in English, and 4 dominant in English. A point to note is that a bilingual might use both languages daily, but have greater mastery, or feel more comfortable with using one of their languages; on the other hand, a balanced bilingual may have equal command in both languages but may not use both languages daily (Gathercole et al., 2010). Thus, we should not confuse balanced bilingualism with daily use and/or exposure of both languages.

35% of the 17 children had additional caregivers (i.e., grandparents and one domestic helper) who conversed with them in Malay most of the time. In terms of language use with

siblings, out of the 15 children with siblings, only 2 of them used 100% English with their siblings – 1 of whom has an autistic brother who only spoke English. The other 13 used both languages to converse with their siblings, although, on average, English was used more frequently. The majority of the 17 children conversed with frequently contacted relatives in both languages – usually in Malay to older relatives (i.e., aunts, uncles, grandparents), and English to younger relatives (i.e., cousins). Approximately 80% of the sample's overall entertainment (i.e., television programs, computer games) was English, mainly due to more mainstream cartoons and children's educational shows being available in English rather than Malay.

Finally, all 17 caregivers mentioned it was important for their child to be bilingual, and were actively involved in teaching the child both languages either through reading books in both languages to the child, or through revising the child's school work (in both languages) with them. All 17 children had at least one caregiver who reads books (either English or Malay, or b oth) to them either on a daily basis, or a few times each week. In summary, the MQ results of the 187children revealed that all of them were not only exposed to, but used two languages on a daily basis. Hence, based on the caregivers' reports of the MQ, the 17 children can be considered to be active bilingual learners.

Based on our classification of the children as either balanced or dominant bilinguals, comparisons were made between these two groups, and this is summarized in Table 6. Father's education (Fed) in the dominant bilingual group ($n = 8$) was significantly higher than the Fed in the balanced bilinguals ($p=.024$). Additionally, Mother's education (Med) was almost significantly higher in the dominant bilingual group ($p=.064$). Despite this, both groups of balanced and dominant bilinguals did not significantly differ on their performance on all components of the child-ANT.

Table 6.

Comparison of Balanced & Dominant Bilinguals

Components of ANT	Balanced (*n* =9)	Dominant (English/Malay) (*n* =8)
Overall Accuracy	95.44 *(4.45)*	93.88 *(3.23)*
Mean RT	1065 *(145)*	1141 *(196)*
AlertingZ*	-0.33 *(0.50)*	-0.38 (0.92)
OrientingZ*	0.22 *(0.97)*	0.25 (1.39)
ConflictZ*	0.33 *(1.32)*	-0.25 *(0.71)*
Inverse Efficiency	12.53 *(2.98)*	14.35 *(4.47)*
Fed	2.89 *(0.78)*	3.88 *(0.84)*
Med	2.56 *(1.01)*	3.50 *(0.93)*
Y	2.67 *(0.87)*	3.00 *(0.76)*

*Note: *Standardized Alerting, Orienting, and Conflict scores (ms) were employed*

5.3 Cognitive Tasks

Results from the child-ANT and the KBIT-2 are summarized in this section.

5.3.1 Child-ANT

In this section, we present results of the components of the child-ANT, including overall ANT Accuracy scores, Reaction Time (*ms*), 3 network efficiency scores (*ms*), and Inverse Efficiency Scores. Again, scores from the English-Chinese sample in Kang's (2009) study will also be presented to provide a rough idea of how the Malay sample fared.

5.3.1A Overall ANT Accuracy & SES Measures

The mean ANT Accuracy for this sample is 94.85% (*SD* = 3.25), ranging from 86% to 100%. To provide an idea of how this Singaporean English-Malay bilingual sample fared (on ANT Accuracy) compared to other age-matched groups of monolinguals and bilinguals, the

overall ANT Accuracy scores of a subset of the youngest children in this sample (*n*=10) were compared against the age-matched sample in Yang et al.'s (2011) study, where the child-ANT was also employed to measure EA. Table 7 summarizes the participants' descriptions from Yang et al.'s (2011) study and the youngest subset of participants from this study.

Table 7.

Summary of demographics of Yang et al.'s (2011) study and present sample

Groups	Background profiles			
	Mean age (*SD*)	Age range (months)	Gender ratio (M:F)	PPVT raw (*SD*)
English monolinguals (N = 15)	56 (3.2)	49 – 60	8 : 7	79 (19.8)
U.S. Korean monolinguals (N = 13)	53 (1.8)	51 – 56	12 : 1	40 (13.6)
ROK Korean monolinguals (N = 13)	52 (3.6)	49 – 60	8 : 5	55 (16.9)
Korean-English bilinguals (N = 15)	57 (2.4)	51 - 60	8 : 7	47 (16.6)
English-Malay bilinguals (N = 10)	57.3 (2.4)	54 - 61	4 : 6	66.3 (15.3)

Notes: M = Male, F = Female, ROK = Republic of Korea

Independent samples t-tests revealed that the English-Malay bilinguals scored significantly higher (*M*=92, *SD*=3) on the overall ANT accuracy, compared to all three groups of monolinguals − U.S. English monolinguals (*M*=72, *SD*=14; Cohen's *d* = 1.98), U.S. Korean monolinguals (*M*=74, *SD*=12; Cohen's *d* = 2.06), and Republic of Korea (ROK) monolinguals (*M*=81, *SD*=14; Cohen's *d* = 1.09); all *p*s<.05. Figure 7 below summarizes these comparisons. Although the English-Malay bilinguals did not score significantly higher than the Korean-English bilinguals (*M*=88, *SD*=8); *p*>.05, the Cohen's *d* was 0.66 (i.e., large effect size). We highlight that direct comparisons cannot be made across these groups given our lack of information about the SES and demographic characteristics of the groups in Yang et al.'s (2011) study. However, this comparison was included as a benchmark to see how our (subset of)

bilingual sample fared in comparison to monolingual groups, since we did not have monolingual

samples to draw comparisons from.
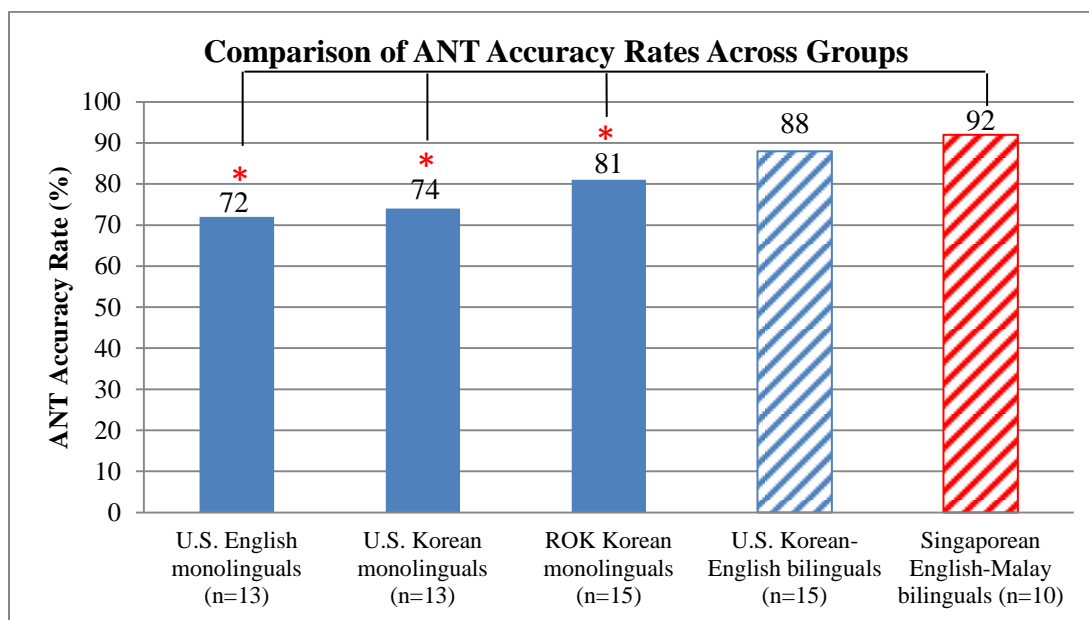
Figure 7. Comparison of overall ANT accuracy scores across monolingual and bilingual groups for the youngest sub-set of the present sample.

