Chapter 7: General discussion

During communication, both speakers and listeners organize their thoughts and actions in a goal-directed manner. A speaker in a conversation has to decide between words in order to convey information while the listener has to understand the intent of the sentence heard not just based on what is being said but also using one’s knowledge about the world and personal characteristics of the speaker. Similarly, bilinguals need to manage not only the content and intention to speak but also the use of two languages. All these processes are executed in a flawless manner with the help of cognitive control mechanisms. The present study examined the multifarious effects of bilingualism in terms of the influence of language proficiency on the component processes of cognitive control (namely selection and inhibition) using a combination of methodologies and measures i.e., behavioural (reaction times), EEG/ERP (ERP amplitudes) and case study method (accuracy and reaction times). In addition, the current study looks at the variability in the interaction of L1 and L2 proficiency with control processes such as selection and inhibition.

Testing bilinguals is called for in the Indian multilingual environment, where being a monolingual can be considered as an exception. Languages are not learnt in a strict simultaneous or sequential manner in the Indian multilingual context, which may result in variability in self-report with respect to language proficiency. Therefore, the current study emphasizes upon the use of objective tasks of language proficiency along with subjective information. Both objective and subjective measures of language proficiency were employed in order to have a comprehensive profile of each bilingual participant with respect to the language skills across
speaking/understanding and reading/writing domains as well as self reported information.

In the last decade, there have been a growing number of evidences looking at the relationship between bilingualism and cognitive control among bilinguals as compared to monolinguals as well as addressing the differences in cognitive control mechanisms within bilingual groups. Although, group comparisons were primarily made between two extremes of the bilingual population, categorized as balanced vs. unbalanced or high vs. low proficient bilinguals or between monolingual and bilingual population. We have considered language proficiency as a continuous variable, and have explored the predictive nature of L1 and L2 proficiency in different experimental tasks pertaining to selection and inhibition. To further enhance our understanding, these issues were studied by using linguistic and non linguistic versions of the cueing paradigm and negative priming paradigm. Such stimulus-level comparisons were made in order to tap the distinction between bilingual language control and general purpose cognitive control. In addition, the dual mechanism of cognitive control i.e. the proactive and reactive modes of control with respect to control mechanisms were also examined among healthy bilingual individuals as well as individuals with bilingual aphasia. Slow and fast trials were compared to achieve this objective.

The salient findings of the current study are as follows: the study discussed in chapter 3 established that the assessment of both L1 and L2 language skills is crucial for profiling the bilinguals. It was interesting to find different clustering patterns across language skills for both L1 and L2. Thus both the languages may influence
performance on cognitive control tasks (particularly those using linguistic stimuli) differently. Secondly, chapter 3 also sets the basis for considering language proficiency as a continuous variable.

Studies discussed in chapter 4 and chapter 5 considered this notion of bilingualism and looked at the performance based differences in cueing and negative priming tasks as a function of language proficiency. Voluntary orienting showed differences in performance between linguistic (word) and non linguistic (picture stimuli) stimuli in Hindi-English Bilingual group, with presence of a significant cueing effect for linguistic as compared to the non linguistic stimuli. In contrast to selective attention, inhibition effects were present for both linguistic and non-linguistic stimuli indicated by behavioural reaction time data as well modulations in the N200 amplitudes. It was interesting to note that the weight of a particular language in a given trial was an important determinant of the control mechanism. Our results pertaining to the selection and inhibition mechanisms among bilinguals clearly indicate that performance benefits could be different for linguistic versus non-linguistic stimuli and also with respect to L1 versus L2 as a function of familiarity and strength of representation.

Results based on regression analysis showed the predictive nature of language proficiency towards the performance on experimental tasks. Results were found to be consistent across paradigms, methodologies and control processes of selection and inhibition particularly with respect to the influence of language proficiency. Finally, the current study revisited the interaction between bilingualism and cognitive control described above, in chapter 6 through reverse inference. Four case studies of
individuals with bilingual aphasia were conducted. Comparisons were drawn within each participant with respect to his/her performance on different control tasks namely the linguistic and non-linguistic flanker tasks as well as the non-linguistic negative priming task.

