BILINGUAL PROFICIENCY AND EXECUTIVE FUNCTIONS

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CERTIFICATE

This is to certify that this dissertation entitled **"Bilingual Proficiency and Executive Functions"** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 15SLP018. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Bilingual Proficiency and Executive Functions "** is the result of my own study under the guidance of Dr. Abhishek B. P, Lecturer in Speech Sciences, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Chapter I

Introduction

Bilingualism is defined as the usage and proficiency in at least two languages by an individual, which may change depending on the opportunities to use the languages and exposure to other users of the languages (ASHA, 2004). Haugen (1953) asserted that bilingualism starts when an individual communicating in one language can equally communicate in another language using meaningful utterances. Innumerable definitions have led to the emergence of a number of classification systems to describe the various types of bilingualism.

Based on the age of exposure to the two languages, bilinguals are classified as early and late bilinguals (Beardsmore, 1986), depending on how two or more linguistic codes are organized and stored by individuals, bilinguals are grouped as compound, coordinate and subordinate bilinguals (Weinreich, 1957) and based on the proficiency and the competency in both the languages, bilingualism has been classified into balanced and dominant types (Peal & Lambert, 1962). When L1 competence is equal to L2 competence, the condition is called balanced type and in the dominant type the L1 competence is greater than or less than the L2 competence.

The competency may include a variety of skills, and since proficiency varies across the two languages at all linguistic levels for a bilingual, proficiency has to be assessed in a variety of domains such as understanding, speaking, reading and writing in both the languages. Many measures have been proposed to measure proficiency levels. McNamara (1967) grouped the measures of bilingual ability which assesses proficiency into mainly four categories, which include fluency tests, rating scales, dominance tests and flexibility tests. Among the many rating

scales available Language Experience and Proficiency Questionnaire developed by Flege, 1999 and revised by Marian, Blumenfeld & Kaushanskaya, 2007 is a valid and reliable questionnaire for assessment and quantification of a bilingual's proficiency. It has also been adapted to the Indian context by Ramya & Goswami (2009)

Bilingualism has been found to have positive effects on the linguistic, cognitive and emotional abilities of an individual. It helps an individual to become more sensitive to fine distinctions between languages. Further it enhances the effective use of their first language and aids in learning other languages. Various studies conducted in this area have found that bilingualism can enhance a bilingual's cognitive processes throughout life and they could develop better cognitive functions which are termed as the bilingual advantage where bilinguals demonstrate a superior performance relative to the monolinguals (Bialystok, Craik, Klein & Viswanathan, 2004). Apart from just being able to converse with a wider range of people bilingualism also helps in resolving internal conflicts and gives the mind a workout that strengthens its cognitive muscles. It has been found that there is a delay in cognitive damage and hence the onsets of dementia symptoms are significantly delayed in bilingual individuals. Also improved cognitive skills in bilinguals are beneficial as they help in developing more efficient and faster monitoring systems and also better performances on the various tasks of executive functioning. Cognitive linguistic flexibility and selective attention abilities has always been an advantage of bilingualism as bilinguals have more experience in switching between various languages which has attracted many researchers across the world to carry out research pertaining to this field.

Bilingualism has been found to have a positive effect in the efficiency of the executive functioning (EF) system. “Executive functions” (EFs), is a broad term which includes many cognitive processes and behavioral competencies (Chan, Shum & Chen, 2008). Cognitive flexibility, response inhibition or resistance to interference, verbal reasoning, problem-solving, planning, resistance, feedback utilization, multitasking sequencing, attention skills, and the ability to deal with novelty. Executive functioning in bilinguals refers to higher processes that involve conscious control of thought and action (Zelazo & Muller, 2010).

Bilinguals have the advantage of being able to constantly shift between two languages and paying attention in selecting the required word from a set of distracting stimulus which boosts their cognitive development. Bilinguals took lesser time as compared to the monolinguals in the switching tasks, indicative of the fact that better experience in can lead to better efficiency in the ability to shift flexibly between mental sets. The advantages of bilingualism in executive function are not only applicable to response inhibition tasks but also to flexibility in cognitive switching.

Vishwanathan & Bialystok (2009) found faster and better performance by bilinguals on tasks of cognitive flexibility and inhibitory control which made them conclude that bilingualism is responsible for enhanced executive control. Bunge (2002) found that bilinguals had an advantage over monolinguals in tasks of interference suppression. Similar results were found on nonverbal tasks to manage the two languages without the interference from the language systems (Bialystok, 2009). Hence it was concluded that throughout lifespan bilingualism is an important

component in executive processing and bilinguals performed better than monolinguals in tasks of attention.

Bilingual advantages in executive function which is an emerging area in the field of cognitive development can be assessed by tapping various domains of response inhibition, cognitive flexibility, attention and working memory using tasks which could be verbal or nonverbal. (Bialystok, 2001)

Response Inhibition or interference refers to the ability to block the extra information in order to focus on a particular task. There are many tasks to measure inhibition in bilinguals. One such is the Stroop task where there would be asterisks appearing in colored ink along with color words appearing in both congruent and incongruent ink. The difference between the speed of responding to all the asterisks and the speed for naming the incongruent stimuli will be considered as the Stroop effect. Simon's task can also be used wherein colored squares would appear on either one side of the computer screen and participants have to press either the right shift key or left shift key for the respected colors. The difference between the speed of response when the trial is congruent and the speed of response when the trial is incongruent would be calculated as the Simon effect. Flanker task is another task where there will be a central target stimulus along with the presence of congruent (same direction) and incongruent flankers (opposite direction). Here the central target stimulus will be assigned a particular direction either left or right.

Cognitive flexibility or set shifting is the ability of an individual to shift quickly between different response sets (Anderson, 2002). Prior & MacWhinney in 2010 claimed that this

switching requires the selection of a situation-appropriate language between two active language systems. There are a series of nonverbal tasks also such as the the local-global task where a global larger figure composed of local smaller figures would be presented. This task comprises of both congruent and incongruent trials and the difference between the speed of responding for a congruent trial from the time that of an incongruent trial will be considered as the shifting effect. Also tasks similar to the Simon task, Stroop task, Letter- number task can be used to test for set shifting.

Attention refers to how an individual can actively process specific information in the environment. Attention in bilinguals can be measured using Navon's figures where a bigger recognisable shape, such as a letter is presented. The larger letter will comprise of smaller different shapes and the subjects have to pay attention and perceive the global as well as the local features of the items presented. Attentional Network Task (ANT) can also be used which is a combination of the Flanker task (Eriksen & Eriksen , 1974) and a cue reaction time task (Posner , 1980) where three attentional networks measure the ability of an individual to attend to a task. In addition Simon's task and Stroop task can also be used to test for attentional capacity.

Working memory is another core executive function, which involves both the storage capacity of working memory and also processing capacity (Zelazo, Muller, Frye, & Marcovitch, 2003). Among the various tasks used to measure working memory in bilinguals is the Corsi block tests. In this task a cross hatch would appear in the center of the screen for the first trial after which nine grey blocks would appear on a black background of the computer screen. Based on the order in which the blocks are highlighted the participants should click on the block and the point

at which participants got all three trials of a single length incorrect will be calculated. Letter memory tests and Digit span tests (Forward and Backward) can also be used. Here the task involves recital of numbers from 2-9 in the order in which they were presented and the digit spans was categorized as the point at which participants incorrectly repeated two lists of the same length.

Different linguistic and non linguistic tasks have been employed to test executive functions. Non linguistic tasks includes Flankers task, Stroop object Task , Attentional network task (ANT) , Simons task while linguistic tasks include priming experiments which tap for listening comprehension, dichotic listening tasks and Stroop task etc.

Very few studies on executive functions in high proficient and low proficient bilinguals have been carried out and hence the current study was conducted to explore the effects of bilingualism on the two groups of bilinguals in the various domains of executive functions namely attention, response inhibition and cognitive flexibility.

Need For the Study

Executive functions are considered as a critical component of cognitive and social development in bilinguals. The research done in the field of bilingualism has many clinical implications for understanding the development of executive function and also the various practical issues with respect to second-language instruction in homes and schools. India is a country having bilinguals of varied proficiency. Executive functions vary as a function of degree of bilingual proficiency.

Till date a very few attempts have been made to assess the effects of bilingualism on executive functioning in the Indian context. There are many domains of executive functioning, however this study is aimed at studying the effects of bilingualism specifically on the domains of cognitive flexibility, response inhibition and the ability to sustain attention as these tasks are sensitive to vary with respect to high and low proficient bilinguals by using tasks of varying complexity for each of the domains.

Aim of the Study

The aim of the present study is to measure the effects of bilingualism on executive functions.

Objectives of the study

- To study the attention in high and low proficient bilinguals.
- To study the response inhibition in high and low proficient bilinguals.
- To study the task switching ability in high and low proficient bilinguals.

Chapter II

Review of Literature

2.1 Bilingualism

Language is a system of communication using symbols or sounds that enables an individual to express thoughts, ideas, feelings and experiences (Goldstein, 2008). People tend to use more than one language in daily life. (Kroll & DeGroot, 2005). Bilingualism is defined as the use of at least two languages either by an individual or by a group of speakers. There is no universal definition of bilingualism however it is regarded as occurring on a continuum (Beardsmore, 1986). At one end of the continuum is a monolingual speaker and on the other end of the continuum is an individual who has acquired two languages from childhood. Bilingualism is defined as the usage and proficiency in at least two languages, which changes depending on the exposure to other users of the languages and the opportunities to use the languages. (ASHA, 2004).

Along the continuum are the individuals who illustrate greater or lesser degrees of bilingualism, which involves the bilinguals who speak both languages fluently and proficiently but are more dominant in one than the other and the adult second language learners with varying degrees of proficiency and mastery of the second language (L2).

There has been several attempts to classify bilinguals according to the distinction between the degree of proficiency in the languages, by age, context, manner of acquisition of the languages, and based on the hypothesized processing mechanisms or hypothesized language representation

which include: (a) the early/late, (b) simultaneous/successive, (c) compound/co-ordinate/subordinate bilinguals (d) acquired/learnt (e) formal/informal.

Considering the multi-dimensionality of bilingualism, researchers have obtained various classifications determined by the different dimensions of bilingualism they focused on.

(a) Early and Late Bilinguals: Based on the exposure to the two languages bilinguals can be categorized into early and late bilinguals. When an individual acquires more than one language in the pre-adolescent phase of life, they are termed as early bilinguals. (Beardsmore, 1986). Whereas acquiring of one language earlier and the other language after the age of 8 years is termed as late bilinguals.

Depending on when a bilingual attains linguistic competence the early and late bilinguals can be classified. When a bilingual attains native-like linguistic competence in the two languages he is termed as an early bilingual however non-native speakers of L2 language or those who have attained the second language after the critical period and who are not very competent in the second language are termed as late bilinguals. Late bilingualism is considered as successive bilingualism as it occurs after the acquisition of the first language.

Early bilingualism further can also be classified into two types, mainly:

Simultaneous early bilingualism and successive early bilingualism. When an individual learns two languages at the same time they are termed as simultaneous bilinguals whereas successive early bilingualism is the acquisition of the second language following the acquisition of the first language.

(b) Balanced and Dominant Bilinguals: An individual who possesses equal proficiency in both languages are defined as balanced bilinguals, whereas dominant bilinguals are those individuals whose proficiency in one language is higher than that in the other language. Peal and Lambert (1962) claimed that the difference between both the groups of bilinguals is dependent on the relationship between the proficiencies and fluency of the languages which bilinguals master.

(c) Compound, Coordinate, and Subordinate Bilinguals: Weinreich (1953) claimed that based on how the linguistic code is organized bilinguals can be classified into compound, coordinate, and subordinate groups. In compound bilinguals, there is a systematic storage of both the linguistic codes as one meaning unit; whereas in coordinate bilinguals, the codes are individually stored and organized as two meaning units.

Before the 1960's research on bilingual individuals claimed that being a bilingual was detrimental to an individual's linguistic and cognitive development, and that bilingual individuals were at a disadvantage compared to monolinguals as they had smaller vocabularies and minimal cognitive abilities. However, the studies had several disadvantages as they did not control for socioeconomic status and many of the tests administered verbal-intelligence tests to non-proficient speakers in their second language.

In 1962, Peal and Lambert conducted a study which controlled factors such as age, gender, and SES. They also used a standardized measure for bilingualism. Bilinguals were matched with monolinguals in the study and results obtained were suggestive of a bilingual advantage in both verbal and non-verbal tests. Since then there has been reports of bilingual advantage being seen

consistently in various domains of executive functioning, perception and development of language.

Being a bilingual can also have tangible practical benefits. There have been reports of better and faster sensory and cognitive processing in bilinguals which thereby manifests in a bilingual cognitive advantage being seen where an individual can inhibit irrelevant information and focus on the relevant information. Due to this it is easier for a bilingual to acquire a third language than a monolingual to acquire a second language. Compared to the monolinguals, bilingual individuals are better able to access newly learned words and gain elaborate vocabulary.

Grosjean (2001) explained the concept of "language mode" which refers to the activation of a bilinguals language and the language processing mechanisms at a particular point in time. In a bilinguals language mode a base language would be chosen and the other language is activated in the form of code-switching whereas in a monolinguals language mode, the bilingual individual deactivates on language. Codeswitching requires more executive and attentional control, and has greater effects on nonverbal tasks also. This is because the language control in bilinguals relies on a neural system that aids in detecting any conflicts in the verbal and nonverbal domain and also helps in resolving them. (Abutalebi et al. 2012).

A theory of Cognitive Complexity and Control (Zelazo & Frye, 1997) was developed to explain the cognitive advantages of being a bilingual. It consists of the ability to ignore the irrelevant information and focus on the rules by constructing a mental hierarchy.

Green (1998) designed an Inhibitory Control Model to explain the mechanism of code switching and also to explain the ability of a bilingual individual in speaking a particular language as compared to another. The model explains the ability of bilinguals to inhibit distracters and

control the language systems at the lemma level. The concepts are associated with a lemma which thereby leads to an activation of the associated word form.

Bialystok et al. (2009) claimed that there are many variables that can affect bilingualism. Some of the potential variables include age which is considered as an important factor because of the strong association between age of acquisition of a language and attaining proficiency in that language.

Proficiency is another factor that affects bilingualism which influences the neural organization of language. Language opportunities and use are crucial as they give information about the quantity, quality and content of the interactions which an individual uses to communicate in an environment. Language quantity is the amount of language exposed to an individual whereas the quality of language is as a measure of the accuracy and complexity of utterances shared with the individual.

Timing of exposure plays a role which involves identifying at what stage the language is introduced. For example there may be evident differences if acquisition of the first language is right from birth and second language is from preschool versus acquisition of the first language right from birth and second language from high school. Timing of exposure also depends on when the language is introduced. The second language can be introduced either simultaneously or sequentially.

Language contexts which refer to the environments in which the child experiences the languages and also aspects of culture which refers to cultural beliefs and values and frequency of usage of the words presented in the task are other variables which can affect bilingualism. The community of the individual also plays a major role in enhancing bilingual language development.

To strike a relative balance between two languages, the bilingual brain relies on executive functions. Bilinguals use the control mechanisms whenever they speak or listen as their language systems are always active which thereby strengthens the mechanisms.