On the other hand, as Figure 8 shows, independent *t*-test revealed no significant

differences between the overall ANT accuracy scores of our Malay sample (*M*= 94.85, *SD*

=3.25) with the Chinese sample (*M*=93.26, *SD* = 6.47), *p*>.05; Cohen's *d* = 0.31 (i.e. medium

effect size), though the Malay bilinguals scored slightly higher than the Chinese bilinguals.
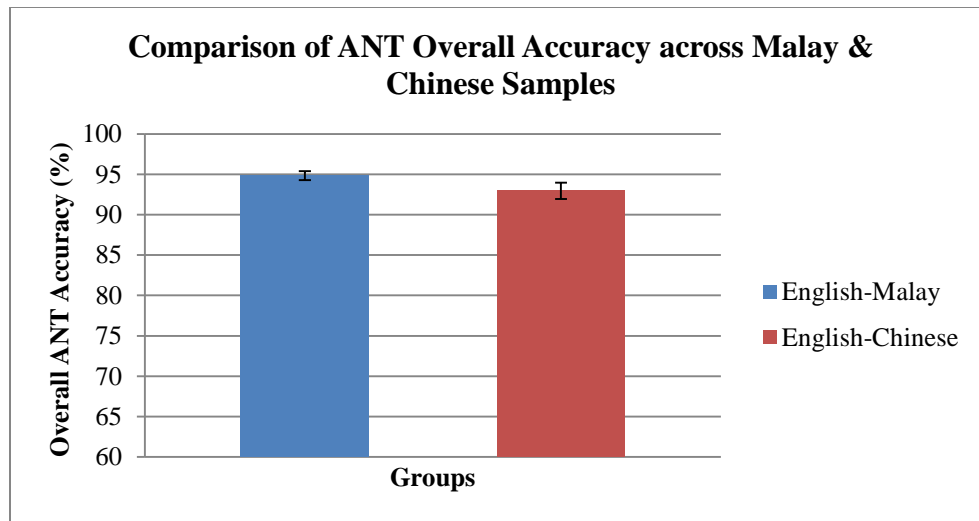
Figure 8. Comparison of overall ANT accuracy scores across Malay and Chinese (Kang, 2009) samples.

5.3.1B Reaction Time (RT) & SES Measures

The mean reaction time (RT) for the child-ANT task was 1072.06 ms ($SD = 159.80$),

ranging from 763 ms to 1375 ms. Independent t-test revealed no significant differences between

our Malay sample ($M=1072$, $SD=160$) and Kang (2009)'s Chinese sample ($M=1029$, $SD=181$);

$p>.05$; with a Cohen's d of 0.25 (i.e., small effect size). Figure 9 summarizes this difference.
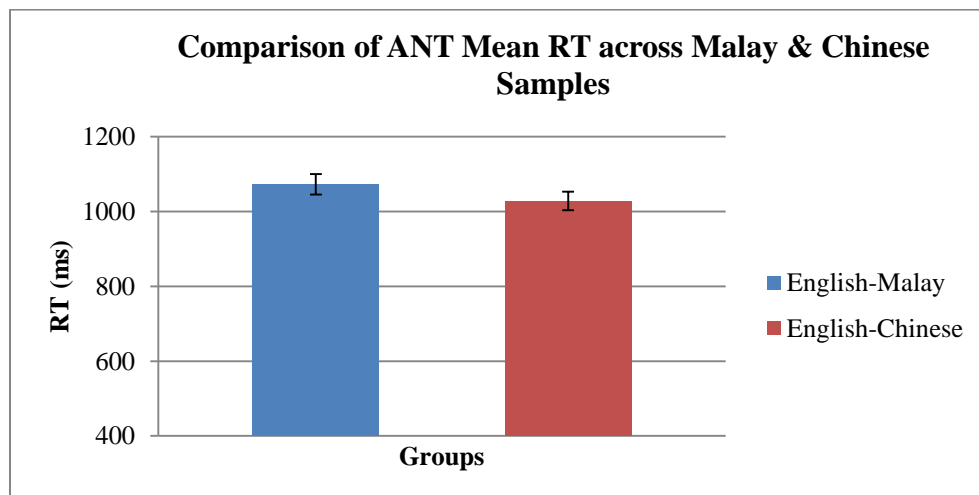
Figure 9. Comparison of ANT Mean Reaction Times across Malay and Chinese (Kang, 2009) samples.

5.3.1C Three Network Efficiencies

The efficiency scores of the three networks are measured through observing how alerting cues, spatial cues, and flankers (congruent, incongruent) influence reaction time and accuracy. A smaller network value indicates more efficient performance in that given network.

Table 8 summarizes the calculations of each network efficiency score.

Table 8.

Summary of Descriptive Statistics for Three Network Efficiencies

Network	Mean (*SD*)	Range
Alerting = Mean RT (no cue) - Mean RT (double cues)	36.71 *(63.04)*	(-93, 150)
Orienting = Mean RT (center cue) – Mean RT (spatial cue)	10.35 *(63.42)*	(-140, 182)
Executive Control = Mean RT (incongruent) – Mean RT (congruent)	99.71 *(83.56)*	(-55, 275)

Typically, positive values should be obtained from each network efficiency calculation, given that the first component of each subtraction equation consists of a more challenging condition (thus, a greater RT value), whilst the second component has a facilitating effect (and thus should have a smaller RT value). However, obtaining negative scores is often the case when the child-ANT is used with very young children (i.e., below the age of 6), because they often have greater trouble with finding the central fish amongst the distractors (personal communication with Rueda, 2013). Unlike adults or children above 6 years of age, locating the middle/central fish is a huge challenge for young children during congruent trials. However, incongruent trials facilitate them in finding the middle fish more than congruent trials, because the flanker fish are all pointing in the opposite direction.

In addition to this, reaction times are generally very variable (i.e., high standard deviations) for young children, hence, obtaining negative scores might not be surprising due to this high variability. Consequently, the inverse efficiency scores provide us with more accurate information about children's performance, as theses scores are based on percentage accuracy on accurate trials, rather than solely relying on reaction time measures. To further ascertain if the negative scores by the children in this sample were a cause of concern, correlational analyses were conducted and scatterplots were performed to investigate if those children with negative scores displayed any sort of pattern or trend (as advised by Rueda in our personal communication, 2013). Results revealed that there was no significant correlation between age and negative scores (i.e., younger children did not have significantly more negative scores). There was also no significant correlations between negative scores and overall accuracy (i.e., those with negative scores did not perform significantly worse on overall ANT accuracy). Finally, children with negative scores completed all three blocks on the child-ANT; thus, in light of these analyses, we can safely conclude that the negative scores were coming from subjects who did not understand how to play the child-ANT and were randomly pressing on buttons during the task.