7.1 Cognitive control mechanism: dichotomies at various levels

The current study examined the interaction between bilingualism and components of cognitive control. Firstly, by manipulating the stimuli (linguistic vs. non-linguistic) we were able to look at the involvement of bLC and GPCC. Secondly, dual mechanism of control was further studied by analyzing slow and fast trials within each experiment to look at the involvement of proactive and reactive modes of control for L1, L2 and non-linguistic stimuli. Thirdly, the investigation of control processes as a function of language proficiency also provided support to the findings related to bLC and GPCC.

Performance on the cuing task showed dissociation between linguistic and non-linguistic stimuli, while comparing performance on valid and invalid cue types in an animacy judgment task. Linguistic stimuli showed stronger cueing-effects as compared to non-linguistic stimuli which could be due to the nature of stimuli i.e., pictures are more familiar as compared to the words. Similarly, differences observed in the behavioural reaction times as well as the ERP amplitudes and latencies of the N200 component for linguistic and non-linguistic stimuli on the negative priming task indicate the involvement of bLC and GPCC (see Chapter 4). On the contrary, inhibitory control mechanisms underlying the processing of linguistic and non-
linguistic stimuli also showed an overlap in the form of similarity in the morphology of the ERP waveforms. Previous studies suggest that the bilingual language control and general purpose cognitive control consist of overlapping systems (Green & Abutalebi, 2007). However, different patterns of performance in the linguistic and the non-linguistic switching tasks suggest that the bLC system is not completely subsidiary to the domain-general EC system (Calabria et al, 2011).

In addition to the differences observed between linguistic and non-linguistic stimuli, the selection and inhibition effects were also found to be different for L1 versus L2. For instance, cuing effects for words in L1 were primarily driven by familiarity and thus showed stronger effects with respect to voluntary orienting as compared to L2. This form of language specific modularity was also observed in the negative priming task. Variations in inhibition related effects between the two languages were also explored in terms of the involvement of proactive and reactive modes of control. It was interesting to note that proactive inhibitory control was employed for L1 (Hindi), which is suggestive of the anticipation of the response for stimuli in the target language and the involvement of reactive inhibitory control for L2 English, with the requirement of sustained control over a period of time. Fast trials showed reduced inhibition effect for L1 Hindi. This is justified as L1 has a stronger language representation which may result in better anticipation for stimuli in the respective language.

Finally, the relationship between L1 and L2 proficiency and cognitive control was investigated by looking at the performance of bilinguals on the negative priming task that was employed as a measure of inhibitory control. Findings based on
regression analysis taking language proficiency as a predictor variable demonstrate that the selection and inhibition effects for linguistic and non-linguistic stimuli are modulated differently by proficiency in L1 and L2. This finding also lends support to the dissociation between bLC and GPCC.

7.2 Bilingualism: language proficiency as a measure

Bilingualism was one of the key areas to be explored in the current study in terms of understanding the Hindi-English bilingual population under study in Indian context. Traditionally, age of acquisition, language use and language proficiency are widely studied measures of bilingualism. In the current study, all these aspects were recorded by using the language background questionnaire based on self report and language proficiency which was also measured through objective tasks. Continuous nature of language proficiency was explored. Although, such ideas have previously been well advocated in literature (Bialystok, 2005; Grosjean, 1999), there have been fewer attempts to execute them in an experimental setup.