2.2 Executive functions

Executive functions refers to a variety of skills which help in making socially responsible, self serving , independent and purposive behavior possible. (Lezak, 1995). Miyake and his colleagues (2000) claimed that executive functions is not an unitary construct and composes of many functions such as problem solving, mental flexibility, attentional control, inhibitory control, and task switching. They investigated tasks that are commonly used for assessing executive functions and their findings suggested the existence of three major executive functions: the “inhibition” of unwanted responses, the “shifting” between tasks and mental sets (also called “cognitive flexibility”), and the “updating” and monitoring of working memory representations. There is no gold standard for assessing executive functions in a bilingual however there are several tests and procedures that enable an examiner to obtain components of the various domains of executive functions.

2.3 Executive functions in bilinguals

Research from the past decades have found that bilingualism can enhance certain executive functions. There have been several studies investigating bilingual advantages in tasks such as

response inhibition, set shifting, attention and memory and the major goal of such studies is to find out how bilingualism can enhance executive functions in the bilingual population. These tasks are relatively difficult to categorize as individual executive function components although they certainly require executive functioning for performing the task.

Hakuta and Diaz (1987) administered tests to measure cognitive ability in a sample of bilingual children. Raven's Progressive Matrices was the test administered and the results revealed high correlation with the degree of bilingualism.

Bialystok (2003) made a distinction between two types of processing that help children in development of language. Analysis which involves the ability to represent and understand abstract information, and control, which involves the ability to selectively attend to specific aspects of structures while ignoring irrelevant information. Bilinguals have an advantage over monolinguals in cognitive abilities. In another study, Bialystok (2003) administered a non-linguistic card-sorting task where the participants had to demonstrate flexibility in problem solving while inhibiting irrelevant information. Results revealed bilingual children performed better than their monolingual peers.

In a following study, Bialystok and Martin (2008) aimed to determine the factor which gave bilinguals an advantage in solving the card-sorting task. Both the groups could equally represent the stimuli and inhibit learned motor responses. Bilingual advantage was seen on tasks of inhibition and also it was found that the ability to create new representations and inhibit competing information changes across tasks.

Bilinguals ability to selectively attend to important attributes of a stimulus has been explained by the fact that bilinguals have different representations in each language for similar concepts and hence they need to be aware of what word to use in what context and the language which they are using to carry out the task by inhibiting irrelevant information and attending to the relevant stimuli. Bilinguals also can use two languages in the same modality better as compared to monolinguals which require them to make the decision about how to respond in a situation and what language to use based on the context.

The authors have also done extensive research into the cognitive advantages of bilingualism. In several studies bilinguals performed better than the monolinguals indicative of the presence of a bilingual advantage and better control of attention which facilitates faster processing and functioning in several cognitive tasks. Also bilinguals demonstrated better skills in inhibiting irrelevant information.

2.4 Domains of executive functions

2.4.1 Attention

Attention refers to how an individual can actively process specific information in the environment. Attention in bilinguals can be measured using Navon's figures where a large shape, such as a letter, composed of copies of a smaller different shape is presented and the subjects have to pay attention and perceive the global as well as the local features of the items presented and also the Attentional Network Task (ANT) where three attentional networks measure the ability of an individual to attend to a task. In addition Simon's task and Stroop task can also be used to test for attentional capacity.

Ben-zeeve (1977) claimed that bilinguals can be distinguished from monolinguals for resisting interlanguage interference based on a special facility. Metalinguistic tasks were used that determined how well bilinguals can control the interference between the syntactic and semantic processes by ignoring the irrelevant information. Recently researchers have found out that the cognitive advantage seen in bilinguals results from executive attention (Bialystok, 1999; Yang, 2004). Posner and Fan (2004) postulated that there is an essentiality for attentional resources in human which help them to select required information and inhibit the unwanted information. They suggested that to ignore the distractions and select the required stimuli there must be some specialized system of network in the brains of the bilinguals which aids in the process of executive attention.

Bilinguals are usually considered better compared to monolinguals, in their ability to pay attention to important information and ignore the irrelevant information which was observed on the Stroop test done on seventeen balanced English-Korean bilinguals and ten English monolinguals (Yan, Ceci & Wang , 2005)

Bialystok, Martin and Viswanathan (2005) investigated the performance of bilinguals and comparison to monolinguals on tasks of attention using the Simons task. Results revealed better performance by bilinguals compared to monolinguals in early childhood, adulthood, and later adulthood whereas in younger adults there was no significant difference noticed.

2.4.2 Response Inhibition

Response Inhibition or interference is defined as the ability to block out irrelevant information and focus on the rules of interactions or tasks. There are many tasks to measure inhibition in bilinguals. One such is the Stroop task wherein the participants will be shown a series of asterisks in color ink and color words (e.g., blue) in congruent or incongruent ink and the Stroop effect will be the difference in the processing speed scores obtained for responding to all asterisk stimuli from the processing speed for naming all incongruent stimuli. Simon's task can also be used wherein participants will be shown colored squares on either the left or right side of the computer screen and the participant have to press either the left or the right shift key for the respective colour. The Simon effect will be considered as the difference in the processing speeds of congruent trials from the incongruent trials. Flanker task is another task where the target arrow is flanked by non-target stimuli which also contain congruent flankers, incongruent flankers and neutral flankers and a directional response will be assigned to the target stimulus.

The effect of inhibitory control on executive functioning in French – English bilinguals was demonstrated by Bialystok and colleagues (2008) and found that both older and younger bilingual participants had significantly faster reaction times on the conflict condition compared to their monolingual peers on the Stroop test and also younger adult participants were significantly faster compared to older adult participants which indicated a larger Stroop effect for older and monolingual participants suggesting that bilinguals did better on tasks measuring interference suppression.

Colzato et al (2008) evaluated the inhibition hypothesis by comparing monolinguals and bilinguals with regard to stop signal performance, inhibition of return, and the attentional blink. Inhibition hypothesis is based on the basic assumption that during the performance of any mental task requiring a minimum of mental effort, the subject actually goes through a series of alternating latent states of distraction (non-work *0*) and attention (work *1*) which cannot be observed and are completely imperceptible to the subject. These three phenomena, it can be were used to tap different aspects of inhibition. Monolinguals and bilinguals did not differ in stop signal reaction time and thus were comparable in terms of active-inhibitory efficiency. However, bilinguals showed no facilitation from spatial cues, showed a strong inhibition of return effect, and exhibited a more pronounced attentional blink. These results suggest that bilinguals do not differ from monolinguals in terms of active inhibition but have acquired a better ability to maintain action goals and to use them to bias goal-related information.

The consequences of bilingualism on inhibitory control was investigated by Rodrigues & Zimmer (2016) by testing 20 monolinguals and 20 bilinguals having Brazilian Portuguese as L1 and English as L2. Simon's task was used and statistically significant differences were found between the two groups. Martin-Rhee & Bialystok in 2008 studied French –English bilinguals to study inhibitory control in bilinguals and monolinguals. Bilinguals obtained faster responses to both congruent and incongruent stimuli as compared to monolinguals on response inhibition tasks and shorter reaction times on the Simon's tasks as they have better interference suppression because of the ability to manage attention by inhibiting distracting spatial cues in rapidly changing contexts.

2.4.3 Cognitive Flexibility

Cognitive flexibility or set shifting refers to the ability to switch rapidly between different response sets (Anderson, 2002). Nonverbal tasks measuring shifting have been measured using the local-global task where a geometric, global, figure composed of much smaller, local, figures (i.e., Navon figures) would appear on a computer screen and congruent and incongruent trials are presented and the shifting effect will be obtained as the difference between the processing speed for congruent and the incongruent trials. Also tasks similar to the Simon task, Stroop task, Letter- number task can be used to test for set shifting.

Peal and Lambert (1982) conducted a study on French-English bilinguals and French monolinguals and hypothesized that both the groups would perform similarly. However the researchers found that bilingual children performed better than the monolinguals in all of the tasks including nonverbal intelligence.

Bialystok, 1999 conducted a study on Spanish-English bilinguals. He postulated that life-long bilingualism is advantageous in shifting between mental sets efficiently. A battery of executive functions was assessed. The study controlled for factors such as age, parent education and parent income level, and results showed significantly better performance by bilingual children. The advantage was seen on managing conflict tasks but not on delay tasks. These results were suggestive of the fact that that both specificity and generalizability of bilingual experience is a crucial factor in the development of cognition in a child.

Vishwanathan & Bialystok (2009) found faster and better performance by bilinguals on tasks of cognitive flexibility and inhibitory control which made them conclude that bilingualism is responsible for enhanced executive control. Bilinguals advantages were seen in interference suppression, (Bunge, 2002) and on nonverbal tasks because of the usage of executive functions to manage the two languages without the interference from the language systems.

Ibrahim & Prior (2013) conducted a study on a group of balanced and dominant Hebrew and English bilingual adults which tapped for two types of cognitive flexibility namely reactive flexibility and spontaneous flexibility. Results indicated significant differences between the two groups and better performance by the balanced bilingual group. In both the flexibility tasks, the balanced-bilinguals had a superior performance compared to the Hebrew-dominant group. Also significant difference was found in the task which required spontaneous cognitive flexibility and the task which required reactive cognitive flexibility.

The study conducted by Prior & MacWhinney (2010) used a non-linguistic task switching paradigm to investigate whether there was a bilingual advantages in set shifting. They considered English – Spanish bilinguals and it was found that bilinguals performed better than monolinguals on the set shifting task suggesting that life-long experience in switching between languages can lead to increased efficiency in the ability to shift flexibly between mental sets.

Soveri , Fornelli and Lains (2011) tested 38 Finnish–Swedish early bilinguals and found that the frequency with which the bilinguals switched between languages in their everyday life

significantly predicted the mixing cost in the Letter-number task. The result was suggestive of a bilingual advantage being seen due to a lifelong experience in using two languages.

2.4.4 Memory

Working memory is another core executive function, which involves both the storage capacity of working memory and also processing capacity (Zelazo, Muller, Frye, & Marcovitch, 2003). Among the various tasks used to measure working memory in bilinguals is the Corsi block tests which begins with a cross hatch appearing in the center of the computer screen followed by nine grey blocks on a black background. Participants are instructed to click on the blocks in the order in which they were highlighted and the point at which participants got all three trials of a single length incorrect will be calculated. Letter memory tests and Digit span tests (Forward and Backward) can also be used where participants are made to tell numbers from 2-9 based on the order of presentation in and the digit spans was categorized as the point at which participants incorrectly repeated two lists of the same length.

Bilingual advantage on nonverbal working memory tasks has been shown, on tasks such as the backward Corsi block task (Feng, 2008 ; Feng & Bialystok , 2009; Milner, 1971) where the participants were French- English bilinguals and monolinguals. Results indicated no difference between the two groups on simple task whereas better performance by the bilinguals on the difficult task which demanded greater executive control on working memory which was attributed not only due to advantages in working memory but also because of updating.

2.5.1 Studies with nonlinguistic tasks

Bialystok et al. (2004) carried out a study to find out if older bilingual groups demonstrated a cognitive advantage associated with executive functions. Bilinguals from Hong Kong and India were compared with Canadian monolinguals and the researchers found bilingual cognitive advantages especially on the Simon's task in all the groups, cross-culturally.

The same set of authors carried out another study in which there were more number of trials in the Simon Task as compared to study 1 and they found out bilingual advantage was still present. There has been several other studies also done and the results were corroborated from the study done by Bialystok et al. (2004) on Simons task Other tasks such as the Flanker tasks, Stroop Task and Attentional network task (ANT) were also administered which contained both congruent and incongruent trials.

Costa, Hernandez and Sebástian-Gallés (2008) found out that under high processing demands the efficiency of the executive network would be more evident and that the speakers had to maintain a language control and monitor themselves by deciding what language to speak and to whom. (Costa et al, 2009)

Billig (2009) used the Stroop and Simon nonlinguistic tasks in their study. However they did not see any bilingual advantage. Also in another study carried out by Kramer (2011) no bilingual advantage among early bilinguals was seen compared to their monolinguals. In the absence of finding convincing bilingual advantage results. Billig (2009) concluded that the absence of bilingual advantage may have been because of the lower level of schooling of the bilinguals, compared to the Canadian ones.

Kramer (2011) found out few factors for the absence of a bilingual advantage in few bilingual populations. He stated that there may be an absence of literacy practices or low proficiency in reading and writing and due to such inconsistenies it is very hard to determine the conditions in which a bilingual advantage can be seen.

Hilchey and Klein (2011) formulated two hypotheses: BICA (Bilingual advantage inhibitory control) and BEPA (Bilingual executive processing advantage). According to the BICA hypothesis since bilinguals use inhibitory processes frequently it leads to more efficient processing and hence results in advantages in management of conflicts. However the second hypothesis claims that bilingual advantage is seen in all tasks of executive functioning. The BEPA hypothesis monitors and manages the variations between the trials based on the presence or absence of conflict.

Lauchlan, Parisi and Fadda (2013) carried out a study on bilinguals from Scotland and Sardinia who were speakers of minority language. They found out that bilinguals were better compared to the monolinguals on the inhibitory control task. There were no significant differences between the two groups. The authors attributed the results to the fact that the bilinguals from Sardinia received formal education in Italian, however the individuals from Scotland received formal education in the minority language. They concluded that bilingualism is a very important factor in cognitive performance of an individual. (Bialystok, 2009).

However, the studies conducted by Brazilian researchers could not replicate the finding. They investigated the speakers of minority languages which included mainly the southern population of bilinguals. The method of the Brazilian study was similar to that of the Canadian study , however a bilingual advantage was not seen however they found out that bilinguals performed faster compared to the monolinguals.

In summary in most of the studies using non linguistic tasks investigating executive functions, bilinguals have performed better than their monolingual counterparts and cognitive advantage was seen.

2.5.2 Studies with linguistic tasks

In order to investigate listening comprehension with competition between two languages, Blumenfeld and Marian (2011) developed a priming experiment and used it in eye tracking paradigm which aimed at investigating listening comprehension. The participants were made to listen to the words and identify the target word in English (first language). The target pictures appeared with a distractor and two neutral pictures. Eye movements were tracked and it was found that bilinguals were able to inhibit the distractors and hence they could reach the baseline activation state faster than monolinguals

Filippi et al. (2012) studied the comprehension of syntactically canonical and non-canonical sentences, with or without linguistic interference. The canonical sentences were in the subject-verb-object order, and non-canonical sentences were in the object-verb-subject. A dichotic listening task was used and the subject had to inhibit one of the sentence. Results revealed better performance by the bilinguals compared to the monolinguals on non-canonical sentences and that bilinguals could inhibit the distraction in their L1 however monolinguals were affected by interference.

When this study was replicated in English the authors did not find the bilingual cognitive advantage. The results were interpreted with respect to bilingual proficiency in English, because

part of the sample of participants had no high proficiency in English. They concluded that the higher the English proficiency, the better the bilinguals were in filtering out irrelevant sentences.

In summary bilinguals were able to perform better than the monolinguals on almost all the linguistic tasks as they were able to attend to the relevant information by inhibiting the distractors.