Independent t-tests revealed no significant differences between both groups on all three networks of the child-ANT; all ps>.05. However, for the orienting network, the difference in scores almost reached significance, with the Malays performing almost significantly better (M=10.35, SD = 63.42) than the Chinese (M=38.24, SD=69.25); $t(82) = -1.87$, p=.065. Figure 10 below summarizes these results.
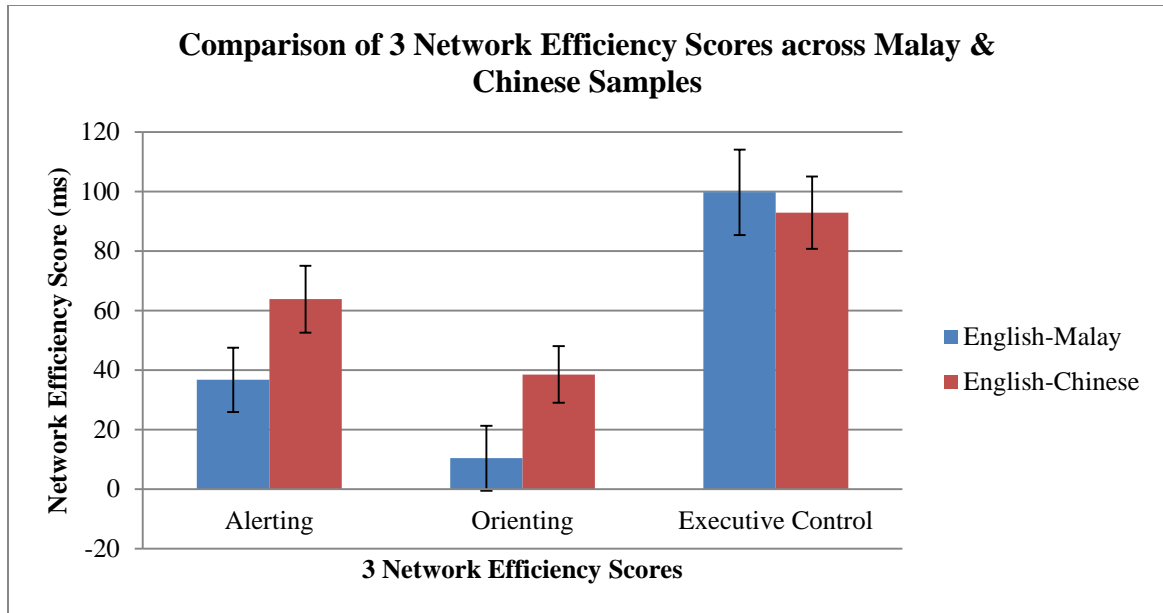
Figure 10. Comparison of 3 network efficiency scores across Malay and Chinese samples.

5.3.1D Inverse Efficiency

To recapitulate, inverse efficiency (IE) scores are calculated using the following formula:

$$Inverse\ Efficiency = \frac{Mean\ Reaction\ Times\ (accurate\ trials)}{Proportion\ of\ accurate\ responses}$$

Inverse efficiency scores are used to analyze both accuracy and RT together, without including speed-accuracy tradeoffs; as such, they provide us with a better understanding of processing efficiency (Townsend & Ashby, 1978). A higher inverse efficiency score represents worse performance. For this sample, the mean IE score was 12.68 ($SD = 3.09$), ranging from 8.91 to 22.16. Independent t-test revealed no significant differences between the inverse efficiency scores of the Malays (M=12.68, SD=3.09) and the Chinese (M=13.79, SD=3.48); p>.05, though the Malays performed slightly better with lower inverse efficiency scores on average. Results are summarized in Figure 11 below.
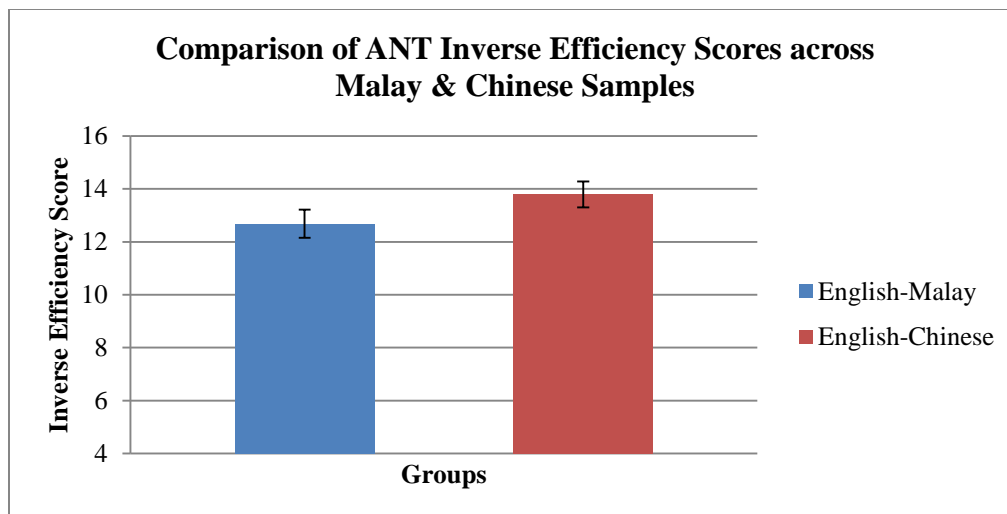
Figure 11. Comparison of Inverse Efficiency scores across Malay and Chinese (Kang, 2009) samples.

To summarize the child-ANT scores, the present sample of English- Malay bilinguals significantly outperformed all three groups of monolinguals in Yang et al.'s (2011) study in terms of overall accuracy. When comparing the Malay sample with the Chinese sample (Kang, 2009) on all the child-ANT components – overall accuracy, RT, three network efficiency scores, inverse efficiency scores, there were no significant differences in both groups' performances.

5.3.2 KBIT-2

The KBIT-2 has three subsets, but this sample only completed the "Matrices" subset. The average raw score for this subset was 18.00 ($SD = 3.09$), ranging from 7 to 27. The rationale behind the addition of the KBIT in this study is to provide a brief background on whether a sub-component of IQ scores correlates with performance on the EA task. As the Chinese sample (Kang, 2009) did not complete this task, there is no basis for comparison for the raw KBIT scores. However, there will be more analyses presented in the next section where KBIT scores

are correlated with the components of the ANT task. Figure 12 below presents the KBIT-2 score distribution in the Malay sample.

