Chapter 1: Introduction

Cognitive control is the ability to flexibly adapt behaviour to current demands by promoting task-relevant information in the face of interference or competition (Dreher and Berman, 2002). Language is seen as a natural phenomenon of human behaviour. Thus, it is goal-oriented behaviour where it acts as a tool to fulfill the aspects of communication. It is rather surprising that a complex act of language formulation is so automatic, that we hardly make any errors in lexical selection or ordering of words/sentences etc. The control of language in its simplest form consists of selection of words. The importance of control over language selection is most obvious when bilinguals inadvertently switch between languages. Some form of a system is required to enable the willed selection of response in a particular language and minimize the interference from the other known languages. Such processing requirements may result in enhanced executive control among bilinguals. Cognitive advantage in bilinguals has been well documented in various research conducted in past decade (Bialystok et al, 2005, Christofells, Formisano & Schiller, 2007, Bialystok, Craik, Klein & Viswanathan, 2004; Martin-Rhee & Bialystok, 2008; Costa, Hernandez & Sebastian-Galles, 2008, Bialystok and Martin, 2004; Costa, Hernander, & Sabastia-Galle 2008, Costa, Hernández, Costa-Faidella, Sebastián-Gallés, 2009; Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010). Optimal information comes from converging methodologies, which include behavioural studies, neuroimaging and electrophysiological studies and from clinical and ageing population data (Costa, Hernender & Sabastia-Galle, 2008; Siegal, Lozzi & Lurian, 2009; Bialystok & Feng, 2009, Abutalebi & Green 2007, Rodriguez-Fornells,
Both cognitive control and bilingualism are multidimensional constructs, and thus an understanding and operationalization of both the constructs are required. The mechanism that underlines the two constructs needs to be understood to explain the cognitive advantage observed among bilinguals. Bilingualism on one hand can be characterized on the basis of age of acquisition, language use or language proficiency whereas cognitive control can be explained based on selection, inhibition and switching as component processes.

1.1 Bilingualism and Cognitive control

Cognitive control is a multidimensional construct, which varies from engaging attention to the relevant information, ignoring the irrelevant and switching between tasks. It involves filtering out irrelevant information, i.e. interference suppression, inhibiting an inappropriate response, maintaining the goal of the task in conflicting condition, switching between tasks and selection between different responses. Bilingualism has been considered to be advantageous, especially in the domain of inhibition and executive attention. In behavioural research, the term inhibition may be used whenever slowing in some activity is seen as a result of manipulating some aspect of the task environment. There are two ways in which the relationship between bilingualism and cognitive control has been explained in literature: 1) It is the bilingual experiences which tune our cognitive control circuits to be advanced as compared to monolinguals for linguistic as well as non-linguistic tasks, 2) Executive attention provides the mechanism by which a
person can manage two language systems with equivalent language fluency. In order to understand the interaction between the two constructs of bilingualism and cognitive control we need to consider the issues related to bilingualism as a complex phenomenon in itself.

1.2 Bilingualism: Issues and Concerns

Bilingualism has been viewed as the equal mastery of two languages. However, there are variations in the way bilingualism has been defined in literature. The extreme view of bilingualism is mastery over both languages with native like competence, and ability to use either of the languages in any context or situation. Bilingualism is often referred to in terms of categories and scales. Such as ideal vs. partial, coordinate vs. compound, high vs. low proficient, early vs. late, which are related to factors like function, proficiency and age of acquisition (Norlund 2005). The phenomenon is so widely prevalent and multifaceted that it is very difficult to define bilingualism. Defining bilingualism becomes more complicated when one begins to consider what ‘knowing a language’ actually means and how one can define various aspects of bilingualism. India is one of the largest bi/multilingual countries. Much of the published literature on bilinguals so far has come from the western countries. These may not be directly applicable to complex linguistic situations seen in countries like India, where many people are not only bilingual but multilingual and certain states by law have an official three language policy. Therefore, we need a better understanding of bilingualism as it exists in our country with respect to the various aspects of language processing (Chengappa 2009, Romaine, 1995).
1.2.1 Measures of bilingualism

Language per se has many dimensions such as age of acquisition, mode of acquisition, language use and language proficiency. An interesting observation in the field of bi/multilingualism by Francois Grosjean (1998) is that the studies in the field of linguistics, psycholinguistics, language development and neurolinguistics have often produced conflicting results, which could be directly attributable to methodological and conceptual issues. However, despite the conflicting results, findings from research on language diversity, bilingual language processing, acquisition and learning are important to understand core issues in cognitive psychology such as the nature of attentional control in bilingualism (Colzato et al 2008), language representation in our mind (Chauncey, Holcomb and Grainger, 2009) and lexical access (Kroll and Stewart, 1994). It has been reported that age of acquisition alone cannot account for advantage in cognitive control in bilinguals (i.e. early vs. late) rather there is upcoming evidence supporting the role of proficiency (Green, 2007; Costa and Santesteban, 2004). All these factors (age of acquisition and language proficiency) influence language representation in the brain and may thus influence different aspects of cognitive control. In recent past, bilingualism has mostly been considered as a categorical variable based on the level of language proficiency, age of acquisition or (and) language use. Most of the studies have employed methods like confrontation naming (i.e. in the form of Peabody Picture Vocabulary Test) or self-reported questionnaires to depict the level of bilingualism (Carlson and Meltzoff, 2008; Yang and Lust 2004, Bialystok et al, 2004). Only recently have been researchers acknowledging the use of both self-reported measures of proficiency and some form of
objective language tests, example: Lextel, to establish the level of bilingualism (Khare et al, in press).