2.6 Indian studies related to bilingualism

Kamat et al (2012) conducted a study to see whether bilingualism had an effect on executive functioning in Hindi and Marathi languages. A bilingualism index was generated using self-reported Hindi and Marathi proficiency and the association between bilingualism and cognitive performance was examined. The authors found better performance on the inhibition task and the task switching components of executive functioning. Hence the authors concluded that being a bilingual had an advantage on measures of executive functioning.

Singh & Mishra (2012) conducted a study on Hindi-English bilinguals to see whether response inhibition and performance monitoring differed based on language proficiency in bilinguals. The results from the study suggested that language proficiency had an effect on performance monitoring, but not the inhibitory control. The authors concluded that higher proficiency can lead to superior cognitive flexibility and an ability to adjust behaviour that can facilitate the attainment of the cognitive goal.

The fact that executive functioning is better in bilinguals is based on the bilingual proficiency of the individual in the particular language. Since there are not many studies in the Indian context to prove the effects of bilingualism on executive functioning, the present study is an attempt for investigating the effects of bilingualism on some of the domains of executive functioning such as cognitive flexibility, response inhibition and attention.

Chapter III

Method

Executive functions are considered as a critical component of cognitive and social development in bilinguals and it has been found that executive functions vary as a function of bilingual proficiency. There are many domains of executive functioning, however this study is aimed at studying the effects of bilingualism specifically on the domains of cognitive flexibility, response inhibition and the ability to sustain attention as these tasks are sensitive to vary with respect to high and low proficient bilinguals.

Objectives of the study were as follows:

1. To study the attention in high and low proficient bilinguals.
2. To study the response inhibition in high and low proficient bilinguals.
3. To study the task switching ability in high and low proficient bilinguals.

3.1 Participants

Participants in the age range of 18-25 years were considered for the study. They were divided into 2 groups having 20 participants each which include equal number of both males and females.

Participant selection criteria:

Inclusionary criteria

- All the participants were successive bilinguals having Kannada as L1 and English as their L2.

- All of the participants had exposure to L2 (English) right from their childhood with a minimum of 10 years of exposure to the language.
- The participants were tested through informal screening for normal vision.

Exclusionary criteria

- Participants who were multilinguals were not included in the study.
- Participants who did not have minimum of 10 years of exposure to English were excluded from the study.

The participants were divided into two groups based on bilingual proficiency.

Group 1: High proficient bilinguals (The participants had high proficiency in L2)

Group 2: Low proficient bilinguals (The participants had less proficiency in L2)

3.2 Administration of LEAP-Q: Classification of Bilinguals

Language Experience And Proficiency Questionnaire - LEAP Q is a tool to assess bilingual proficiency which was developed by Flege, 1999 and revised by Marian, Blumenfeld & Kaushanskaya, 2007. It has also been adapted to the Indian context by Ramya & Goswami (2009). The participants were divided as high proficient and low proficient bilinguals on the basis of LEAP- Q findings. The questionnaire contains 18 questions eliciting details about language acquisition and usage which was used to determine bilingual proficiency. Question 10 of the questionnaire required the participants to rate their proficiency on four domains: understanding, speaking, reading and writing using a four point rating scale (where, 1-Zero Proficiency, 2-Low, 3-Good and 4-Perfect Proficiency). Based on LEAP-Q, Hayward (2013) claimed that if a bilingual has a score of 3 or 4 on the speaking domain of L2 they can be

classified as high proficient bilinguals whereas Hickey (2010) claimed that a bilingual should receive a score of 4 in the understanding domain and a minimum score of 3 on all the other domains (speaking, reading and writing) in order to be classified as a high proficient bilingual. Based on the ratings done by the participants they were classified as high proficient or low proficient bilinguals by adopting Hayward's criterion and were put into group 1 and group 2 respectively.

Table 3.1: Details of participants in High Proficient group

High Proficient Group			**Domains of LEAP-Q**			
S. No	Gender	Age	Understanding	Speaking	Reading	Writing
1	Female	19 years	4	4	4	4
2	Female	21 years	3	3	4	4
3	Female	21 years	4	4	4	4
4	Female	23 years	3	4	4	3
5	Female	21 years	3	3	4	4
6	Female	23 years	4	4	4	4
7	Female	24 years	3	3	3	4
8	Female	23 years	4	4	4	4
9	Female	23 years	3	3	3	3
10	Female	18 years	4	4	4	4
11	Male	18years	3	3	4	4
12	Male	22 years	4	3	4	4
13	Male	23 years	4	3	4	3

14	Male	21 years	4	4	4	4
15	Male	21 years	4	4	4	4
16	Male	23 years	3	3	4	4
17	Male	18 years	4	4	4	4
18	Male	22 years	3	3	3	3
19	Male	22 years	4	4	4	4
20	Male	22 years	3	3	4	4

Table 3.2. Details of participants in Low Proficient group

Low Proficient group			Domains of LEAP-Q			
S. No	Gender	Age	Understanding	Speaking	Reading	Writing
1	Female	23 years	3	3	3	3
2	Female	22 years	2	2	3	3
3	Female	19 years	3	2	3	3
4	Female	19 years	3	3	3	3
5	Female	21 years	3	3	3	3
6	Female	21years	2	2	2	2
7	Female	24 years	2	2	3	2
8	Female	23 years	3	3	3	3
9	Female	23 years	3	3	4	4
10	Female	18 years	2	2	3	3
11	Male	18 years	3	3	4	4

12	Male	19 years	3	3	3	3
13	Male	22 years	3	3	3	3
14	Male	24 years	3	3	4	4
15	Male	22 years	3	2	3	3
16	Male	23 years	2	2	2	2
17	Male	23 years	3	2	3	3
18	Male	19 years	3	3	3	3
19	Male	20 years	2	2	3	3
20	Male	21years	3	3	3	3

3.3 Tasks

There were 2 tasks of varying complexity in each of the three domains tapping for attention (Tasks 1 and 2), response inhibition (Tasks 3 and 4) and cognitive flexibility (Task 5 and 6).

In addition to these tasks, alternating fluency task was also used and it is assumed to tap for all the three processes (attention, response inhibition and cognitive flexibility).

3.4 Instrumentation

The stimulus for all the tasks was presented in visual mode on a 15.6 inch laptop through the DMDX software.

The participants were made to sit at a distance of 50cm from the laptop screen and the testing was done in a silent room. Instructions varied with respect to each task and are described under each task.

3.5 Procedure

Task 1 for Attention: Shapes Task

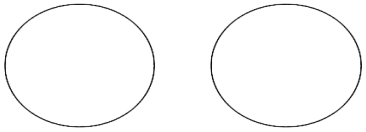
Stimulus: Different shapes were used which was chosen indiscriminately.

Task description: Two shapes were displayed on the computer screen. If both the shapes are the same the condition would be a congruent trial and if both the shapes appearing are different then the condition would be an incongruent trial.

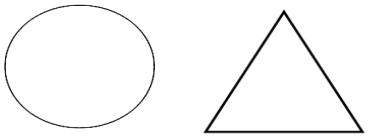
Procedure: The participant was instructed to press 1 for congruent trial and 0 for incongruent trial.

Analysis: Reaction time and accuracy was measured for this task

Example: Both the shapes appearing were circles - congruent trial.



The two shapes appearing was a circle and triangle- incongruent trial



Task 2 for Attention: Letter monitoring task

Stimulus: The letter /p/ was chosen as the target and the words were chosen from a study done by Yashaswini & Abhishek (2015)

Task description: The stimulus used was English letters a pre set phoneme (/p/ for example was chosen. The task of the participants was to verify if the presented words have the target letter as its constituent regardless of the loci. The participant had to press the button 1 in the key board if the pre-set phoneme is present and 0 if the word does not contain the preset phoneme. The order of presentation of the stimulus was random.

Procedure: The participant was asked to press 1 if the letter and its constituents are same (congruent trial) and 0 if the letter and its constituents are different (incongruent trial).

Analysis: Reaction time and accuracy was assessed for the task.

Example

Pet, cup etc-The participant had to press 1 as the pre set letter (target) is present in these words.

Goat, Mat etc- The participant had to press 0 as the pre set letter (target) is absent in these words

Task 3 for Response inhibition: Flankers Task

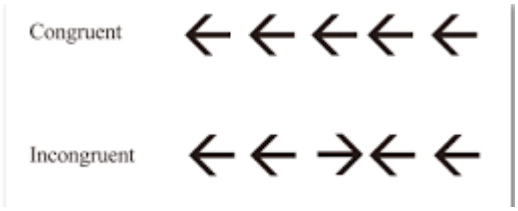
Stimulus: The stimulus was arrow marks which were chosen indiscriminately.

Task description: The central target was aligned towards the right or left side. The participant was required to look for the direction of the central arrow and press the keys based on the alignment of the stimulus.

Procedure: The participant was asked to press the right key for congruent flankers and left key for incongruent flankers.

Analysis: The reaction time and accuracy was calculated here.

Example:



Task 4 for Response inhibition: Picture Naming Task

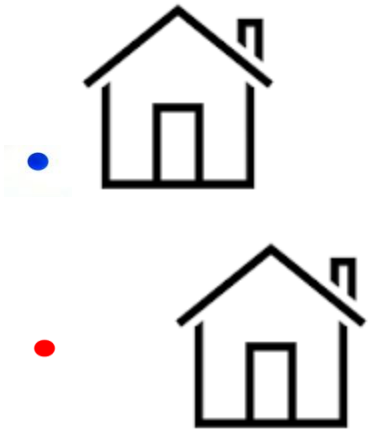
Stimulus: The pictures for the task were chosen indiscriminately and the pictures was accompanied with a blue or red dot.

Task description: A picture appeared on the computer screen with the presence of a red or a blue dot. Depending on the color of the dot the participant had to name the picture. The stimulus was presented randomly and reaction time and accuracy was calculated.

Procedure: The participant had to name the item in Kannada if the picture was accompanied by a blue dot and in English if the picture was accompanied by a red dot.

Analysis: Reaction time and accuracy was measured for this task.

Example:



Task 5 for Cognitive flexibility: Stroop Object Task

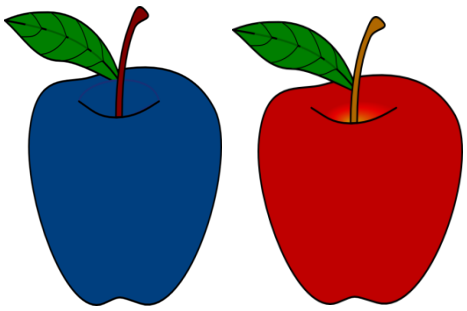
Stimulus: The stimulus used was taken from a study done by Pavithra & Prema (2015). The stimulus was pictures of certain items in either congruent or incongruent color ink.

Task description: Randomized presentation of the pictures was done with a few items shown in different color ink and few in congruent ink.

Procedure: The participants were instructed to press 1 if it is a congruent condition and 0 for incongruent condition.

Analysis: Reaction time and accuracy for all of the trials was calculated.

Example: A picture of an apple was shown in red as well as blue



Task 6 for Cognitive flexibility: Letter Number Task

Stimulus: The stimulus included numbers in English and letters in both Kannada and English.

Task description: In this task the number was presented in English and was kept constant throughout. The letters presented alongside the number was in either Kannada or English. The stimulus included both congruent and incongruent trials and was presented in random order.

Procedure: The participant was asked to press 1 for congruent condition and 0 for incongruent condition.

Analysis: Reaction time and accuracy was measured.

Example: 1 E (Congruent trial) and 6 ಠ (Incongruent trial)

Task 7 for Alternating fluency task

Stimulus: 3 Lexical categories was considered (Animals, fruits, vegetables)

Task description: Under each lexical category, the person had to name a lexical item in Kannada and name one lexical item in English. The participant was instructed to adhere to the lexical category and name different lexical items in both the language (not translation equivalents)

Procedure: The number of correct lexical items named in L1 (Kannada) and L2 (English) mentioned under each lexical category was taken into consideration

Analysis: Quantitative analysis was carried out

Example: If the prescribed lexical category is animals, correct response would like /kudure/ and /lion/ which are distinctive responses and incorrect response would be like /ka:ge/ and /lion/ (as they belong to distinct lexical category or /kudure/ and /horse/ (as they are translation equivalents)

Table 3.3: Description of tasks

TASK	STIMULUS	DOMAIN ASSESSED
Task 1	Different shapes	Attention , Perception
Task 2	Letter monitoring (English letters with and without pre set target letter)	Attention, Perception
Task 3	Arrows	Response inhibition
Task 4	Pictures accompanied by a color dot	Response inhibition
Task 5	Pictures	Cognitive flexibility , Selective attention
Task 6	English numbers and letters in Kannada and English	Cognitive flexibility
Task 7	Alternating fluency	Attention, Response Inhibition and Cognitive flexibility

3.6 Scoring and Analysis

Statistical analysis for calculating the mean reaction time and accuracy was done using the software Statistical Package for Social Sciences (SPSS) version 16.0 for

- Studying the attention in high and low proficient bilinguals.
- Studying the response inhibition in high and low proficient bilinguals.
- Studying the task switching ability in high and low proficient bilinguals.

Shapiro Willis test for normality was administered for the high proficient and the low proficient group for all the parameters.

The following non parametric tests were administered using the SPSS software:

(a) Mann Whitney U test was administered to see the significant differences between males and females and also for checking the difference between high proficient and low proficient groups.
(b) Wilcoxon's Signed Rank test was administered for comparison between Task 1 and Task 2 for the three domains irrespective of proficiency.
(c) Friedman test was administered for comparisons across the alternating fluency tasks.

Chapter IV

Results and Discussion

The primary aim of the study was to measure the effects of bilingualism on executive functions specifically on the domains of cognitive flexibility, response inhibition and the ability to sustain attention as these tasks are sensitive to vary with respect to high and low proficient bilinguals. Participants in the age range of 18-25 years were considered for the study. They were divided into 2 groups of high proficient and low proficient bilinguals comprising of 20 participants each. Each of the group included equal number of both males and females. Statistical analysis for calculating the mean reaction time and accuracy was done using the software Statistical Package for Social Sciences (SPSS) version 16.0. The data was subjected to test of normality by using Shapiro Willis test and it was observed that the data was not abiding to properties of normal distribution ($p<0.05$) and hence non-parametric tests were used for all objectives.

Objectives of the study were as follows:

4. To study the attention in high and low proficient bilinguals.
5. To study the response inhibition in high and low proficient bilinguals.
6. To study the task switching ability in high and low proficient bilinguals.

The results of the present study are discussed under the following headings:

A. Comparison of reaction time and accuracy between the high proficient and low proficient group in the domains of

i. Attention

ii. Response Inhibition

iii. Cognitive flexibility (between groups comparison)

B. Comparison between Task 1 and Task 2 for the three domains for both high proficient and low proficient group across mean reaction time and accuracy (within group comparison).

iv. Comparisons across the alternating fluency tasks between the high proficient and low proficient group (between groups comparison)

Objective 1

A. Comparison of reaction time and accuracy between the high proficient and low proficient group on the domains of

i. Attention

Task 1 for attention: Shapes task. Two shapes were displayed on the computer screen. If both the shapes were the same the condition was considered as a congruent trial and when both the shapes appearing were different then the condition was considered as an incongruent trial.