KBIT-2 Score Distribution
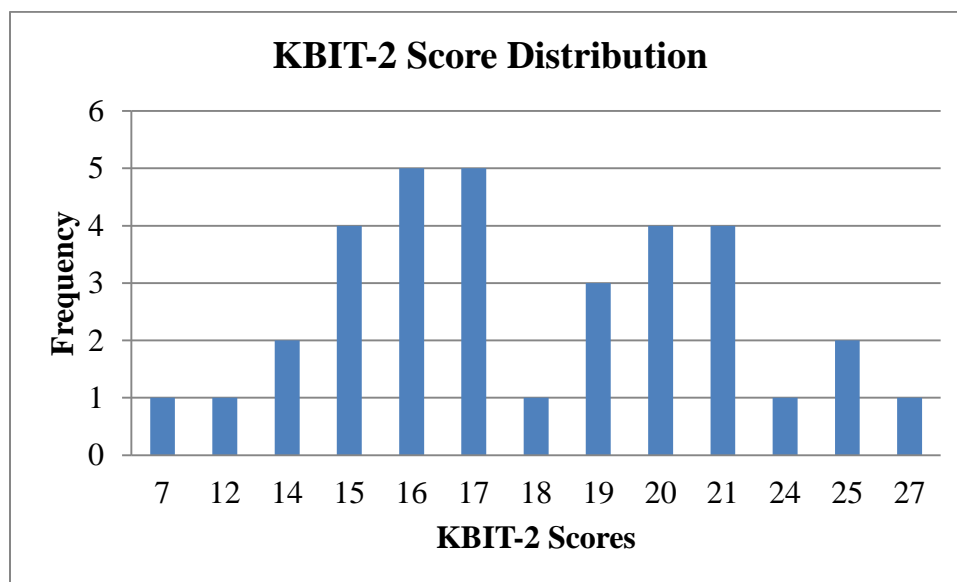
Figure 12. Malay sample's KBIT-2 score distribution.

5.4 Correlational analyses

Correlational and partial correlational analyses were conducted to further examine how SES (Y, Fed, Med), English vocabulary (PPVT), and cognitive task scores (KBIT-2, and child-ANT components) were related to each other. These results are summarized in Tables 9 and 10. Table 9 first presents results of the correlational analyses of the three SES variables with PPVT, KBIT and components of the ANT scores. Table 10 then presents results of the partial correlational analyses of the same variables after controlling for Fed, Med, and Y.

Table 9.

Correlational Analyses

	Fed	Med	Y	PPVT	KBIT-2	ANT Acc	Mean RT	A	O	C	IE
Fed	-	.542**	.334	-.047	-.142	-.027	.199	-.114	.075	-.064	.251
Med		-	.634**	.099	.051	-.155	.226	.135	.048	.060	.236
Y			-	.455**	.231	.144	-.010	-.204	-.042	.074	-.019
PPVT				-	.431*	.527**	-.475**	-.105	-.064	-.003	-.443**
KBIT-2					-	.367*	-.280	-.044	-.351*	.365*	-.442**
ANT - Acc						-	-.336	.105	-.298	-.047	-.595**
Mean RT							-	-.181	.094	-.229	.866**
A								-	.096	-.126	-.214
O									-	.037	.274
C										-	-.265
IE											-

*Note: ** Correlation significant at .01 level (2-tailed). * Correlation significant at .05 level (2-tailed)*

ANT Acc: ANT Overall accuracy; PPVT: Peabody Picture Vocabulary Test score; Mean RT: Mean reaction time (ms); A: Alerting network; O: Orienting network; C: Conflict network; IE: Inverse efficiency score (A higher IE score represents worse performance); Fed: Father's highest educational attainment; Med: Mother's highest educational attainment; Y: Average monthly household income

Correlational analyses revealed that none of the three SES measures – Father's education (Fed), Mother's education (Med), Income (Y) – were significantly correlated with any of the ANT scores (overall accuracy, mean RT, 3 network efficiency scores, inverse efficiency score); ps >.05. However, PPVT scores were highly significantly correlated with Y, $r(34) = .455$, $p<.01$, overall ANT accuracy, $r(34) = .53$, $p <.01$, as well as Mean RT, $r(34) = -.48$, $p < .01$, and Inverse Efficiency, $r(34) = -.44$, $p <.01$. On the other hand, KBIT scores were significantly correlated with overall ANT accuracy, $r(34) = .37$, $p <.05$, as well as the Orienting network efficiency, $r(34) = -.35$, $p <.05$, and Conflict network efficiency, $r(34) = .37$, $p <.05$. KBIT scores were highly significantly correlated with Inverse Efficiency, $r(34) = -.44$, $p <.01$.

After controlling for Fed, Med, and Y, table 10 presents results from the partial correlational analyses.

Table 10.

Partial Correlational Analysis (controlling for Fed, Med, Y)

	PPVT	KBIT	ANT Acc	Mean RT	A	O	C	IE
PPVT	-	.341	.494	-.480	.099	-.018	-.054	-.427
KBIT		-	.349	-.248	.063	-.339	.350	-.419
ANT Acc			-	-.276	.280	-.286	-.047	-.573
Mean RT				-	-.333	.063	-.237	.851
A					-	.057	-.123	-.389
O						-	.046	.253
C							-	-.272
IE								-

*Note: ** Correlation significant at .01 level (2-tailed). * Correlation significant at .05 level (2-tailed).*

PPVT: PPVT score; KBIT: KBIT-2 score; ANT Acc: Overall ANT Accuracy; Mean RT: Mean Reaction Time (ANT); A: Alerting efficiency score; O: Orienting efficiency score; C: Conflict efficiency score; IE: Inverse efficiency score.

As seen in Table 10, after controlling for all three measures of SES (Father's education, Mother's education, and average household monthly income), some significant correlations earlier were no longer significant. These include the following correlational pairs:

a) PPVT: KBIT, Accuracy, RT, IE

b) KBIT: Accuracy, Orienting, Conflict, IE

c) Mean RT: IE

5.5 Regression Analysis

In this section, we present results from hierarchical linear regression analyses – with overall ANT accuracy results and inverse efficiency scores as the outcome variables in the two models. Regression was used to find out how much each SES variable (Fed, Med, Y) influenced the EA performance (as measured by accuracy and IE scores).

First, we estimated a hierarchical linear regression model predicting overall ANT Accuracy results from the three SES variables – Father's and Mother's education, and income, as well as PPVT and KBIT scores. Raw scores of all the predictors were used. In the hierarchical linear regression model, father's education was first entered, followed by mother's education, and income. Table 11 summarizes the results of the raw score regression.

Table 11.

Hierarchical linear Regression with ANT accuracy as outcome variable

	R^2	Std error	R^2 change	*p*-value
Model 1 (Fed)	.001	3.30	.001	.877
Model 2 (Model 1+ Med)	.028	3.30	.028	.355
Model 3 (Model 2 + Y)	.127	3.18	.099	.075
Model 4 (Model 3 + PPVT)	.340	2.82	.213	.005**
Model 5 (Model 4 + KBIT)	.372	2.79	.032	.240

*** Significant at .01 level (2-tailed)*

Standard checks of assumptions of linear regression did not yield any alarming results. The model that only included Fed (father's education) had an R^2 of .001 and this was not significant (*p*>.05). The model with both Fed and Med had an R^2 of .028 and this was not

significant as well ($p>.05$). However, when Y was added to the model, there was a .099 R^2 change that almost reached significance; $F(1,30) = 3.40$, $p =.075$. When PPVT was added to the model, there was a significant .213 R^2 change; $F(1,29) = 9.35$, $p<.01$. Lastly, adding KBIT to the model resulted in a .032 R^2 change that was not significant, $p>.05$.

Next, we estimated a hierarchical linear regression model predicting Inverse Efficiency Score from the three SES variables – Father's and Mother's education, and income, as well as PPVT and KBIT scores. Inverse efficiency scores were used instead of mean RT, because they analyze both accuracy and RT together, without including speed-accuracy tradeoffs; thereby providing a better understanding of processing efficiency (Townsend & Ashby, 1978). Table 12 summarizes the results of the raw score regression.

Table 12.

