Chapter 2: Review of Literature

In order to bring a responsible link between bilingualism and cognitive benefits, many of the researchers have attempted looking at the causal relationship between bilingualism and cognitive control. Most of the research rests on the assumption that bilingualism is associated with cognitive advantage and cognitive abilities also in turn enhance language learning. Optimal information comes from converging methodologies. Furthermore, to date, studies focus more globally on control over language per se, rather than more specifically on control processes. It is likely that impact of a range of factors on the development of such control processes, and language-related factors (such as relative proficiency) cannot be ignored. Data from bilingual aphasia (Green and Abutalebi, 2008; Green et al, 2009) as well as electrophysiological/imaging techniques enhance our understanding of the processes that underlie the observed behaviour and suggest other avenues of exploration.

In the search for a locus of selection and inhibition effects bilingual word processing, researchers have turned to methods that can better explain the time-course and locus of cognitive processes involved in selecting and producing words in both the languages. While behavioural methods have been used to examine time-course issues by varying stimulus onset asynchronies and manipulating task constraints, they have a distinct disadvantage of relying on a discrete measure which may reflect the combined result of many stages and loci of processing. Response times of the order of hundreds of milliseconds may obscure the fine-grained series of events, which underlie fluent language processing. Unlike response time measures, event-related potentials (ERPs) can
allow for the evaluation of neurocognitive processes with millisecond resolution. The ERP technique provides an invaluable opportunity to “observe” on-line processing of stimuli without requiring overt responses or additional decision processes needed for most behavioural measures (Kroll et al, 2008). The interaction between bilingualism and cognitive control has been investigated by using various methodologies, including behavioural reaction time methods, ERP, fMRI, and lesion method. The studies have reached a consensus that the control mechanisms strongly support bilingual language processing and hence need to be understood with respect to the extent of impact this interaction generates in terms of the cognitive functioning in a bilingual as well as the extent of overlap that may exist between the two systems.

2.1.1 Bilingual language control and general purpose cognitive control

Language processing with respect to lexical selection, morphosyntactic organization (ordering the words in correct sequence) and discourse (organization of sentences in an appropriate order according to the context) appear seemingly simple and automated. However, these processes involve a number of sub components and require a great deal of planning and sequencing of various elements. These complexities bring us to language control, an important mechanism associated with bilingualism. Language control refers to the mechanisms that control which language to use at a given moment and context. It allows bilinguals to selectively use one target language while minimizing the effect from the non target language. Language control as a language-specific mechanism may transfer to general cognitive control in bilinguals.
A lot of work has been done on language control in bilinguals using ERP as a tool. There are ERP data, which were interpreted as a confirmation of the inhibition hypothesis: A language switch is brought about by inhibition of the non-target language and more inhibition is needed to suppress L1 on L2 switch trials than to suppress L2 on L1 switch trials (Christoffels, Firk and Schiller, 2007; Costa and Santesteban, 2004). An ERP study conducted by Khatheb et al (2007) on the language selection mechanism among bilinguals suggests that language selection is achieved through a neural network involving areas implicated in both general cognitive processes and language processing. Wang et al (2009) suggest that sustained and transient language control induce differential lateral activation patterns and such activations in the human brain modulate the behavioural costs during language switching.

For studying cognitive and language control various experiments were conducted using behavioural reaction times, ERP and eye movement method. Most of the results suggest an obvious advantage in cognitive control for bilinguals as compared to monolinguals as well as there is a lifespan related advantage for bilinguals, suggesting slowing of the process of cognitive decline as a function of ageing. Most of the literature on ERP, reviewed in previous section suggests similar underlying mechanism involved in language control and cognitive control. Rather, there is a general speculation that knowing two languages shapes the cognitive control system (i.e. language control modifies/defines cognitive control). Language control is exerted through inhibition of the “other language” task schema when speaking target language. Upon a switch back to the “other language”, this generalized inhibition of previously attended language (i.e. previous target language) must be undone, a process associated with a measurable cost.
Costa and Santesteban, 2004 has shown larger switch cost while switching back to a stronger L1, which is directly related to proficiency. However, confounds between age of acquisition and relative proficiency effects make it difficult to determine the importance of either factors.