Task 2 for attention: Letter monitoring task. The stimulus used was English letters a pre set phoneme (/p/ for example was chosen). The task of the participants was to verify if the presented words have the target letter as its constituent regardless of the loci. The participant had to press the button 1 in the key board if the pre-set phoneme was present

and 0 if the word did not contain the preset phoneme. The order of presentation of the stimulus was random.

The overall mean, standard deviation (SD) and median were calculated for the performance of Group I (High proficient) and Group II (Low proficient) across the two tasks for both mean reaction time and accuracy.

Table 4.1 shows the performance of both the groups across the two tasks.

Table 4.1

Mean, SD and Median for mean reaction time for Group I (High proficient) and Group II (Low proficient) across the two tasks of attention

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
Task 1	651.56	51.18	638.62	745.86	74.43	717.61
Task 2	712.96	76.22	692.28	704.19	82.42	681.93

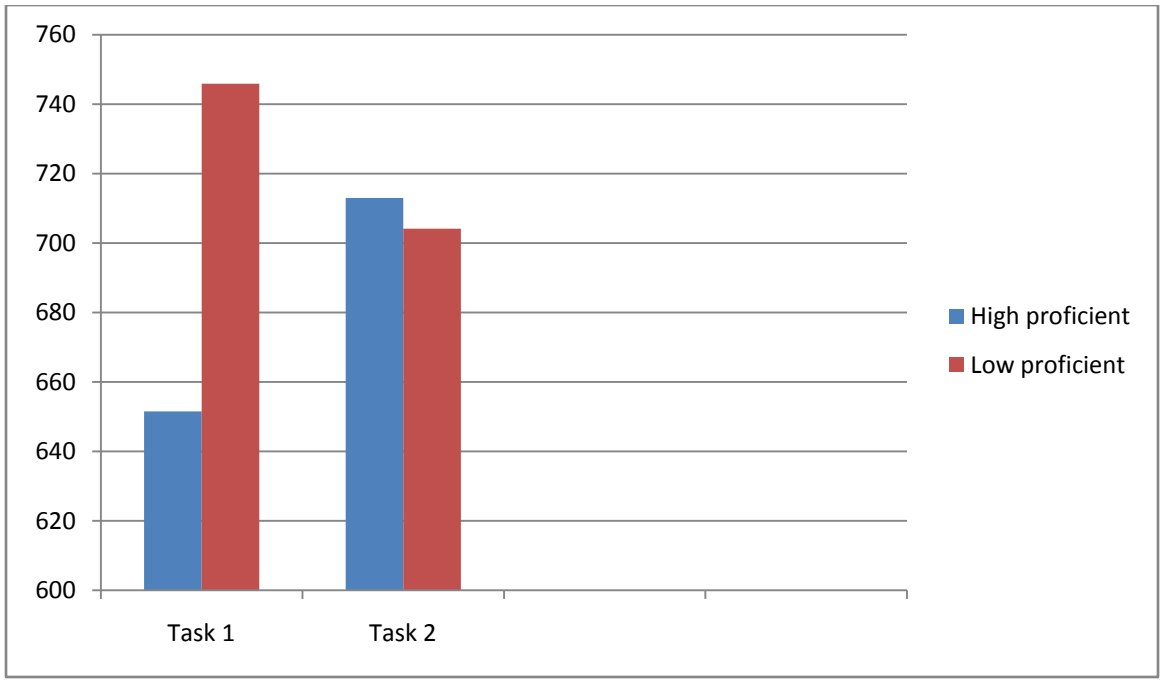


Figure 4.1. Mean scores for mean reaction time for group I and group II on Task 1 and Task 2

As depicted in Table 4.1 and Figure 4.1 the mean reaction time taken by the high proficient group (Mean = 651.56, Median = 638.62) was lesser than the low proficient group (Mean = 745.86 , Median = 717.61) on Task 1 of attention. However for Task 2 of attention the mean reaction time of the high proficient group was found to be slightly higher (Mean = 712.96 , Median = 692.28) than the low proficient group (Mean = 704.19 , Median=681.93). In reaction time studies, lesser the time taken to perform the task, the better is the performance. SD was more for low proficient group compared to high proficient group.

Table 4.2

Mean, SD and Median for accuracy for Group I (High proficient) and Group II (Low proficient) across the two tasks of attention

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
Task 1	96.44	2.01	96.60	93.96	4.26	94.95
Task 2	92.96	3.40	93.30	86.63	3.42	86.60

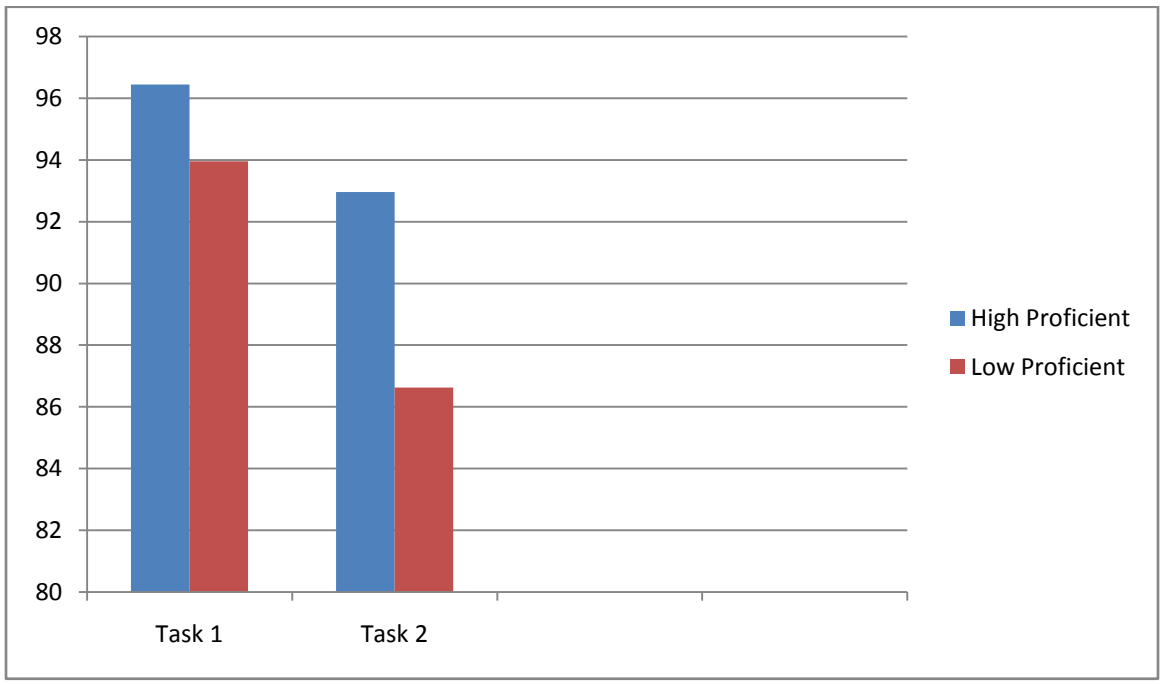


Figure 4.2. Mean scores for accuracy for group I and group II on Task 1 and Task 2

In addition to mean reaction time, accuracy of responses was also computed. Accuracy scores for the high proficient group (Mean = 96.44, Median = 96.60) was greater compared to the low proficient group (Mean = 93.96, Median = 94.95) on Task 1. Scores obtained on Task 2 also followed a similar trend, (Mean = 92.9, Median =93.30) for high proficient group and (Mean = 86.63, Median = 86.60 for low proficient group.

In order to verify if there was any significant difference between high and low proficient groups on Task 1 of attention, Mann Whitney U Test was carried out. While measuring the reaction time the |Z| score obtained was 3.841 and the corresponding p value showed no significant difference. On measuring accuracy the |Z| score obtained was 1.991 and the corresponding p value showed significant difference. On Task 2 of attention the |Z| score obtained for mean reaction time was 0.541 and for accuracy 4.451 and the corresponding p values for both the measures showed significant differences.

To summate the high proficient group outperformed the low proficient group in terms of accuracy of responses as there was a statistically significant difference ($p<0.05$) for both the tasks. In regard to reaction time, statistically significant difference was seen for only task 1 of attention and for task 2 no significant difference ($p>0.05$) was seen.

Comparison of reaction time and accuracy between the high proficient and low proficient group on the domains of

ii. Response Inhibition

Task 3 for response inhibition: Flankers task. The central target was aligned towards the right or left side. The participant was required to look for the direction of the central arrow and press the keys based on the alignment of the stimulus.

Task 4 for response inhibition: Picture naming task. A picture appeared on the computer screen with the presence of a red or a blue dot. Depending on the color of the dot appearing the participant had to name the picture.

Table 4.3

Mean, SD and Median for mean reaction time for Group I (High proficient) and Group II (Low proficient) across the two tasks of response inhibition

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
Task 1	743.22	119.04	738.03	719.60	89.78	711.99
Task 2	1089.97	95.82	1076.23	1120.75	112.31	1123.22

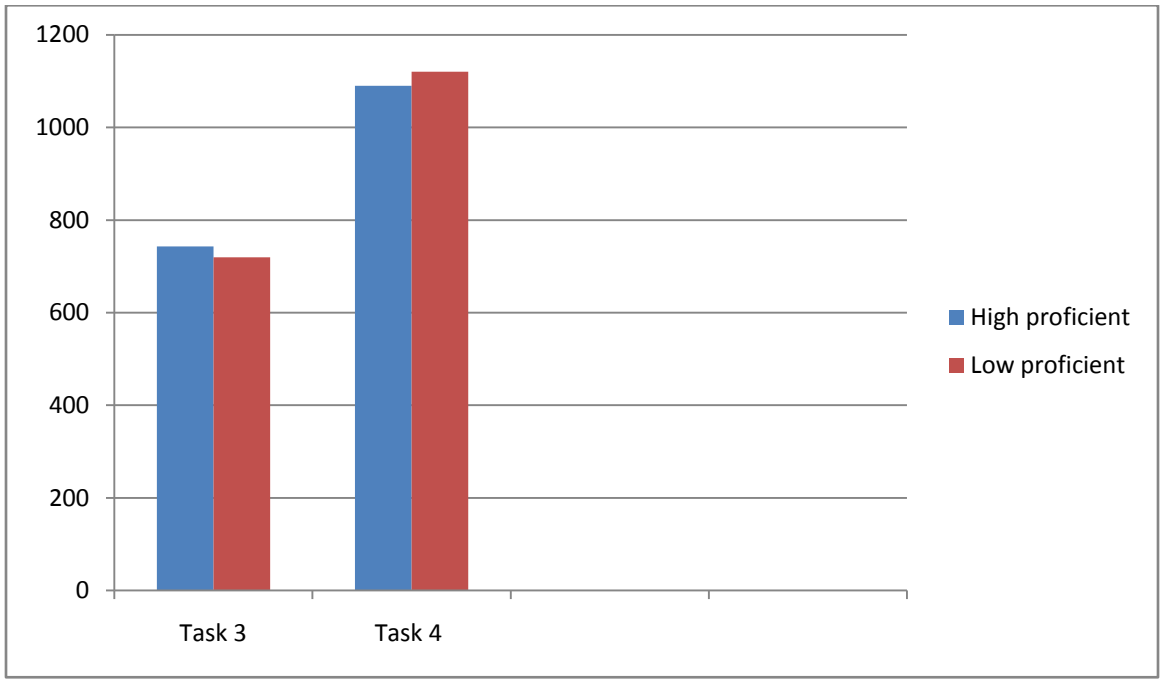


Figure 4.3. Mean scores for mean reaction time for group I and group II on Task 3 and Task 4

As shown in Table 4.3 and Figure 4.3 the high proficient group (Mean =743.22 , Median = 738.03) took more time than the low proficient group (Mean = 719.60 , Median = 711.99) on Task 3 of response inhibition. For Task 4 of response inhibition the mean reaction time of the high proficient group Mean= 1089.97, Median = 1076.23) was lesser than the low proficient group (Mean = 1120.75 ,Median=1123.22).

Table 4.4

Mean, SD and Median for accuracy for Group I (High proficient) and Group II (Low proficient) across the two tasks of response inhibition

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
Task 1	92.29	4.06	93.30	91.46	3.97	93.30
Task 2	92.31	3.75	93.30	87.30	5.25	86.60

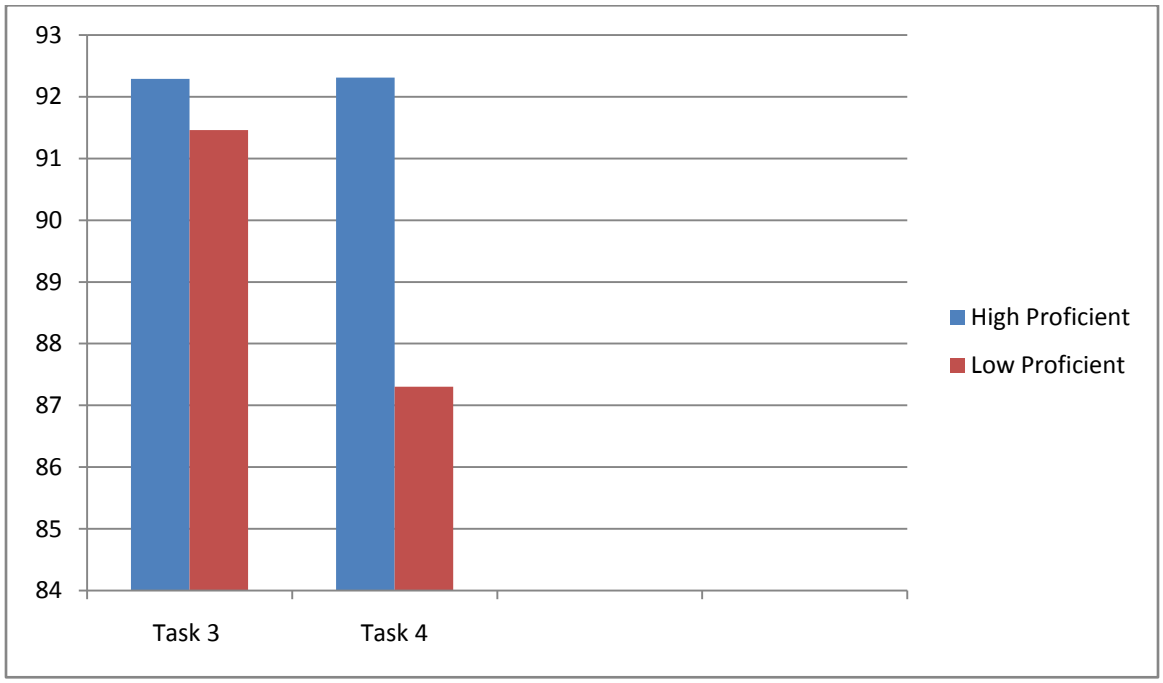


Figure 4.4. Mean scores for accuracy for group I and group II on Task 3 and Task 4

As depicted above, the accuracy of responses for both the groups was noted. The high proficient group (Mean= 92.29) had better accuracy of responses than the low proficient group (Mean = 91.46) on both Task 3 and Task 4 Mean = 92.31 for high proficient group and Mean = 87.30 for low proficient group on the domain of response inhibition. The median values also followed the same direction.