Hierarchical Linear Regression with Inverse Efficiency Score as outcome variable

	R^2	Std error	R^2 change	*p*-value
Model 1 (Fed)	0.63	3.04	.063	.153
Model 2 (Model 1+ Med)	.018	3.06	.014	.493
Model 3 (Model 2 + Y)	.036	3.03	.047	.215
Model 4 (Model 3 + PPVT)	.284	2.79	.160	.017*
Model 5 (Model 4 + KBIT)	.358	2.69	.074	.084

* Significant at .05 level (2-tailed)

Standard checks of assumptions of linear regression did not yield any alarming results. The model that only included Fed (father's education) had an R^2 of .063 and this was not significant ($p>.05$). Adding Med into the model resulted in an R^2 change of .014, which was

not significant as well (p>.05). When Y was added to the model, there was a .047 R^2 change which was also not significant (p>.05). However, when PPVT was added to the model, there was a significant .160 R^2 change; F(1,29) = 6.47, p<.05. Lastly, adding KBIT to the model resulted in a .074 R^2 change that was not significant, p>.05.

5.6 Summary of findings

The 54 to 101-month-old Malay population studied in Singapore was confirmed by the MQ to be highly bilingual. This Malay population revealed several SES measures below the Singapore mean: educational attainment, monthly income, and household size. When comparisons were made between the Malay and Chinese sample, only income was significantly different between both groups. Despite the low SES nature of this English-Malay population, the children displayed high EA rates (i.e., ANT scores). These EA rates are high when compared to other populations of monolingual and bilingual children studied with similar methodology (M = 54.6 months) (Yang et al., 2011). This high EA holds even in the youngest children (M= 57.3 months) in our sample. EA was strongly correlated with English vocabulary comprehension, and high English vocabulary correlated with higher performance on EA. However, none of the SES measures correlated significantly with EA.

Correlational analyses between the SES variables – Y, Fed, Med –, the English vocabulary scores, the KBIT-2, and the child-ANT components revealed that none of the SES measures were significantly correlated to any of the child-ANT scores. Thus, the three SES variables alone did not explain the EA performance of this population. On the other hand, however, income was significantly correlated to the English PPVT scores. Regression analyses examining how much each SES variable influenced the accuracy and inverse efficiency scores of the child-ANT showed that none of the three SES variables significantly influenced the

performance on the EA task. However, English vocabulary scores (i.e., PPVT) significantly explained the EA performance. Both the correlational and regression analyses have shown that the three SES variables studied in the present thesis alone are insufficient to account for the children's performance on the Executive Attention task.

The hypothesis of this thesis is whether SES alone is sufficient to diminish the executive attention advantage in this low-SES English-Malay sample. Despite significantly having lower income levels compared to the Chinese sample, the Malay group's EA scores were NOT significantly different from the Chinese group's EA scores. Thus, in line with our hypothesis, results revealed that SES did not arrest EA development in our group of young Malay bilinguals between four and 6 years of age. At the same time, results of our study also begin to reveal the complexities of measuring SES across cultures. Results from initial MQ results (as in Table 5) revealed that although this population was considered as low SES, they still had literacy practices that were atypical of a low SES population. For example, parents appeared to be reading books in either English or Malay, or both, to their children at least a few times a week. On top of this, a majority of the children's parents had an educational attainment of up to a "Level 4" out of 5 levels (i.e., Tertiary/University), despite the below-average average monthly income levels. Thus, this highlights the need to study SES variables in greater detail, because as the present study has revealed, low income does not necessarily indicate low parental education.

CHAPTER 6

DISCUSSION

The main objective of the current thesis was to investigate if SES diminishes the cognitive advances in young bilinguals between the ages of 4 and 6. We recruited English-Malay bilinguals in Singapore and administered the child-ANT, which measures executive attention, to these participants. The PPVT and KBIT were also incorporated to provide a more comprehensive background of the nature of our sample. Several SES variables were evaluated. Although family background income suggested that these participants were low in SES (by Singapore's standards), they still exhibited high performance levels on the child-ANT relative to other groups of monolinguals and bilinguals (Yang et al., 2011; Kang, 2009).Comparisons with other samples (i.e., Chinese and Korean), as well as correlational and regression analyses further reiterated that the components of SES included in this thesis – income and parental education, does not diminish EA advantages in this bilingual sample.

A critical comparison made in this thesis was between the Malay and Chinese (Kang, 2009) samples. Both groups were recruited in Singapore, and were not significantly different in terms of age. Although both samples did not significantly on father's and mother's highest educational level, the Chinese sample (Kang, 2009) were reported to have significantly higher average monthly income levels. In this chapter, we discuss potential reasons for our findings.

Language Assessments: PPVT-IV & CMQ

The PPVT-IV task was used as a measure of English receptive vocabulary of our sample. In this task, the raw scores of our Malay sample were considered as fairly high scores that were comparable with the PPVT raw scores of the age-matched Chinese sample (Kang, 2009). No

significant differences were observed in the PPVT scores of both samples. This implies that the English receptive vocabulary of the Malay sample did not fall behind their age-matched Chinese counterparts, despite their low SES.

As for the CMQ, data from half the sample was collected (*n*=17). The CMQ is a report completed by a child's caregiver, and explores the sociolinguistic background as well as the nature of the child's bilingualism/multilingualism. Caregiver reports in the 17 questionnaires provided comprehensive information on the family and child language background, and child language exposure and use across various settings (i.e., home, school, other places). After summarizing the results of the questionnaire, three trained researchers independently evaluated the questionnaires using evaluation criteria previously formulated by a research group at the CLAL. Based on the caregiver reports, each researcher objectively evaluated the 17 children's English and Malay proficiency in Listening Comprehension, Oral Production, and Overall proficiency.

Caregiver reports were summarized and all 17 children were exposed to both languages before age 4. This classifies them as simultaneous bilingual learners, Patterson's (2002) definition of simultaneous bilinguals being children exposed to two languages during infancy and early childhood. Summary of the results also revealed that all 17 children were exposed to and used two languages on a daily basis, across various settings. As such, these children can be characterized as active bilingual learners. Based on our classification of the children as either balanced or dominant bilinguals, comparisons were made between these two groups. Although the Father's education (Fed) for the dominant bilinguals was significantly higher than the balanced bilinguals, both groups (balanced and dominant bilinguals) did not significantly differ

on all the components of the child-ANT. This preliminary analysis suggests that level of bilingualism did not significantly influence executive attention.

Cognitive tasks: child-ANT & KBIT-2

The child-ANT was used as a measure of EA in our study. In this task, the three attentional networks (alerting, orienting, executive control/conflict) were measured through overall accuracy scores, mean reaction time, network efficiency and inverse efficiency scores. The Malay sample had fairly high overall accuracy scores, significantly outperforming monolinguals in Yang et al.'s (2011) sample, as well as having comparable performances with the English-Chinese bilinguals in Kang's (2009) sample and the Korean-English bilinguals in Yang et al.'s (2011) study. In terms of Mean RT, no significant differences were seen between the Malay and Chinese sample either. This implies that both groups took almost equivalent time to respond to the direction of the arrow in the target fish presented on the screen.

For the three network efficiency scores, no significant differences were found between Malay and Chinese samples. However, for the orienting network, the Malays had lower efficiency scores, and this difference almost reached significance. To recap, the orienting network measures the ability of the child to utilize spatial pre-cues to direct his/her attention to the cued location. Lower efficiency scores reflect higher network efficiency, as this indicates a small increase in RT when conditions become more difficult. Thus, the Malays' lower orienting score implies that the Malay children were better able make use of the spatial cues to orientate their attention to the location of the screen where the target fish will appear, resulting in higher orienting network efficiency. Lastly, significant differences were also not found between both groups on the inverse efficiency scores. However, the Malays performed slightly better with

lower inverse efficiency scores, compared to the Chinese sample. Like the network efficiency scores, a lower inverse efficiency scores reflect higher network efficiency. This implies that the Malays had slightly higher processing efficiency even when analyzing both accuracy and RT together.