1.2.2 Language proficiency: Methodological Concerns

Language proficiency is the ability of an individual to speak or perform in a particular language. As theories vary among pedagogues as to what constitutes proficiency, there is little consistency as to how different studies classify it. This leads to a question that “how much an individual should know the elements of a language to be considered as a bilingual.” Second issue while dealing with language proficiency is whether to consider all domains (spoken and written) of language production and comprehension to account for the effects of bilingualism. All these issues may determine how we operationalize language proficiency and bilingualism. The operational definition of Hindi/English bilinguals in this study involves a self-reported use of both languages daily and at least seven years of basic education in both the languages. In the present study, bilingual language proficiency in both speaking/understanding and reading/writing modality was the measure of bilingualism.

1.2.3 Bilingual language processing

Bilingual language processing is well addressed by description of many models and theories in literature. To address this, most of the models try to explain how bilingual languages are represented as well as how bilingual languages are accessed. Models are well distributed between processing mechanism described as language specific or language non-specific. Most of these models come from an extension of
monolingual language production models. De Bot (1992) was the first to postulate a bilingual language production model based on Levelt’s (1989) model for monolinguals. Following which, many models were proposed based on three approaches namely: picture-word interference effect studied predominantly by use of Stroop tasks, language switching effects by using switching paradigm and thirdly by studying the effect of language-specific properties, i.e. to look at the cognate effects, phonological as well as an orthographic effect on language selection. By stating that, it is “language specific” in nature it means that lexical knowledge of the bilingual may be represented in two language-specific memory systems, one for each language. Language non specific hypothesis considers common conceptual representation, which can be accessed for language selection. There are models like Bilingual Interactive Activation model, Revised Hierarchical Model and Inhibitory Control Model, which support one or both the hypotheses (Dijkstra & Van Heuven, 2002; Kroll & Stewart, 1994, Green, 1998). Bilingual language processing based on the Revised Hierarchical Model considers common conceptual representation with two individual language nodes. It also consists of two lexical nodes, which act based on level of proficiency, as the level of proficiency increases; the conceptual to lexical representation becomes stronger. Inhibitory control model accounts for the top-down inhibitory processes which suppress the non target candidate as they become activated. Green’s model proposes a reactive inhibition process. For instance, if the activation level of L2 becomes sufficiently high, then inhibition will be applied to L2 lexicon when retrieval of a word in L1 is required. According to this hypothesis, inhibition is proportional to the activation of the word which needs to be inhibited. Languages can be represented across syntactic,
phonological, orthographic, semantic, pragmatic, and discourse dimensions. Apart from discussing models to describe bilingual language representation and processing, a lot of case studies and fMRI studies enlighten us on the neuroanatomy of bilingual language representation. These distinctions can vary depending on the two languages. For example, Chinese and English are very different orthographically and phonologically. In contrast Spanish and English, are more similar orthographically but very different in syntax in that the former uses a very large number of morphological markers. When we talk about Indian languages, they vary not only at phonological, syntactic semantic levels but also there is a drastic difference in language acquisition and learning as compared to languages in the West. Evidence based on brain lesions have shown that a lesion may affect one language and not the other indicating that languages are represented in different areas of the brain. There is evidence for different degrees of recovery in each language after stroke (Vendrell & Vendrell 1995). Hernandez et al. (1997) addressed this issue using functional magnetic resonance imaging (fMRI) for Spanish-English bilinguals. Participants were asked to name a picture in their first language, second language, or to alternate between each language on successive trials. Results revealed slower reaction times and an increase in the number of cross-language errors in the alternating condition relative to the single-language condition. In the fMRI study, there was no difference when comparing activation for naming in the first and second language. However, activation in the prefrontal cortex increased significantly when participants were asked to alternate between languages. Thus it appears that the left prefrontal cortex may also act to reduce the amount of interference between languages (as indexed by slower reaction times and increased cross-language errors. On similar lines,
there are numerous evidences supporting common cortical representation (Chee et al 1999, Perani et al 1998, Illes et al 1999) as well as separate cortical representation for both the languages (Ojemann & Whitaker, 1978, Gomez-Tortosa et al, 1995, Perani et al 1996, Kim et al 1996, Dehaene et al 1997). Language use in bilinguals also influences the processes involved in interference suppression and monitoring. Existing literature has shown advantage in cognitive control among bilinguals as compared to monolinguals. Language control in terms of effective activation-suppression mechanism while switching between languages, utilizes wide-spread cognitive and neural networks. Information from converging methodologies can provide a wider picture. Also, to date, studies focus more globally on control over language per se, rather than more specifically on control processes. Language control and general purpose cognitive control were often studied separately. However, it is likely that both are not mutually exclusive and may interact at a different level. Multitude of information can be gathered through range of factors on the development of such control processes, and language-related factors (such as relative proficiency) as well as data from bilingual aphasia. Previous studies on language proficiency of bilinguals have often focused on L2 proficiency and have rarely discussed the influence of L1 proficiency. Categorizing bilinguals on various parameters has been a traditional approach and it would be interesting to explore the measure of bilingualism, i.e. language proficiency as a continuous variable. In light of contrasting findings seen in literature on bilingualism, there is a greater need to have a tool which is not defining an individual as bilingual based on one task or self-reported measure, rather it creates a profile of the individual based on both self-reported information as well as various objective linguistic tasks in both the languages.
1.3 Motivation