In an attempt to verify if there was a significant difference between high and low proficient groups on Task 3 of response inhibition, Mann Whitney U Test was carried out. While measuring the reaction time the |Z| score obtained was 0.568 and the corresponding p value showed no significant difference. While measuring accuracy the |Z| score obtained was 0.730 and the corresponding p value also showed no significant difference. On Task 4 of response inhibition the |Z| score obtained for mean reaction time was 0.649 and the p value showed no significant difference, however for accuracy the |Z| value obtained was 3.218 and the corresponding p value showed significant difference.

In summary statistically significant difference was seen only on accuracy scores of Task 4 ($p<0.05$). Mean reaction time for high proficient and low proficient group was not significant statistically for both task 3 and task 4. Statistically significant difference was not seen between the high and low proficient groups in regard to accuracy scores for task 3.

Comparison of reaction time and accuracy between the high proficient and low proficient group on the domains of

iii. Cognitive Flexibility

Task 5 for cognitive flexibility: Stroop object task. Randomized presentation of the pictures was done with a few items shown in different color ink and few in congruent ink.

Task 6 for cognitive flexibility: Letter number task. In this task the number was presented in English and was kept constant throughout. The letters presented alongside the number was in either Kannada or English. The stimulus included both congruent and incongruent trials and was presented in random order.

Table 4.5

Mean, SD and Median for mean reaction time for Group I (High proficient) and Group II (Low proficient) across the two tasks of cognitive flexibility

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
Task 5	730.81	89.06	714.86	719.42	79.79	703.20
Task 6	730.39	119.32	703.94	730.17	73.30	723.55

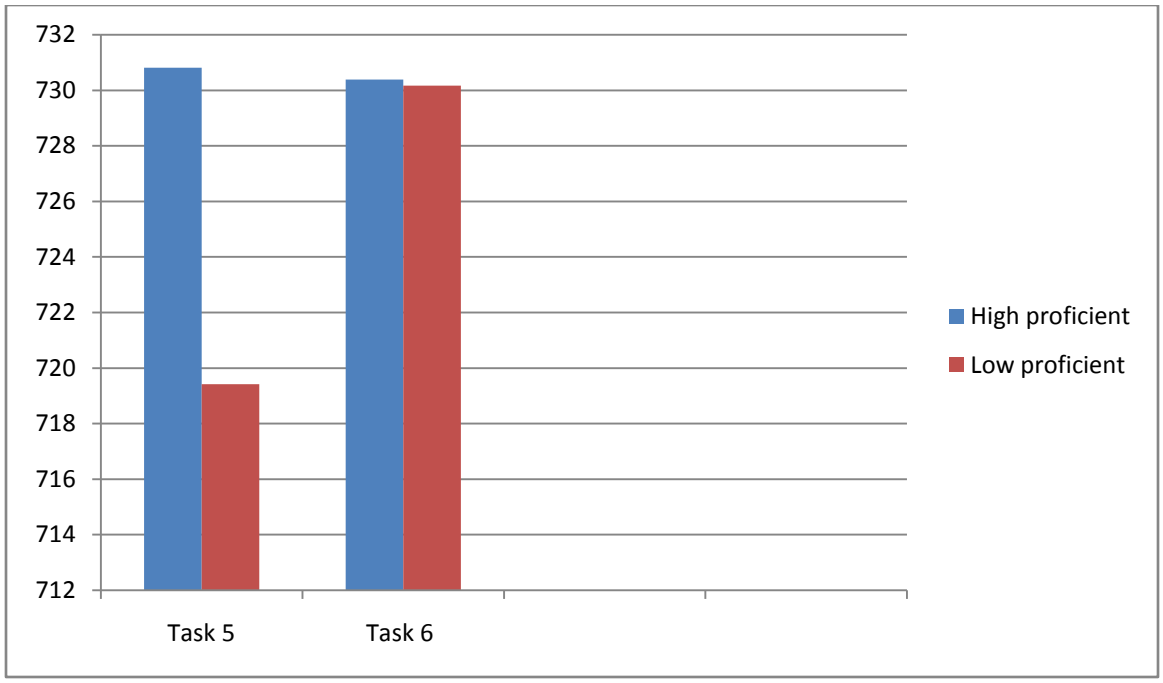


Figure 4.5. Mean scores for mean reaction time for group I and group II on Task 5 and Task 6

Table 4.5 and Figure 4.5 shows the mean reaction time taken by the high proficient group (Mean = 730.81 , Median = 714.86) which was found to be greater than the low proficient group (Mean = 719.42 , Median = 703.20) on Task 5 of cognitive flexibility. For Task 6 of cognitive flexibility the mean reaction time of the high proficient group was in par (Mean = 730.39 , Median = 703.94) with the low proficient group (Mean= 730.17 , Median= 723.55).

Table 4.6

Mean, SD and Median for accuracy for Group I (High proficient) and Group II (Low proficient) across the two tasks of cognitive flexibility

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
Task 5	95.93	3.00	96.60	91.80	5.11	93.30
Task 6	96.64	3.26	96.60	93.80	4.87	93.30

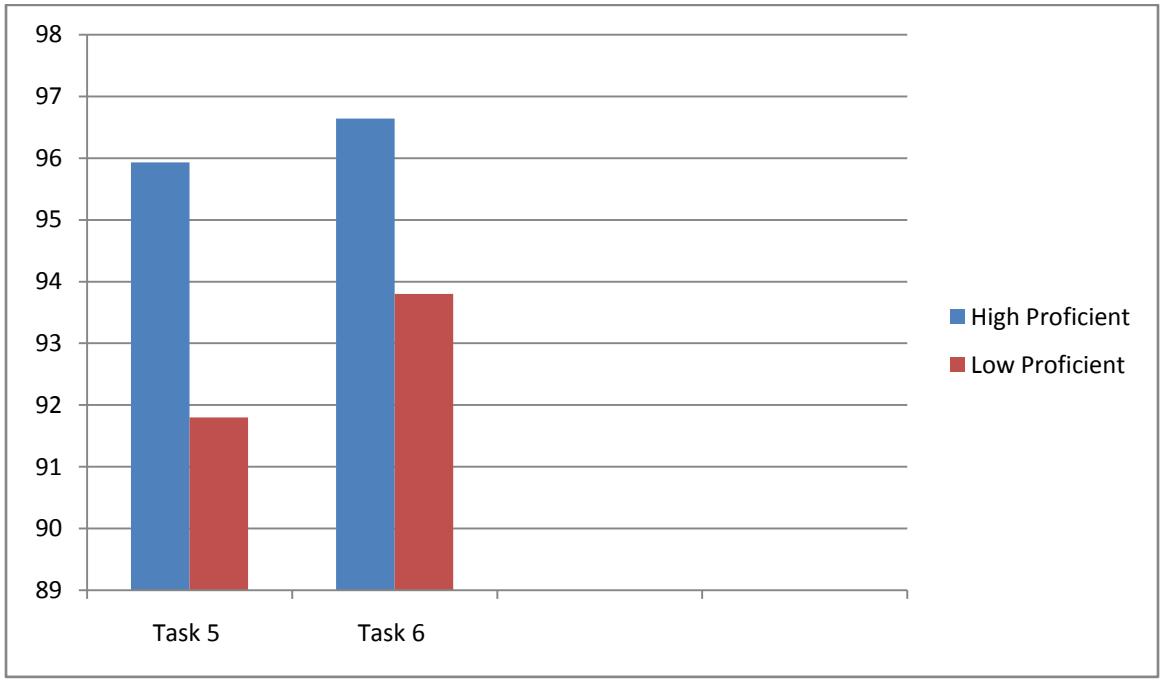


Figure 4.6. Mean scores for accuracy for group I and group II on Task 5 and Task 6

In addition to mean reaction time, accuracy scores was also computed for the two groups. Accuracy scores for the high proficient group (Mean = 95.93, Median = 96.60) was greater compared to the low proficient group (Mean = 91.80, Median = 93.30) on Task 5. Scores obtained on Task 6 also followed a similar pattern, (Mean = 96.64, Median =96.60) for high proficient group and (Mean = 93.80, Median = 93.30 for low proficient group with the high proficient group obtaining better accuracy than the low proficient group. .

Mann Whitney U Test was carried out to verify if there was any significant difference between high and low proficient groups on the two tasks of cognitive flexibility. While measuring the reaction time on Task 5 the |Z| score obtained was 0.460 and the corresponding p value showed no significant difference. While measuring accuracy the |Z| score obtained was 2.999 and the corresponding p value showed significant difference. On Task 6 of cognitive flexibility the |Z| score obtained for mean reaction time was 0.027 and the p value indicated no significant difference , however for accuracy the |Z| value obtained was 1.941 and the corresponding p value showed a significant difference. In a nutshell there was a statistically significant difference observed on the accuracy scores for high and low proficiency groups on both Task 5 and Task 6 ($p<0.05$). However in terms of reaction time statistically significant difference was not seen across the groups (for both the tasks). From all these tasks it can be inferred that the high proficient bilinguals outperformed the low proficient bilinguals

Bilingualism is defined as the usage and proficiency in at least two languages, which changes depending on the exposure to other users of the languages and the opportunities to use the

languages. (ASHA, 2004). Since people tend to use more than one language in daily life. (Kroll & DeGroot, 2005) it can be seen that when a bilingual person uses one language, the other language is also active at the same time. For bilingual people, this activation is not limited to a single language as the auditory input activates corresponding words *regardless* of the language to which they belong.

The findings of the current study is in line with the research carried out in the past which have found that bilingualism can enhance certain executive functions which include response inhibition, set shifting, attention and memory and the presence of a bilingual advantage being present. To maintain the relative balance between two languages, the bilingual brain relies on executive functions, because both of a bilingual individual's language systems are always active and competing, and hence they use these control mechanisms and it is this constant practice that strengthens the control mechanisms and changes the associated brain regions. (Marian & Shook, 2002) As stated by Bialystok (2003) who through his study indicated better performance of bilinguals than the monolinguals as they demonstrated better skills in inhibiting irrelevant information and better control of attention which facilitated faster processing and functioning in several cognitive tasks thereby confirming the presence of a bilingual advantage.

The reason that bilinguals are able to selectively attend to important attributes of a stimulus has been explained by the fact that bilinguals have different representations in each language for similar concepts and hence they need to be aware of what word to use in what context and the language which they are using to carry out the task by inhibiting irrelevant information and attending to the relevant stimuli. Bilinguals also can use two languages in the same modality better as compared to monolinguals which require them to make the decision

about how to respond in a situation and what language to use based on the context (Bialystok and Martin , 2008).

The findings are consistent with the study done by Peal and Lambert (1962) who reported of bilingual advantage being seen consistently in various domains of executive functioning , perception and development of language. Also better and faster sensory and cognitive processing was seen in bilinguals which was attributed to the fact that there is manifestation of a bilingual cognitive advantage where an individual can inhibit irrelevant information and focus on the relevant information.

In the current study bilinguals outperformed monolinguals on tasks of attention which is consistent with the findings from the past where researchers have found out that the cognitive advantage seen in bilinguals over monolinguals results from executive attention (Bialystok, 1999; Yang, 2004). Posner and Fan (2004) postulated that there is an essentiality for attentional resources in human which help them to select required information and inhibit the unwanted information.

Also on tasks of response inhibition , bilinguals obtained faster responses to both congruent and incongruent stimuli as compared to monolinguals and shorter reaction times which can be attributed to the fact that they have better interference suppression because of the ability to manage attention by inhibiting distracting spatial cues in rapidly changing contexts (Rodrigues & Zimmer , 2016)

Another support for this fact comes from a study by Bunge, 2002 who reported of bilingual advantages in interference suppression, and on nonverbal tasks because of the usage of executive functions to manage the two languages without the interference from the language systems.

Bilingual people often perform better than monolingual people at tasks that tap into inhibitory control ability and also at switching between two tasks , reflecting better cognitive control while changing strategies (Marian &Shook , 2002)

Findings from the cognitive flexibility domain of executive function indicated better performance by bilinguals than monolinguals suggesting that life-long experience in switching between languages leads to increased efficiency in the ability to shift flexibly between mental sets (Prior & MacWhinney , 2010)

Since it's rare to get monolinguals in the current scenario as almost every individual would have some exposure to another language apart from their mother tongue, the current study has considered high proficient and low proficient bilingual population to see how proficiency has an effect on executive functioning. As seen on the measures of reaction time and accuracy the high proficient group outperformed the low proficient group thus suggesting the presence of a bilingual advantage and also confirming the fact that there is a relation between bilingual proficiency and executive functioning.

Objective 2

Comparison between Task 1 and Task 2 for the three domains between the high proficient and low proficient group.

Two tasks were used to tap the each domain of executive functions, the two tasks varied in terms of the linguistic load associated with each of the task. The even tasks (task 2, 4 and 6) were more linguistically loaded as compared to the odd tasks (task 1, 3 and 5).

Figures mentioned below depict the performance of the high proficient and low proficient group in terms of mean reaction time and accuracy on the two tasks (odd and even) across the three domains.

i. Attention

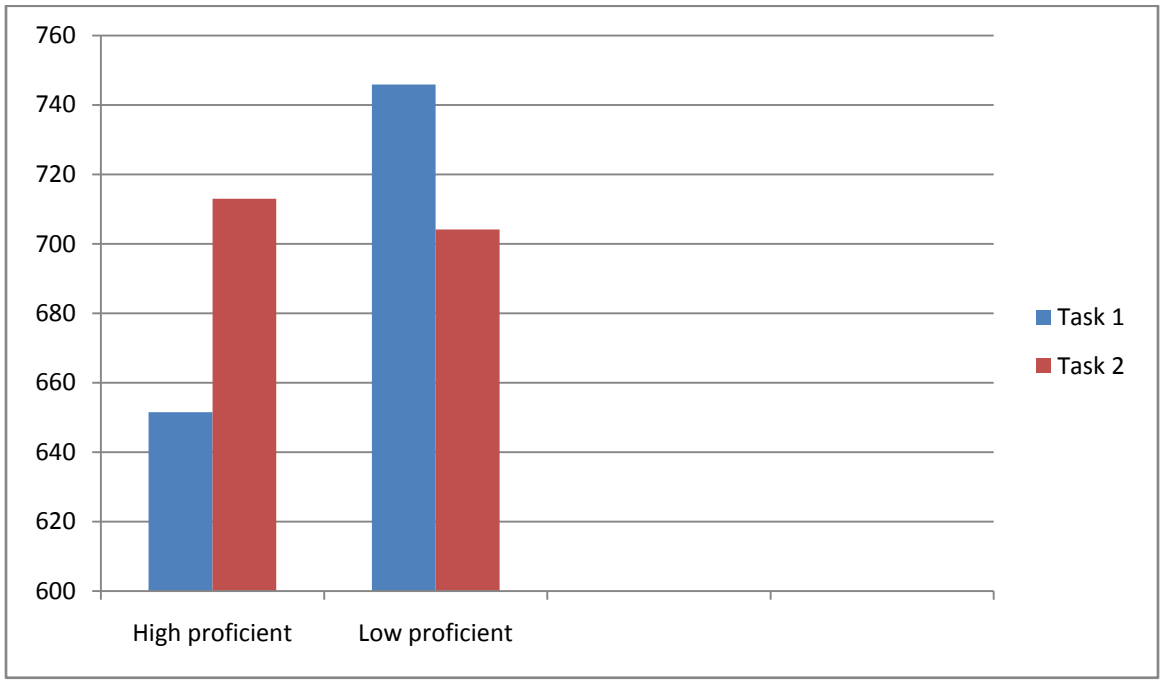


Figure 4.7. Mean scores for reaction time for group I and group II on Task 1 and Task 2

Figure 4.7 depicts the time taken for completing the two tasks. Mean reaction time for Task 1 was found to be lesser (Mean = 651.56) compared to Task 2 (Mean = 712.96) in the high

proficient group; whereas in the low proficient group the time taken to complete Task 1 (Mean = 745.86) was more compared to Task 2 (Mean = 704.19.