2.1.2 Neural basis of the interaction between bilingualism and cognitive control

The Prefrontal cortex is considered to be engaged in the phenomenon of cognitive control. There is evidence regarding the presence of different executive control circuits, which vary with respect to component processes involved (Miller and Cohen, 2001). An understanding of how the cognitive control circuit dynamically recombines and interacts with other systems; especially language processing, could also help us to develop full understanding of how cognitive control is implemented in the brain. Abutalebi and Green (2007) report higher L2 related activations in participants with low proficiency, not only in regions traditionally involved in L1 processing, but also in regions responsible for the ‘cognitive control’, such as the prefrontal cortex (BA 9, 46, 47), anterior cingulate cortex, and inferior parietal cortex. According to the authors, these activation patterns reflect monitoring processes aiming at inhibiting incorrect responses and filtering out of unnecessary information available in the environment. Using neuroimaging techniques, Rodriguez- Fornell, Balaguer and Munte (2006) described cognitive control in bilingual speech production and two interrelated control/inhibitory mechanisms:

1) A top-down control inhibitory mechanism could be implemented by the prefrontal cortex when language schemas are activated (regulates a local inhibitory system).

2) This prefrontal selection/inhibition mechanism could interact with more local and
bottom up inhibitory mechanism that regulates the level of activation of the non-target language.

Along with the neural substrates of bilingual language processing and cognitive control, there is some evidence on the temporal dynamics of control processes involved in language processing in bilinguals. Bilingual aphasia is one of the clinical conditions, which is studied to understand the language representation mechanisms among bilinguals. However, so far studies have not directly addressed the involvement of central mechanism underlying pattern of language disturbances and recovery among bilingual aphasics.

2.2 Research on Bilingual Aphasia

In all, it is evident that the ability to switch between two different language sets may result in an advantage on the cognitive control tasks for a bilingual. Cognitive advantage associated with bilingualism needs to be understood with respect to the components of cognitive control processes. Different frameworks have been suggested to study the mechanisms underlying the interaction between bilingualism and cognitive control. One of the most interesting and informative frameworks other than normative bilingualism is, the one provided by the clinical population.

2.2.1 Bilingual aphasia

Importance of control processes is highlighted in bilingual aphasics. The study of bilingual aphasia is also important to be able to recommend treatments consistent with a plausible estimate of the course of recovery. There are differing viewpoints while
explaining the mechanism of language recovery. Two possible patterns of language deficit and language recovery have been identified in the literature on bilingual and multilingual speakers who had suffered aphasia: parallel and non-parallel. Common scenario is a parallel form of recovery, but there are cases of non parallel form. Green’s IC model accounts for such patterns by assuming that what is lost is to willfully control language selection (and not the language itself). This interplay of language activation and inhibition has been incorporated in theories of polyglot aphasia. Different languages are represented in shared brain regions with common organizing principles. It is also important to consider how individuals control the use of their languages. Certain patterns of deficit reflect problems of control rather than of deficits of representation. Authors further explain existence of two separate circuits, i.e. language representation circuit is different from control circuits; and recovery patterns depend on the damage to these control circuits (Abutalebi and Green, 2007). Parallel recovery in bilingual aphasia might be a result of independent yet interactive mechanism of control as a function of bilingual language proficiency.

2.3.2 Bilingual language control and general purpose cognitive control: Revisited

If bilingualism is a cognitive advantage, then bilingual aphasics may show a faster rate of language recovery as compared to monolingual aphasics. Recent studies have provided some insight regarding the involvement of control mechanisms in the process of language recovery among bilingual aphasics (Green et al 2009). There is also some evidence that bilingual aphasics have some executive functioning advantages compared to monolingual aphasics (Penn et al, 2009), still they do exhibit pathological code
switching and code mixing behaviour. Further, if cognitive control and language control are two separate systems, the interaction between the two is also of interest. Inferences drawn from individuals with aphasia involve reverse extrapolation to (an assumed) the premorbid state of functioning. Looking at the control mechanism from a disorder perspective would provide a different viewpoint. An influential aspect of this approach is that patterns of performance (both intact and impaired) suggest selective damage to (or preservation of) one or more components or processing pathways. Data provided by Green et al (2009) in their work on language control with respect to parallel form of language recovery reveal that there are two distinct control impairments associated with recovery. In their study, they compared two bilingual aphasics who demonstrated parallel form of recovery to the same extent. However, their performance on three explicit control tasks indicated different control mechanism engaged in recovery. One of the patients showed impaired verbal but unimpaired nonverbal control whereas the other demonstrated problem in resolving conflict in the selection of a manual response. And they suggest that complete understanding of the nature of control problems may help us in providing accounts of language recovery patterns in bilingual aphasia. Beyond these theoretical discussions on bilingual aphasia, there are also certain issues related to therapy, for instance: which language should be chosen as the language of speech-language therapy? Is there a transfer of therapeutic benefits from the treated to the non-treated language? Answers to these questions are critical to the study of the influence of cognitive control on therapeutic benefits in bilingual aphasics as well as to understand the mechanism of cognitive control as it operates in bilingual individual.