The current study aimed to investigate the role of language proficiency as a measure of bilingualism in the selection and inhibition sub components of cognitive control by using behavioural, electrophysiological and case study method. Bilinguals have shown an advantage with linguistic tasks tapping the control mechanisms as well as with non-linguistic tasks. However, it would be interesting to study the interaction between language control and general purpose cognitive control and look at the extent of overlap or independence between the two systems. On the other hand, one needs to know the mechanisms that trigger the kind of interaction between bilingualism and cognitive control reported in literature in terms of a cognitive advantage among bilinguals as compared to monolinguals. Hence, the current study aimed to answer questions like: What are the cognitive and neural mechanisms of the interaction between bilingualism and cognitive control? Whether cognitive control and language control are two separate or overlapping systems? Is bilingualism a beneficial component in language recovery and if this is due to the control mechanisms associated with bilingualism? In addition, studying cognitive control in bilinguals would also provide an opportunity to look at broader cognitive mechanisms involved in language processing.

1.4 Objectives

The current study examined the sub-components of cognitive control (selection and inhibition) as they interact with bilingualism as a function of language proficiency by using behavioural (reaction times) and electrophysiological (EEG/ERP) methods. Further, a case study approach was used in order to investigate whether cognitive control
and language control are two separate systems by studying individuals with bilingual aphasia showing parallel recovery patterns.

1.5 Organisation of the thesis

Apart from this introductory chapter, thesis contains six chapters as follows: The second chapter is review of literature; chapter begins with theoretical background on bilingualism and cognitive control. More specifically it brings out the major issues and concerns in the experimental literature on bilingualism like, what is bilingualism, measure of bilingualism. Secondly, this chapter lays down the foundation for the debate in the past with respect to bilingual language control and general purpose cognitive control through experimental evidences as well as clinical studies on individuals with aphasia. An interesting blend of the use of different methodologies towards an understanding of the interaction between bilingualism and cognitive control has been discussed in the section on review of literature. This chapter helps in understanding the phenomenon of bilingualism and cognitive control and thus to identify the gaps in previous research and establishes the motivation for the studies performed in the current thesis.

Third chapter reports the first study of the current thesis in which the relationship between a subjective and objective measure of language proficiency was examined by using an indigenously developed test of language proficiency in Hindi and English and a language background questionnaire. Individual performances on language tests in different domains of Hindi-English bilinguals were compared with self-reported information on age of acquisition, language use and language proficiency. Secondly, this
chapter also highlighted normal distribution of the data based on the performance on various language proficiency tasks in both L1 and L2 across language skills, thus indicating that language proficiency could also be treated as a continuous variable. This chapter provides the foundation for the notion of using correlation and regression analysis with language proficiency as a predictor variable for experimental task performance.

The fourth chapter reports the experimental study on the component process of selection in Hindi and English language among Hindi-English bilingual adults by using Posner's cueing paradigm with linguistic and nonlinguistic stimuli. Effect of proficiency in L1 and L2 on the cueing effects in L1 and L2 and for nonlinguistic stimuli are also discussed.

The fifth chapter deals with the component process of inhibition as a function of language proficiency among Hindi-English bilingual participants from University of Allahabad. This study was done in different stages; firstly, to establish the negative priming paradigm with overlapping linguistic stimuli, which was conducted behaviourally, followed by two ERP experiments with similar H-E bilingual group. Apart from addressing the role of language proficiency on inhibitory control, this chapter also highlights the distinction between bilingual language control and general purpose cognitive control by using linguistic and non-linguistic stimuli in a negative priming task.

Chapter six is based on four case studies of individuals with bilingual aphasia. The participants performed experimental tasks such as flanker task and negative priming task with linguistic and non-linguistic stimuli and their behavioural scores as well as language history information was correlated with their performance.
The last chapter is the concluding chapter of the thesis providing a general discussion based on the findings across the four studies and conclusion in order to provide a coherent and comprehensive picture. Future research avenues in the area of bilingualism and cognitive control are also discussed.