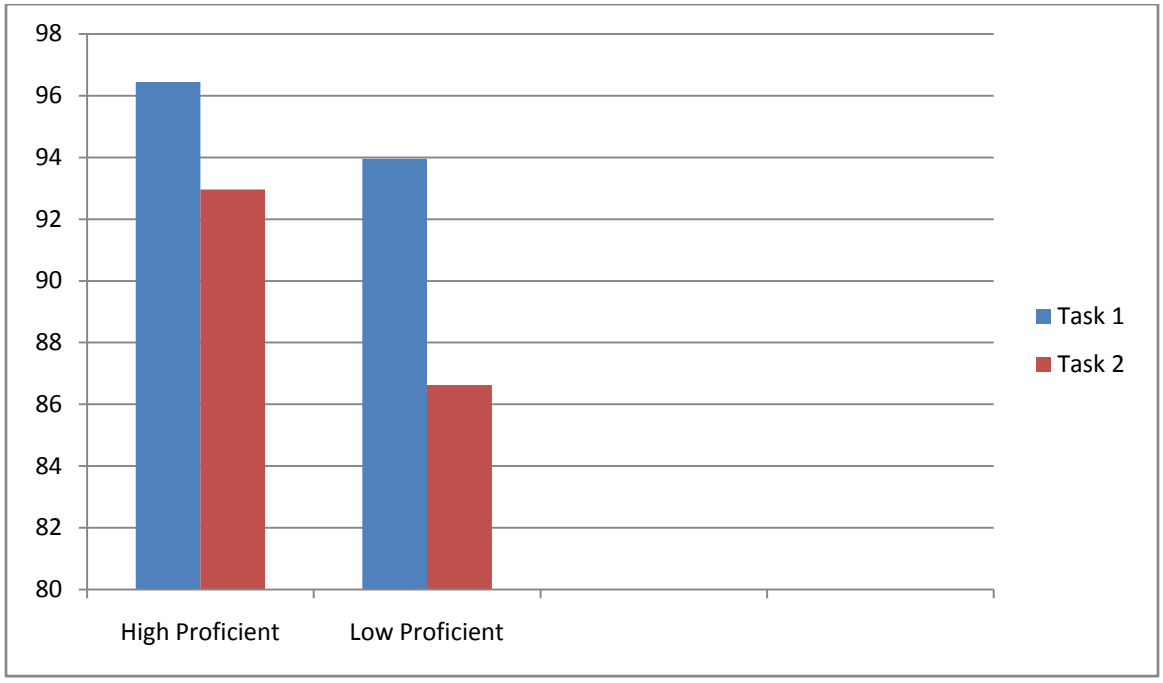


Figure 4.8. Mean scores for accuracy for group I and group II on Task 1 and Task 2

As shown in Figure 4.8 the accuracy of responses for Task 1 was greater (Mean = 96.44) than Task 2 (Mean = 92.96) in the high proficient group. Similar trend was also seen in the low proficient group as there was better accuracy of responses for Task 1 (Mean = 93.96) than Task 2 (Mean = 86.63)

Wilcoxn Signed Rank Test was carried out to verify if there was any significant difference between the two tasks of attention. On measuring the difference between the two tasks of attention in terms of reaction time the |Z| score obtained was 2.949 and while measuring

accuracy, the |Z| score obtained was 2.859. The corresponding p values showed significant difference in both the domains in the high proficient group. Similar trend was seen for the low proficient group in the domain of reaction time the |Z| score obtained was 2.539 and while measuring accuracy the |Z| score obtained was 3.933 and the corresponding p values showed significant difference in both the domains.

In a nutshell, there was a uniform trend seen as statistically significant differences ($p<0.05$) were obtained on both the measures of reaction time and accuracy across the two tasks of attention. As the mean reaction time was more and accuracy was less for even task, it can be inferred that the even task was more complex compared to the odd task for the attention domain.

ii. Response inhibition

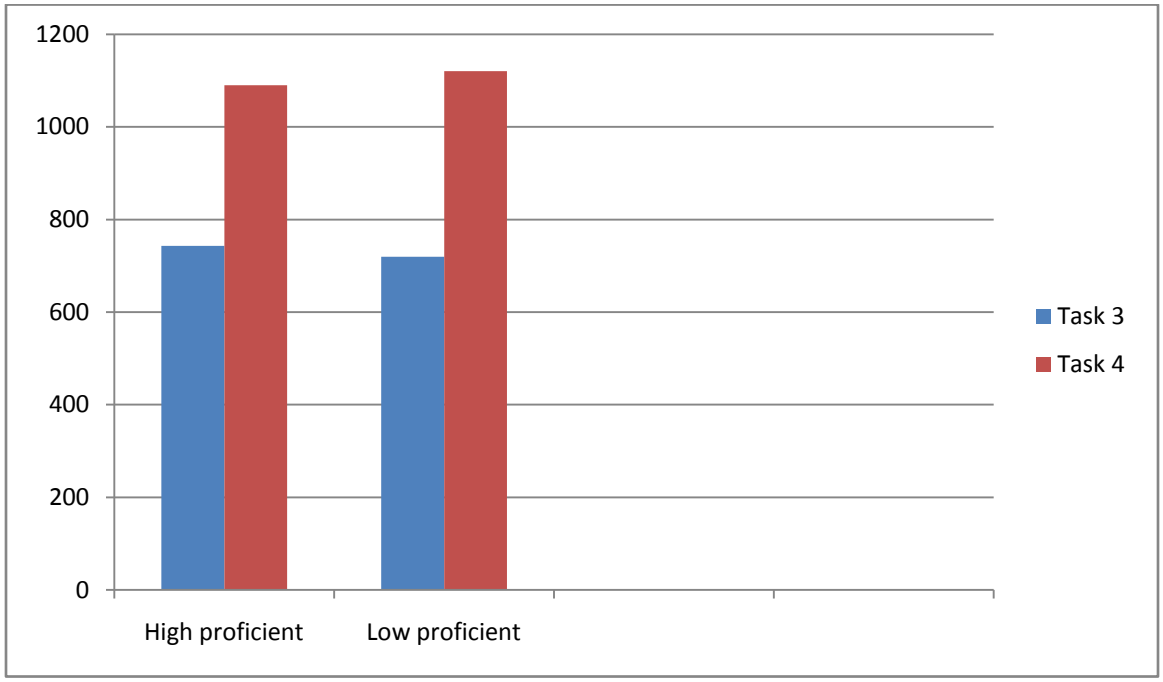


Figure 4.9. Mean scores for reaction time for group I and group II on Task 3 and Task 4

As depicted in Figure 4.9 the time taken for completing Task 3 was lesser (Mean = 743.22) than Task 4 (Mean = 1089.97) in the high proficient group. Similarly the low proficient group also took lesser time to complete Task 3 (Mean = 719.60) than Task 4 (Mean = 1120.75)

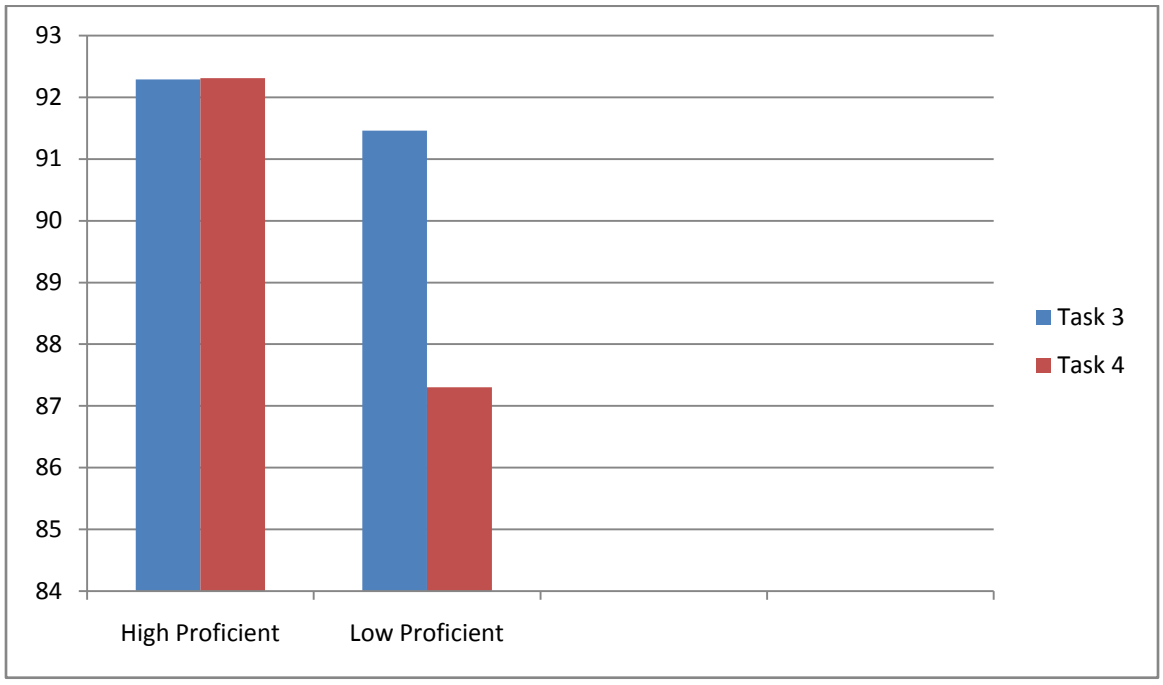


Figure 4.10. Mean scores for accuracy for group I and group II on Task 3 and Task 4

With respect to Figure 4.10 it can be seen that the accuracy of responses for Task 3 was almost equivalent (Mean = 92.29) to that of Task 4 (Mean = 92.31) in the high proficient group. However in the low proficient group there was better accuracy of responses for Task 3 (Mean = 91.46) than Task 4 (Mean = 87.30)

In order to verify if there was any significant difference between the two tasks of response inhibition, Wilcoxn Signed Rank Test was carried out. On measuring the difference between the

two tasks terms of reaction time the |Z| score obtained was 3.920 and the corresponding p value showed significant difference. However while measuring accuracy the |Z| score obtained was 0.862 and the corresponding p values showed no significant difference in the high proficient group. In the low proficient group in the domain of reaction time the |Z| score obtained was 3.920 and while measuring accuracy the |Z| score obtained was 2.709 and the corresponding p values showed significant difference in both the domains.

To summate it was observed that statistically significant differences ($p<0.05$) were obtained on the reaction time scores on both Task 3 and Task 4 of response inhibition. Similar trend was seen for accuracy scores on Task 4. However the accuracy scores of Task 3 indicated no significant differences ($p>0.05$). Based on the numerical findings it can be inferred that the odd task was more simpler compared to even task especially for low proficient group.

iii. Cognitive flexibility

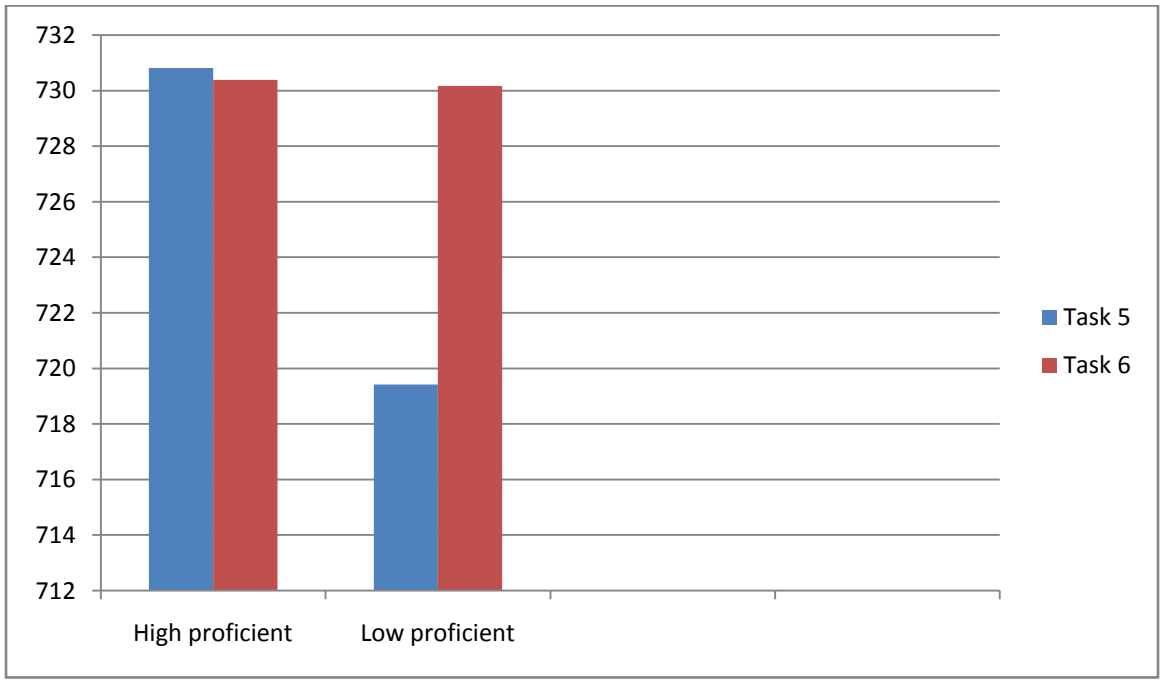


Figure 4.11. Mean scores for reaction time for group I and group II on Task 5 and Task 6

As depicted in Figure 4.11 it can be observed that the time taken for completing Task 5 was in par (Mean = 730.81) with the time taken for completing Task 6 (Mean = 730.39) in the high proficient group whereas in the low proficient group the time taken to complete Task 5 (Mean = 719.42) was lesser than Task 6 (Mean = 730.17)