Another cognitive task was the KBIT-2 that was used as a brief measure of intelligence. Subjects only completed the "Matrices" subset, which measures ability to understand relationships and analyze visual analogies, as well as picking out patterns and trends from a series of figures. For the KBIT scores, we did not have a benchmark for comparison; hence we can only make within-sample inferences about the relationship between a sub-component of intelligence and attention, which will be discussed in the next paragraph presenting results on correlational analyses between KBIT and ANT scores.

Correlational & Partial Correlational Results

Correlational analyses were performed to explore the relationships between the SES measures and the components of the ANT scores, as well as the PPVT and KBIT scores. None of the SES measures (Fed, Med, Y) were significantly correlated with any of the ANT scores. In fact, these correlations appeared to be in the low range (i.e., most were below $r = .2$). That is, within this sample, higher SES (i.e., Fed, Med, Y) did not correlate with better performance on the child-ANT (as measured by accuracy, reaction time, network efficiencies and inverse efficiency). However, as noted before, the range of the household income levels in this sample was rather limited (i.e., majority were on a level 3 out of 5 level), and this might have resulted in the lower correlations between SES and ANT. As such, future studies should recruit participants

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across diverse SES levels to more conclusively find out if SES variation within the bilingual population is correlated with child-ANT performance.

Although none the SES measures were significantly correlated with ANT scores, income (Y) was significantly correlated with PPVT scores. This implies that children in higher income families had higher English vocabulary scores. This is not a surprising finding, given the consistent results from previous studies revealing lower receptive and expressive vocabularies in low SES children (Noble et al., 2005; Whitehurst, 1997; Hart & Risley, 1995). In Noble et al.'s (2005) study, low SES children had significantly worse performance compared to their middle SES counterparts on language tasks, and this had a large effect size. On the other hand, an unexpected result was the insignificant correlation between KBIT and SES measures. Several studies have demonstrated that SES predicted outcome measures like IQ and academic achievement (Bradley et al., 2002; Duncan et al., 1994; Smith, Brooks-Gunn & Klebanov, 1997), and results from one revealed that SES accounted for 20% of the variance in IQ in childhood (Gottfried et al., 2003). What was surprising was that income was not significantly correlated with KBIT scores. One reason for this insignificant correlation could be that the sample was only tested on one subset of the IQ test, which was insufficient in measuring general IQ level of the child. Future studies should incorporate all three subsets of the KBIT, in order to obtain more accurate IQ scores of the sample. Another reason why income was not significantly correlated with KBIT scores could be attributed to other factors mediating the low income of the families – for example, Father's/Mother's education, type of bilingualism (dominant/balanced), and other important factors documented on the MQ (i.e., literacy, both parents using both languages at home), as can be seen from Table 6 earlier.

Other significant correlations were those between PPVT and several components of the

ANT task – Overall accuracy, Mean RT, and inverse efficiency. This implied that children with

higher English vocabulary scores performed better on the ANT task. Initially, it was surprising to

observe such results – having one component of SES (Y) being significantly correlated with

PPVT, none of the SES components (Y, Fed, Med) were significantly correlated with ANT

scores, yet PPVT was significantly correlated with ANT scores. Depicting this pathway with a

simple figure (Figure 13 below) may aid in understanding this relationship better. An important

point to note is that the relationship between the variables in Figure 13 is not causal but

correlational.
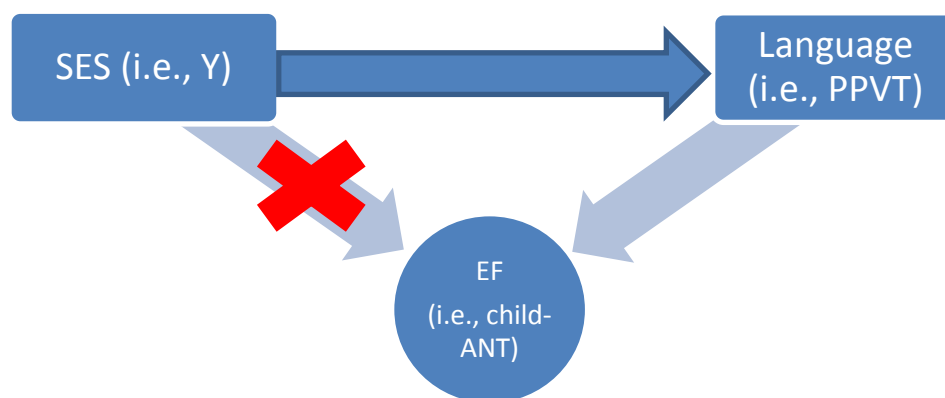
Figure 13. Possible pathway between SES, language, and EF ability.

In Figure 13, we see that income (Y) correlates significantly with English vocabulary.

However, none of the SES components (Y, Fed, Med) were significantly correlated with EF. On

the other hand, English vocabulary was significantly correlated with EF. Related to this, Noble et

al. (2005) argued that there might be a possible causal pathway in the relationship between

language, SES, and EF. In their study, SES did not significantly account for EF variance, above what was predicted by language (Noble et al., 2005). Hence, they concluded that SES might have an effect on language (i.e., vocabulary), which independently drives EF performance.

Finally, there were significant correlations between KBIT and some components of the ANT – Overall Accuracy, Orienting, Conflict, and inverse efficiency. As the "Matrices" subset of the KBIT measures the ability to analyze visual analogies and pick out trends/patterns, it was not surprising to see a significant correlation between performance on KBIT and the network efficiency scores. The orienting network measures one's ability to make use of the spatial cues to respond to the target stimulus efficiently, while the conflict score measures one's ability to overcome distracting/irrelevant stimuli. Thus, these skills are highly similar to the ones required for the KBIT subset, which explains the significant correlations between KBIT and ANT scores.

For partial correlations, after controlling for all three SES measures, none of the above correlations remained significant. This implies that SES has significant effects in the relationship between language, intelligence and EA abilities, which was depicted earlier in Figure 13.

Regression Results

Hierarchical linear regression models were estimated, predicting overall ANT accuracy and inverse efficiency scores from the SES variables (Fed, Med, Y), PPVT and KBIT scores. According to Table 11, when all three SES variables were incorporated into the model, they only accounted for 12.7 % of the variation in overall ANT accuracy scores; this was not significant. Thus, this implies that within the Malay sample, SES variation did not significantly predict the overall ANT accuracy scores. However, when PPVT was added to the model, there was a significant increase in the model's ability to predict the variation in overall ANT accuracy

scores. With PPVT, the model then accounts for 34% of the variation in ANT accuracy scores. This implies that language (specifically English vocabulary) was a better predictor of overall ANT accuracy scores than SES variables.

Next, Table 12 presented results for the linear regression predicting inverse efficiency (IE) scores from the above variables. Similarly, when all three SES variables were added to the model, they accounted for only approximately 4% of the variation in IE scores. However, when PPVT was added, the model now accounts for 28% of the variation in IE scores, and this R^2 change was significant. Again, this reiterates the point that language (English vocabulary at least) was a better predictor of IE scores than SES variables.