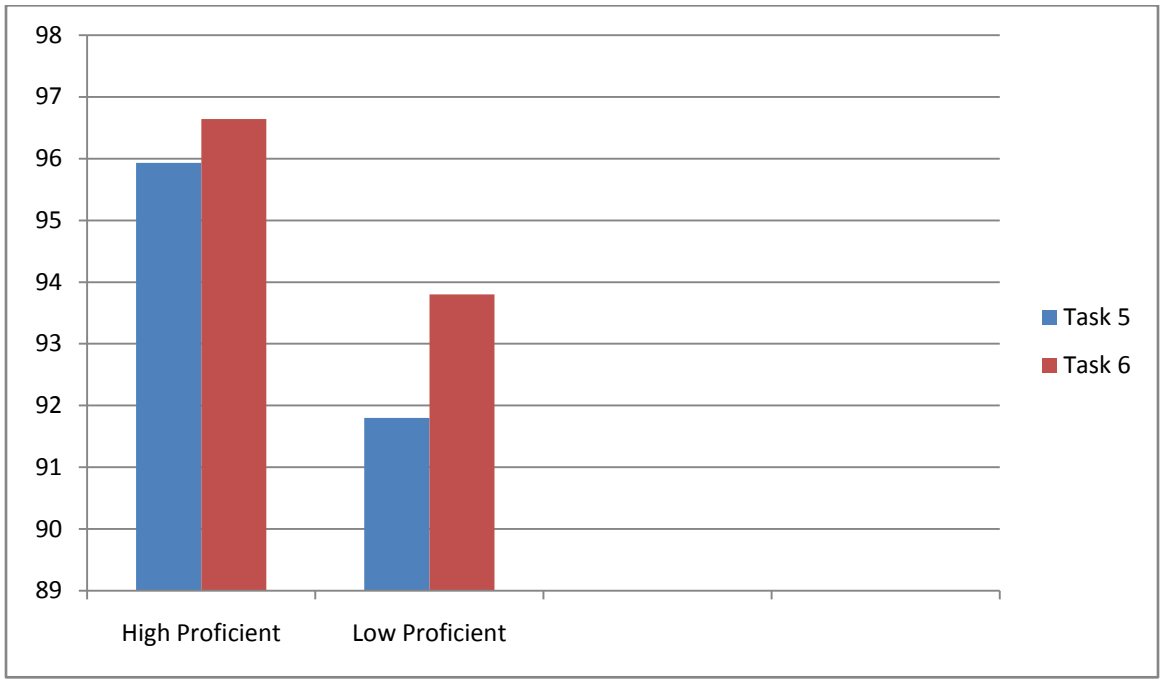


Figure 4.12. Mean scores for accuracy for group I and group II on Task 5 and Task 6

Figure 4.12 shows the accuracy of responses for the two tasks of cognitive flexibility. In the high proficient group Task 5 (Mean = 95.93) had slightly lesser accuracy of responses when compared to Task 6 (Mean = 96.64). Similar trend was also seen in the low proficient group as there was better accuracy of responses for Task 6 (Mean = 93.80) than Task 5 (Mean = 91.80)

Statistical analysis was carried out to verify if there was any significant difference between the two tasks of cognitive flexibility. Wilcoxn Signed Rank Test was administered. On measuring the difference between the two tasks in regard to reaction time, the |Z| score obtained was 0.635 and on measuring accuracy the |Z| score obtained was 1.025 and the corresponding p values showed no significant difference in the high proficient group. In the low proficient group in the domain of reaction time the |Z| score obtained was 0.784 and the |Z| score obtained for accuracy was 1.206 and the corresponding p values showed no significant difference for both the domains.

In summary while comparing across mean reaction time and accuracy no statistically significant differences ($p>0.05$) were observed across both the tasks of cognitive flexibility. It can be inferred that the performance did not vary as a function of task complexity for the cognitive flexibility domain.

The overall findings in the domains of attention and response inhibition are suggestive of the fact that the participants took more time to complete the even tasks which is consistent with the results depicted above. The even tasks being more linguistically complex took more time to be completed when compared to the odd tasks. This finding is in consonance with the study conducted by Bialystok et al. (2004) who reported of better performance on tasks which were relatively simpler. However as the complexity of the task was increased it was reported that the participants took longer time to perform the tasks but the presence of a bilingual advantage still persisted. Another study in support of this finding was Kramer's (2011) study where he found out that there may be an absence of literacy practices or low proficiency in several bilinguals and

due to such inconsistencies it maybe relatively easier for a bilingual to perform less complex tasks better. Also Bialystok (2009) concluded that bilingualism is a very important factor in cognitive performance of an individual. However for the cognitive flexibility domain the performance did not vary as a function of task complexity which can be supported by the claim that under high processing demands the efficiency of the executive network was more evident and hence the performance across the two tasks were similar. (Costa et al, 2009)

iv Comparisons across the alternating fluency tasks between the high proficient and low proficient group.

Under each lexical category, the person had to name a lexical item in Kannada and name one lexical item in English. The participant was instructed to adhere to the lexical category and name different lexical items in both the language (not translation equivalents). The number of correct lexical items named in L1 (Kannada) and L2 (English) mentioned under each lexical category was taken into consideration and quantitative analysis was carried out.

The overall mean, standard deviation (SD) and median were calculated for the performance of Group I (High proficient) and Group II (Low proficient) across the three categories.

Table 4.7 shows the performance of both the groups across the three categories.

Table 4.7

Mean, SD and Median for Group I (High proficient) and Group II (Low proficient) across the three categories of alternating fluency.

Tasks	High proficient			Low Proficient		
	Mean	SD	Median	Mean	SD	Median
L 1	14.25	3.79	15.00	13.75	3.64	14.00
L 2	19.40	5.29	20.00	16.45	5.47	17.00
L 3	12.85	4.22	13.00	11.80	3.33	12.00

Note: L1, L2 and L3 refers to the three lexical categories of fruits, animals and vehicles.

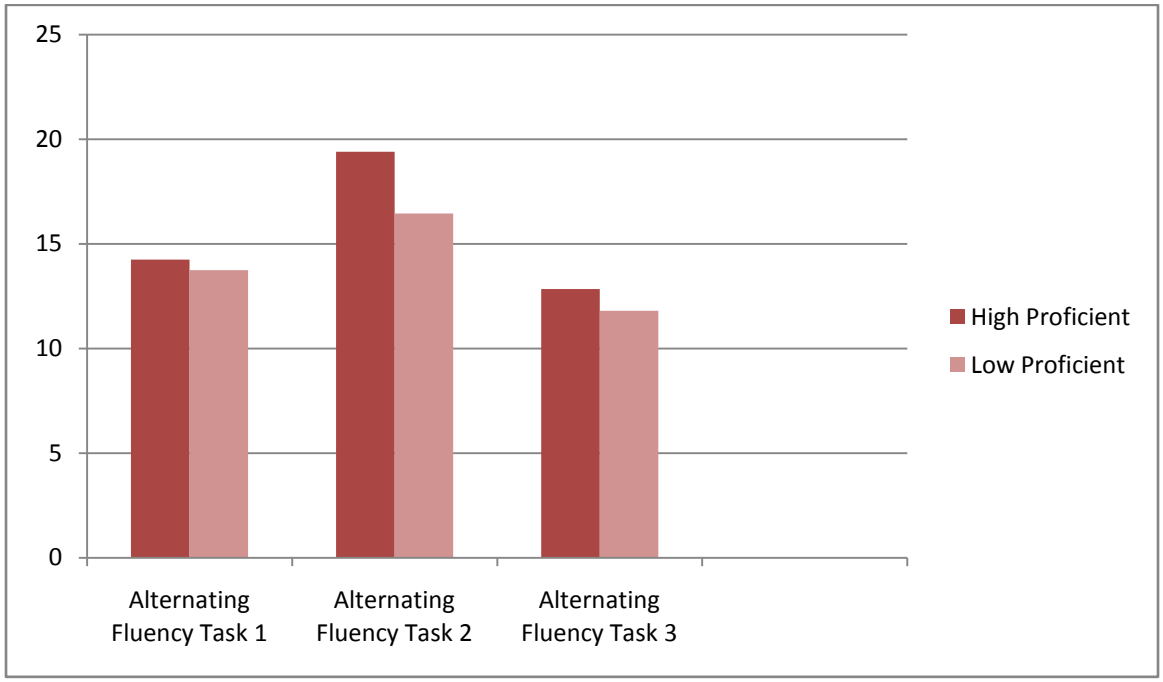


Figure 4.13. Mean scores for group I and group II on alternating fluency task.

Note: L1, L2 and L3 refers to the three lexical categories of fruits, animals and vehicles.

As depicted in Table 4.7 and Figure 4.13 the mean score obtained by the high proficient group (Mean= 14.25) was greater than the low proficient group (Mean= 13.75) on Category 1. Similar trend was also seen on Category 2 (Mean = 19.40 for high proficient group and Mean = 16.45 for low proficient group) and also for Category 3 (Mean = 12.85 for high proficient and Mean = 11.80 for low proficient) on the domain of alternating fluency. The median values of all the tasks followed the same direction.

Mann Whitney U Test was carried out to verify if there was any significant difference between high and low proficient groups across the three categories of alternating fluency. On category 1 the |Z| score obtained was 0.694 and the corresponding p value showed no significant difference. Similar trend was seen in category 2 where the |Z| score obtained was 1.642 and in category 3 where the |Z| score obtained was 0.679 and the p values in both the categories indicated no significant differences. This task showed marked difference between high and low proficient groups.

Friedman test was carried out to see if there was a significant difference between the three categories. The results revealed χ^2 (2) = 46.50 , $p < 0.01$ Chi square value obtained was 46.50 for 2 degrees of freedom and the p value indicated significant difference ($p<0.01$). Hence Wilcoxn signed rank test was performed to verify if there was a significant difference between the three categories of alternating fluency. In the high proficient group on comparing between category 1 and category 2, the |Z| score obtained was 3.551 and the corresponding p value showed significant difference. Similar trend was seen while comparing category 2 and category 3, the |Z|

value obtained was 3.834 and p value indicated significant difference. However while comparing category 1 and category 3 the |Z| score obtained was 1.525 and the corresponding p values showed no significant difference.

In the low proficient group on comparing between category 1 and category 2, the |Z| score obtained was 2.278 and the corresponding p value showed significant difference. Similar trend was seen while comparing category 2 and category 3, the |Z| value obtained was 3.634 and while comparing category 1 and category 3 the |Z| score obtained was 2.530 and the corresponding p values showed significant differences.

To summate comparisons on the alternating fluency task between category 1 and 2 and between category 2 and 3 revealed statistically significant differences in the high proficient group. The same trend was seen in the low proficient group when comparing between each of the three categories. However statistically significant difference was not observed on the comparison between category 1 and 3 in the high proficient group.

The findings suggested that there was a better performance by the high proficient group across the three categories of animals, fruits and vehicles. As hypothesized, and according to that proposed in Diamond's model, the cognitive flexibility component among the executive functions showed strong association with the verbal fluency tests. Since the alternating fluency task is a cognitively loaded task that utilizes the cognitive check mechanism, the findings were also conclusive of the fact that the high proficient group performed better than the low proficient group as they were cognitively more efficient in switching across the two languages. Another support is derived from Hommel et al (2011) who claimed that mastering more than one

language helps an individual to achieve a focused cognitive-control state that exerts a strong impact for processing information. The authors supported this claim by reporting that high-proficient bilinguals outperformed low-proficient bilinguals on tasks of verbal fluency and confirmed the presence of a high-proficient bilingual advantage.

Overall the results of the present study revealed differences between the high proficient and the low proficient groups in the measures of reaction time and accuracy on the various domains of executive functioning namely attention, response inhibition and cognitive flexibility with the high proficient group having a superior performance. Also the study explored the differences between the two groups across the two tasks (odd and even tasks) which were used to tap each of the three domains which revealed that the odd tasks were relatively simpler and less linguistically loaded when compared to the even tasks. Finally the groups were compared on the alternating fluency task which also revealed better performance by the high proficient group.

Chapter V

Summary and Conclusion

Bilingualism is defined as the usage and proficiency in at least two languages by an individual, which may change depending on the opportunities to use the languages and exposure to other users of the languages (ASHA, 2004). Bilingualism has been found to have a positive effect in the efficiency of the executive functioning (EF) system. Executive functioning in bilinguals refers to higher processes such as attention , set shifting, response inhibition, working memory and problem solving that involve conscious control of thought and action (Zelazo & Muller, 2010). Executive functions are critical for cognitive and social development in bilinguals and vary as a function of degree of bilingual proficiency. Different linguistic and non linguistic tasks have been employed to test executive functions in bilinguals. Very few studies on executive functions in high proficient and low proficient bilinguals have been carried out and hence the current study was conducted to explore the effects of bilingualism on the two groups of bilinguals in the various domains of executive functions namely attention, response inhibition and cognitive flexibility.

The primary aim of the study was to study the executive functions in high proficient and low proficient bilinguals. Participants in the age range of 18-25 years were considered for the study. They were divided into 2 groups, each group comprised of 20 participants (10 males and 10 females). All the participants were successive bilinguals having Kannada as L1 and English as their L2 and having exposure to L2 (English) right from their childhood with a minimum of 10

years of exposure to the language. The participants were tested through informal screening for normal vision. Based on the ratings done by the participants on the Language Experience and Proficiency Questionnaire - LEAP Q they were classified as high proficient or low proficient bilinguals by adopting Hayward's criterion. It was decided to test three domains of executive function i.e. attention, response inhibition and cognitive flexibility in high and low proficient bilinguals.

There were 2 tasks of varying complexity in each of the three domains tapping for attention (Tasks 1 and 2), response inhibition (Tasks 3 and 4) and cognitive flexibility (Task 5 and 6). These tasks are labeled as odd task and even task in the study. In addition to these tasks, alternating fluency task was also used. It is assumed to tap for all the three processes (attention, response inhibition and cognitive flexibility).The stimulus for all the tasks was presented in visual mode through the DMDX software. Statistical analysis for calculating the mean reaction time and accuracy was done using the software Statistical Package for Social Sciences (SPSS) version 16.0.

The primary objective of the study was to compare reaction time and accuracy between the high proficient and low proficient group in the domains of attention, response inhibition and cognitive flexibility. The overall mean, standard deviation (SD) and median were calculated for the performance of Group I (High proficient) and Group II (Low proficient) across the two tasks for both mean reaction time and accuracy. Mann Whitney U Test was carried out and it was found that the high proficient group outperformed the low proficient group in terms of accuracy of responses on the three domains. Also the high proficient group took lesser reaction time than the low proficient group. Thus it was seen that the high proficient group had a better performance

than the low proficient group across all the domains. The findings indicated that there is a relationship between bilingual proficiency and executive functioning. Statistically significant difference was obtained on all the tasks except reaction time measure on task 2 of attention, reaction time measure for both task 3 and task 4 of response inhibition and accuracy scores for task 3 of response inhibition. Reaction time measure for both task 5 and task 6 of cognitive flexibility also statistically showed no significant differences.

The second objective was to compare between Task 1 and Task 2 for the three domains for both high proficient and low proficient group across mean reaction time and accuracy. Two tasks (odd and even) were used to tap the each domain of executive functions, which varied in terms of the linguistic load associated with each of the task. The odd tasks were linguistically less loaded than the even tasks. Wilcoxn Signed Rank Test was used and it was found that across the two domains of attention and response inhibition there was a better performance by both the groups on the odd tasks which were less cognitively loaded when compared to the even tasks. However it was found that for the cognitive flexibility domain the performance did not vary as a function of task complexity. This shows the relationship between the language load and executive functions. It was initially speculated that the language load would have had no impact on the performance in high proficient individuals but this assumption was proved false as the performance depended on linguistic loading

The third objective was to compare across the alternating fluency tasks between the high proficient and low proficient group. Mann Whitney U Test was used to verify if there was any significant difference between high and low proficient groups across the three categories of alternating fluency and Friedman test was carried out to see if there was a significant difference between the three categories. It was found out that the high proficient group performed better than the low proficient group. It is assumed that alternating fluency task is a cognitively loaded task that utilizes the cognitive check mechanism, the high proficient group performed better than the low proficient group as they were cognitively more efficient in switching across the two languages in across the three categories. This again served as an evidence for the fact that executive functioning would be superior in bilinguals compared to monolinguals

Thus the study helps us to understand the relationship between executive functioning and bilingualism. In earlier studies the executive function would be compared between bilinguals and monolinguals. In the current day scenario, as we do not get strict monolinguals high and low proficient bilinguals were considered. The executive functions varied as a function of degree of bilingual proficiency. This again supports the claim that bilingualism is advantageous and the advantages of bilingualism would scatter through a variety of executive functions also.

Implications of the study:

- The current study enables researchers to understand the relationship between bilingual proficiency and executive functioning. The results of the study reveal that high proficient

bilinguals are better able to perform on tasks of executive functioning as they maybe cognitively more efficient.

- The study also examined the effect of task complexity on executive functioning in high proficient and low proficient bilinguals. The task complexity had an impact on the performance for both high and low proficiency groups.

Limitations of the study:

- Some of the participants overestimated their proficiency levels while rating themselves on the LEAP-Q. Objective measure of bilingual proficiency would have been considered but the extent of over estimation was limited to very few participants.

- Limited number of participants were considered for the study.

Implications for future research:

- The material used in the study can be employed to test for executive functioning in clinical population like Mild cognitive impairment and Dementia.

- The study can be extended into other bilingual populations

- The study can be carried out on monolinguals if possible and test if the performance would vary between monolinguals, low proficient bilinguals and high proficient bilinguals.

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APPENDIX I

Language Experience And Proficiency Questionnaire - LEAP Q

- **Ramya And Goswami , 2009**

Name: Age: Gender: Male / Female

Instructions:

Please read the questions carefully and choose the most appropriate choice wherever applicable.

1. Name all the languages you know beginning with the language that you learnt first.

Using the below mentioned scale, answer the questions below.

(1- L1, 2-L2, 3-L3, 4- Combination of any of the languages)

L1- First language that you learnt, L2- Second language that you learnt in your life,

L3- Third language.

2. When you were a child, which language did you speak

- At Home 1 2 3 4
- With your father 1 2 3 4
- With your mother 1 2 3 4
- With siblings 1 2 3 4

- With guardians 1 2 3 4
- With neighbors 1 2 3 4

3. Native Language of
   - Father 1 2 3 4
   - Mother 1 2 3 4
   - Sibling's 1 2 3 4
   - Guardians 1 2 3 4
4. Language spoken with you by your
   - Father 1 2 3 4
   - Mother 1 2 3 4
   - Sibling's 1 2 3 4
   - Guardians 1 2 3 4
   - Neighbors 1 2 3 4
5. Which language did you learn first for
   - Understanding 1 2 3 4
   - Speaking 1 2 3 4
   - Reading 1 2 3 4

- Writing 1 2 3 4

6. Mention the age when you first started using each of the languages for each of the following parameters:

	Understanding	Speaking	Reading	Writing
L1				
L2				
L3				

7. Mention the age when you became proficient for each of the following parameters:

	Understanding	Speaking	Reading	Writing
L1				
L2				
L3				

8. How many years of formal education do you have? (please specify your qualification)

What was the medium of instruction? 1 2 3 4

Which language was used maximally? 1 2 3 4

Which language did you speak with teachers 1 2 3 4

Which language did you speak with classmates 1 2 3 4

Which language was spoken by your teachers with you 1 2 3 4

Which language was spoken by your classmates with you 1 2 3 4

Did you change your medium of instruction? Yes No

If yes, specify the changed medium of instruction. At what age did you change your medium of instruction? 1 2 3 4

9. Have you changed your state? If yes, which language do you use to communicate? 1 2 3 4

10. On a scale from one to five, mark your level of proficiency in each of the skill

(1-Zero proficiency, 2- Low, 3- Good, 4- Native like/perfect)

Language	Understanding	Speaking	Reading	Writing
L1				
L2				
L3				

11. How many dialects can you speak in each of the languages?

L1: L2: L3:

12. On a scale from one to five, mark your level of proficiency in each of the skill for each of the dialects in L1, L2, L3.***(1-Zero proficiency, 2- Low, 3- Good, 4- Native like/perfect)***

	L1			L2			L3		
Dialect	D1	D2	D3	D1	D2	D3	D1	D2	D3
Understanding									
Speaking									

13. On a scale from one to five, mark your level of proficiency in shifting from one language to the other

1-Zero proficiency **2- Low**

3- Good **4- Perfect**

14. Use the rating scale mentioned below, indicate which language you used maximum for the following:

(1- L1 , 2- L2, 3- L3, 4- Combination of any of the languages)

Interaction with family	1	2	3	4
Education/ work	1	2	3	4
Listening to instruction tapes at school	1	2	3	4
Text books	1	2	3	4
Dictionary	1	2	3	4
Story books	1	2	3	4
Newspapers	1	2	3	4
Historical books	1	2	3	4
Internet source	1	2	3	4
Writing	1	2	3	4
Interacting with friends	1	2	3	4

Interacting with neighbors	1	2	3	4
Watching TV	1	2	3	4
Listening to the radio	1	2	3	4
Market places	1	2	3	4

15. On an average, mention below the time you are exposed to each of the languages.

Languages	Number of days per week	Number of hours per day
L1		
L2		
L3		

16. Mention the number of years you spent in each language environment:

	Family	School	State	Work place
L1				
L2				
L3				

17. Using the rating scale mentioned below, indicate the extent to which you are currently exposed to each of the languages in the following contexts in a day.

(1- never, 2- sometimes, 3- most of the time, 4- always)

	L1	L2	L3
Interaction with family			
Schooling/ work			

Listening to instruction tapes at school

Text books

Dictionary

Story books

Newspapers

Historical books

Internet source

Writing

Interacting with friends

Interacting with neighbors

Watching television

Listening to the radio

Market places

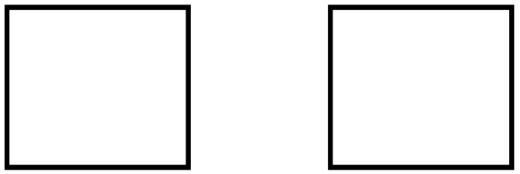
18. Rate how frequently others identify you as a native speaker based on your accent or pronunciation in the language ***(1- Never, 2- Sometimes, 3- Most of the time, 4- Always)***

1. L1 2. L2 3. L3

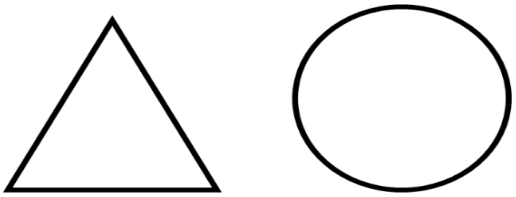
Stimulus Material used for tasks

Task 1 of attention : Shapes Task

Congruent trial



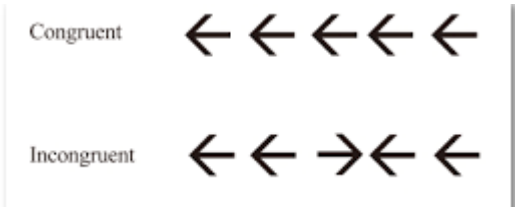
Incongruent trial



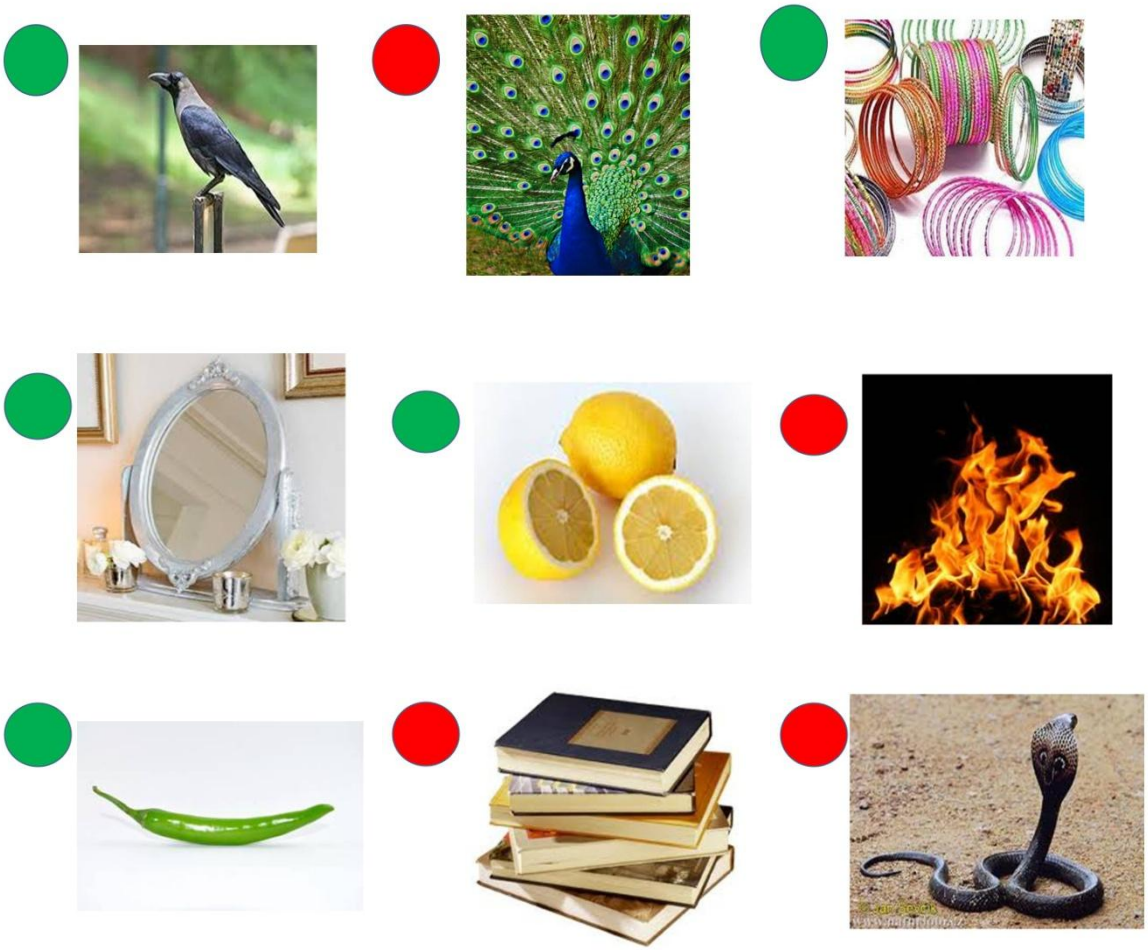
Task 2 for Attention: Letter monitoring task

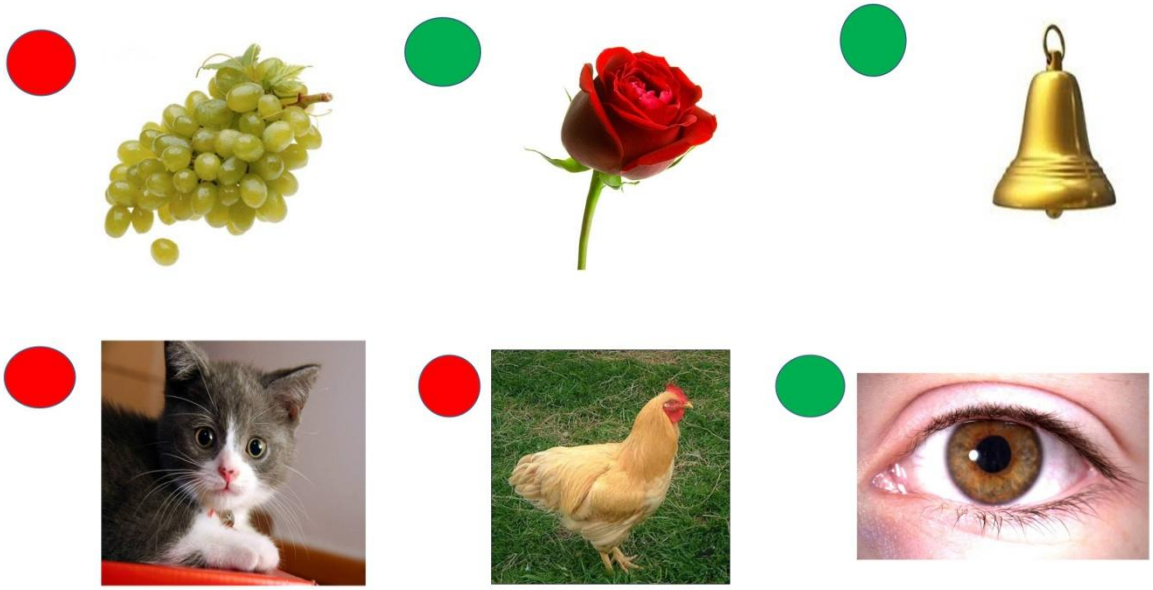
Pan	Song	Bird	Pot	Cupcake	Man
Soup	Cupboard	Apple	Sky	Carrot	Pencil
Room	Listen	Shine	Write	Play	Happy
Sick	Pet	Seven	Rice	Peace	Plant
Line	Bag	Spoon	Last	Pen	Pipe

Task 3 for Response Inhibition: Flankers Task

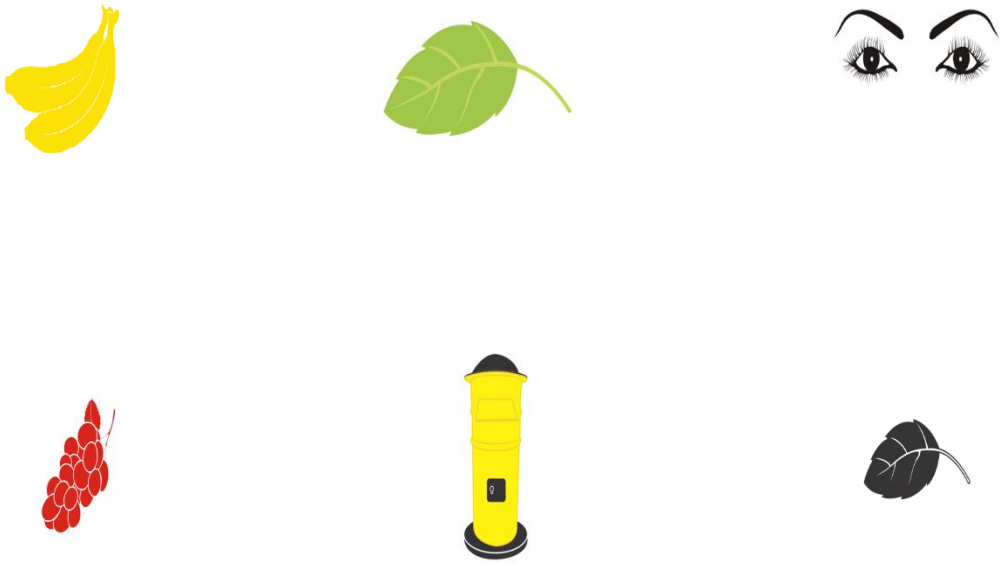


Task 4 for Response Inhibition: Picture Naming Task





Task 5 for Cognitive Flexibility : Stroop Object Task

















Task 6 for Cognitive Flexibility: Letter Number Task

Congruent Trial

Incongruent Trial