Conclusion

The past bilingual literature has consistently showed a bilingual advantage in young bilingual children on executive control tasks (Barac et al., 2012; Bialystok, 1997, 1999; Bialystok et al., 2009; Carlson et al., 2008; Yang et al., 2011). Building on this, the present thesis set out to explore if SES variation affects EF performance similarly within bilingual groups. In summary, despite being considered as low SES by Singapore's standards (i.e., below-average monthly household income levels, above-average household size, occupation types), our English-Malay bilingual sample displayed high ANT scores. Some possibilities of this finding are discussed here.

First, MQ results from the subsample (*n*=17) point to the possibility that this sample might be highly bilingual. All 17 children had daily exposure and use of both languages, and the majority of them were exposed to both languages since infancy. Bialystok et al. (2004) noted that the cognitive advantages of bilingualism are 'more salient' for 'relatively balanced' bilinguals

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(292), and this might explain the present sample's high EA performance, despite the low SES.
Another possible reason could be due to the influences of culture as well. Although this was a
non-Chinese sample, the Malay sample was recruited from Singapore, a Southeast Asian
country, where the East Asian culture still exerts some influence over parenting and educational
practices (i.e., Asian parenting practices emphasizing self-regulation). Thus, the high EA rates of
this low SES bilingual sample may be confounded with the influences of the East Asian culture.
However, statistical reports have consistently shown the Malays to have the lowest educational
attainment in Singapore over the past few years (Singapore Department of Statistics, 2011);
hence, culture and/or parenting practices alone is insufficient to explain the high EA rates of this
low SES sample.

Another possibility for the high EA performance of this sample could be attributed to
learning more than two languages. Although parents did not consider their children as trilinguals,
data from some of the MQs suggest that these children might be emerging trilinguals, given that
they are also exposed to a third language (Arabic) during prayer times every day. Thus, learning
more than two languages might have additional cognitive benefits for these low SES children.
Future studies should compare low and high SES bilinguals and trilinguals to explore if learning
more than two languages does provide additional cognitive benefits.

Bilingualism & SES

As we did not recruit a matched low SES monolingual sample, the present study cannot
make claims on whether bilingualism serves as a buffer against the negative effects of SES on
EA development, based on these child-ANT scores. However, based on the preliminary
comparisons between the monolinguals in Yang et al.'s (2011) study, the youngest subset of

Malay bilinguals in the present sample demonstrated a bilingual advantage. Importantly, results also suggest that the low SES of the Malay sample did not arrest EA development in these young English-Malay bilinguals. Compared to several studies that revealed that low SES impedes performance on EF tasks (Ardila et al., 2005; Howse et al., 2003; Hughes et al., 2005; Lipina et al., 2004; Mezzacappa, 2004; Noble et al., 2005), the present study has shown that SES – measured by income and parental education – did not impair EA development in the young bilingual sample. More research should be conducted to examine the exact nature of how bilingualism influences EF development in young bilingual children from low SES backgrounds.

Future Directions

Due to time and financial constraints, the sample size for this study was very small. Future studies should include a larger sample size to account for more variations in factors like SES and other demographics. More importantly, matched monolingual groups should be recruited to further assess the potential link between bilingualism and cognitive advances in EA. The most ideal comparison would be to compare with low SES Malay monolinguals in Singapore, but this sample would be nearly impossible to obtain, due to Singapore's bilingual education policy and the general linguistic environment where English is the main medium of language everywhere. Thus, the next best alternative would be to recruit low SES monolinguals elsewhere (for example, in USA, or even in Korea/China – to take into account cultural factors playing a role in affecting cognitive advances in EA). Specifically, low SES monolingual children should be recruited to make more direct comparisons between matched groups of low SES monolingual and bilingual samples. If the bilingual group significantly outperforms the monolingual group on tasks measuring EF, this would more concretely prove that bilingualism buffers against the negative effects of SES on cognitive development.

With regards to language assessment, the present thesis only tested receptive vocabulary in English. As we did not directly assess the Malay proficiency level of our sample, we are unable to tell what the fairly high English PPVT scores of the sample mean. For example, the correlation between PPVT and ANT scores should also be evaluated – Does high English vocabulary imply higher bilingualism or language attrition of the other language? What is the relationship between bilingualism, vocabulary level, and EA? Is vocabulary (L1, L2) a mediator in this relationship? High vocabulary scores could mean two things– the child is highly bilingual or experiencing attrition in the other language – Malay. Although preliminary results of the MQ from a subset of this sample (n=17) allowed us to evaluate all 17 children as fairly balanced bilinguals, direct assessments of the children's Malay proficiency is still needed for us to make an objective conclusion on a child's level of bilingualism. Additionally, we would also need to collect more precise information on the actual nature of the home surrounding language of the Malay children to fully understand the nature and extent of bilingualism in each child.

To address this, the quantity and quality of a child's bilingualism should be further assessed through developing and applying measures for assessing the quantity and quality of bilingualism in a child going beyond the caregiver report of the MQ. Using a multi-method approach of direct assessment and caregiver report, we will be able to more accurately assess a child's level of bilingualism/multilingualism. An example of a production task to include would be the Elicited Imitation Task, which is an experimental method to evaluate a child's language production. An elicited imitation task is analytic and reconstructive, and the type of errors a child makes provide critical insight into the child's language system. In such a task, a child is instructed to repeat sentences the experimenter produces. The child's task is to analyze and reconstruct the stimulus sentence to imitate. Through studying what each child can and cannot

imitate, as well as evaluating the types of deformations a child produces, we would be better able to get a window into the child's theory of how language and grammar works. This task is flexible in that researchers are able to design stimulus sentences exactly around what the researcher wants to test. For example, an elicited imitation task measuring syntax would have coordinate sentences, relative clause embedded sentences, and adverbial clause sentences included.

Pertaining to the measure of Executive Function, our present thesis only had one task measuring a specific subset of EF – Executive Attention. To obtain a more comprehensive view of how bilingualism affects cognitive development, we would need to incorporate more EF measures. In our future study, we have included the Hearts and Flowers task (Diamond, 2007) as another EF measure. This task – previously known as the Dots task – measures the inhibition of a behavioral tendency in young children (Diamond, 2007). The Hearts and Flowers task, like the child-ANT, is played on a computer. The child is asked to press one of two keys on the keyboard upon seeing a heart or a flower on the screen. When a heart appears, the child has to press the button that is on the same side of the screen as the heart. When a flower appears, the child has to press the button on the opposite side of it. Thus, this requires an inhibition of behavioral tendency to press on the same side where the stimulus is shown, while keeping in mind the rules of the task (i.e., working memory, which is another component of EF).

With regards to the measurement of SES variables, there were some ambiguous parts in the family background questionnaire pertaining to education and income. For education, caregivers had to choose between one of the five levels provided. However, because there were essentially two choices within each level (i.e., level 2 represents secondary and pre-university), it is ambiguous as to which one of the two options was the choice. On the same note, average monthly income was divided into five levels, but there was too wide a variation within 1 level

(i.e., level 2 had an income range of $1000 to <$3000, while level 3 had an income range of $3000 to <$6000). These options are ambiguous and not ideal for analyzing SES accurately. In future, to measure SES variables more precisely and to allow for more direct comparisons across national samples, a more standardized SES measure should be employed, like the MacArthur Network on SES and Health. On top of the questions we already have in the family background sheet, the MacArthur also has questions regarding home ownership (i.e., do they rent or own the current home) and more subjective questions that require caregivers to indicate where they think they stand on an "SES ladder", with respect to their community. This would provide a more comprehensive and accurate measure of SES that can be compared with other studies using the same SES measurement.

To conclude, results from this study of the Singapore Malay population extend the range of bilingual populations which has been studied for evidence of cognitive advantages, supplementing previous studies of Korean, French-Canadians, African American, and Hispanic populations. Crucially, the present study also revealed that certain SES deficits alone (i.e., low income levels) are not sufficient to diminish high EA rates in bilingual populations, as had been hypothesized in previous literature (Morton et al., 2007). They suggest that development of bilingualism and SES are partially independent variables (Bialystok, 2011; Gathercole et al., 2010); although components of SES can and do modify language development (i.e., vocabulary). It is important for future studies to tease apart the relationship between language, SES variables and EF development, as this has significant practical implications not only for parents, but for schools and policy makers as well.

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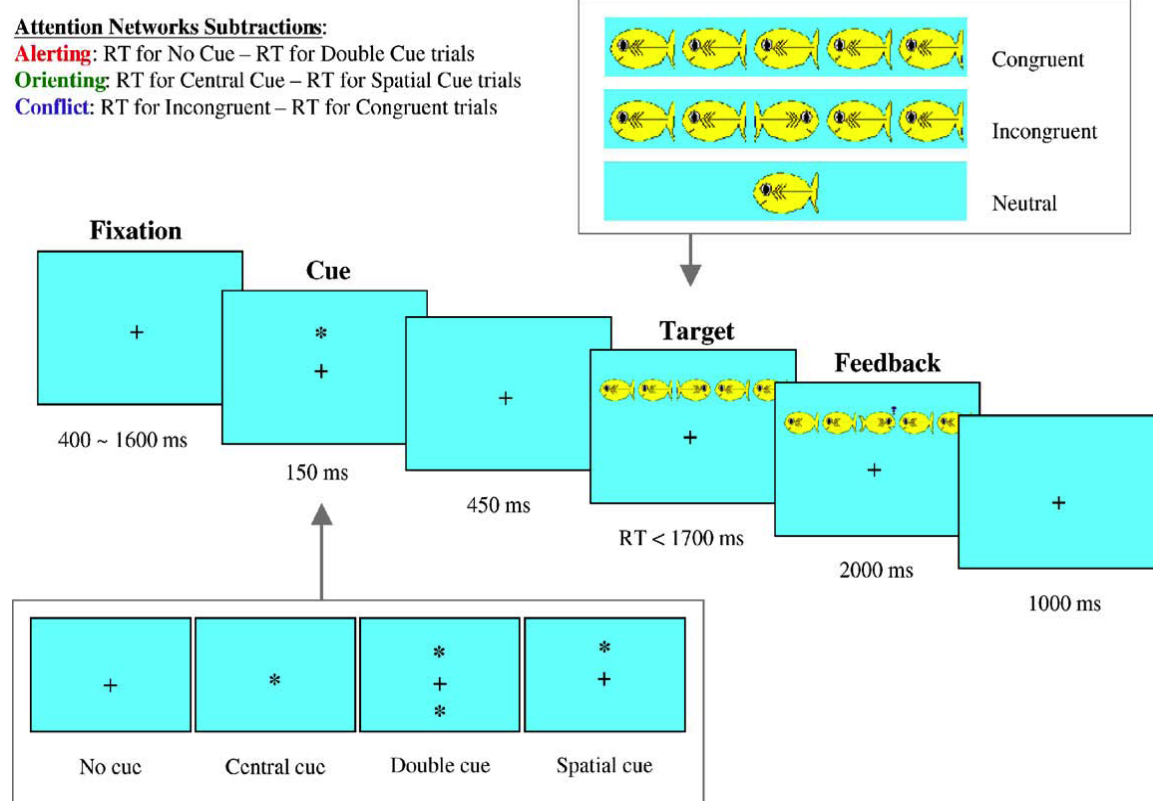
APPENDIX

Figure 2. Pictorial depiction of the child-ANT

Table 5.

Summary of results from the Child Multilingualism Questionnaire (CMQ)

Subject/ Gender	Age *Mth	Age of Acq. (E & M) *Years	Ratio of Child's Overall *Exposure* to E:M	Ratio of Child's Overall *Use* of E:M	PPVT-IV (English) Standardized Scores	Ratio of Mother to child's Language Use (E:M)	Ratio of Father to child's Language Use (E:M)	Additional Caregiver's Language Use (E:M)	Researchers' Evaluation Of Bilingualism Type	Book Reading (Mother)	Book Reading (Father)
1 (M)	60	0, 0	80 : 20	80 : 20	110	80 : 20	-	-	Dom English	Both, everyday	-
2 (M)	63	0, 0	60 : 40	30 : 70	89	Mostly E	-	-	Dom Malay	English, everyday	-
3 (F)	55	0, 0	60 : 40	60 : 40	86	More M	More M	-	Balanced	80% English, almost everyday	-
4 (F)	72	0, 2	60 : 40	60 : 40	86	60 : 40	60 : 40	-	Balanced	Both, everyday	Both, everyday
5 (M)	70	0, 0	90 : 10	90 : 10	116	90 : 10	90 : 10	0 : 100	Dom English (slight)	80% English, 2-3 times/week	-
6 (M)	61	0, 0	70 : 30	50 : 50	74	60 : 40	40 : 60	50 : 50	Dom Malay	Both, fortnightly	Malay, fortnightly
7 (F)	75	0, 0	80 : 20	80 : 20	85	60 : 40	50 : 50	-	Dom English (slight)	More Malay, 3 times/week	Both, less frequently
8 (F)	59	0, 4	50 : 50	60 : 40	103	60 : 40	60 : 40	-	Dom English	70% English, everyday	Mostly English, everyday
9 (M)	66	0, 0	50 : 50	60 : 30 : 10	100	50 : 50	Mostly E	-	Balanced	Both, everyday	English (unknown)
10 (F)	68	0, 1	80 : 20	80 : 20	86	80 : 20	50 : 50	40 : 60	Balanced	English, everyday	-
11 (F)	75	0, 0	80 : 20	90 : 10	107	80 : 20	80 : 20	10 : 90	Balanced	More English, 2 times/week	More English, 2 times/week
12 (F)	72	0, 0	55 : 45	60 : 40	90	50 : 50	30 : 70	-	Balanced	Mostly English, everyday	Mostly Malay, 2 times/week
13 (F)	56	0, 0	70 : 30	75 : 25	88	90 : 10	90 : 10	-	Dom English	Mostly English, every other day	English, 3 times/week
14 (F)	57	0, 0	60 : 40	60 : 40	91	50 : 50	30 : 70	-	Balanced	Both, 3-4 times/week	Both, 2 times/month
15 (M)	65	3, 0	70 : 30	70 : 30	103	100 : 0	0 : 100	50 : 50	Balanced	Both, 2-3 times/week	Father no. *Grandparents do (both languages)
16 (F)	71	3, 0	60 : 40	60 : 40	98	50 : 50	50 : 50	-	Balanced	English, 3 times/week	Malay, rarely
17 (M)	55	0, 3	80 : 20	90 : 10	89	90 : 10	90 : 10	60 : 40	Dom English	Mostly English, 2 times/week	English, 4 times/week *Grandparents L1 sometimes

Note: E refers to English and M refers to Malay