Traditionally, experimental research on bilingual population has led to a comparison of early vs. late bilinguals, simultaneous vs. sequential bilinguals, and high vs. low proficient bilinguals. However, such an approach may lead to a biased comparison of two extremes in the population and may not bring out the relative contribution of the languages known to a bilingual and how proficiency in both the languages could mediate the interaction between bilingualism and cognitive control. Among the different aspects of bilingualism, language proficiency comes out as an important quantifiable variable (as discussed in Chapter 3).
Present study highlights the use of a comprehensive and objective measure of language proficiency particularly for the bilingual and multicultural population. Use of such a comprehensive tool helped us in highlighting the continuous nature of language proficiency (which was measured through normal probability distribution). Language proficiency was assessed across four language domains namely speaking, understanding, reading and writing. An important observation was related to the variability in L1 proficiency and the organisation of language skills, whereas L2 showed a uniform clustering of language skills. Such results were well translated in the experimental effects with respect to the differences in the predictive nature of language proficiency on task performance in all the experiments. Hence, considering bilingualism as a categorical variable and considering L2 proficiency as a predictor of behavioural performance, were rightfully modified in the current study. Though, it certainly depends upon the research question as to which methodology would be appropriate with respect to the treatment of bilingual population i.e., whether to consider the measures of bilingualism as categorical or as continuous variables.

Most of the previous studies on bilingualism and cognitive control have demonstrated the influence of L2 proficiency on control processes (Pivneva, Palmer, and Titone, 2012; Singh & Mishra 2013), whereas it is evident in the current study that L1 proficiency also exerts its influence on control processes even in the case of non-linguistic tasks. We also find that the relationship of L1 proficiency with performance on control tasks is not the same as L2 proficiency as discussed above. This is in accordance with the proficiency data itself, as the L2 tasks clustered as one single factor, whereas L1 performance was more scattered across language skills and
domains. Such a trend was also observed in the experimental data where total score of L2 proficiency predicted performance on experimental tasks, whereas task specific scores of L1 proficiency predicted performance on the same tasks.

7.3 Language proficiency as a predictor variable for selection and inhibition

The nature of the relationship observed between L1 and L2 proficiency on one hand and the experimental effects with respect to selection and inhibition on the other, showed interesting results. It was interesting that both the sub components of cognitive control were predicted in a similar manner by language proficiency. The cueing effects were well predicted by language proficiency scores as compared to age of acquisition and language use variables. Words in L1 and picture stimuli were predicted by task specific scores of language proficiency whereas total score of language proficiency in L2 was able to predict of the cuing effects in L2. Similar pattern was also observed for inhibition effect. Total score of language proficiency tasks in L2 was able to predict the inhibition effect in L2 whereas task specific scores on certain proficiency tasks in L1 were able to predict inhibition effects in L1. This may suggest an overall influence of L1 skills on general purpose cognitive control whereas influence of L2 proficiency on language based control tasks particularly with respect to bilingual language control.

In sum, we observed an interesting interaction between overall language proficiency in L2 with inhibitory control in L2 and a task specific relationship between L1 proficiency and inhibitory control in L1. On the contrary, overall proficiency in L1 and task specific proficiency in L2 predicted the negative priming
effects for the non linguistic negative priming task. Similar results were observed on the cuing task. Proficiency in L1 across language domains predicted performance on the non-linguistic task whereas overall proficiency in L2 predicted performance on the linguistic task. Such a tradeoff observed with linguistic and non linguistic tasks as a function of language proficiency provides support for the dissociation between bilingual language control and general purpose cognitive control mechanisms.

7.4 Revisiting cognitive control mechanism: Reverse inference through bilingual aphasia data

Finally, the case study approach was used by conducting experiments on individuals with bilingual aphasia with parallel recovery patterns in order to explore the dissociation between bLC and GPCC. With the help of CDF analysis, we were able to tease out the differences in performance and thus comment on the involvement of proactive and reactive control mechanisms. CDF analysis was found to be a promising tool for looking at variations in performance within each of the four participants on a range of executive control tasks. Findings based on the four case studies indicate differences in the involvement of control mechanisms L1 and L2 with greater involvement of proactive control mechanisms for L1 and that of reactive control mechanisms for L2. Importantly, proactive and reactive control mechanisms are probably not mutually exclusive but rather interact for the efficient execution of inhibitory control. Thus, data based on case studies also supported the claims made in the experiments conducted with normal bilingual population and through reverse
extrapolation, we were able to establish independent yet interactive mechanisms of language control and general purpose cognitive control.

Individual case studies showed that performance of all the participants on control tasks primarily involved use of reactive control mechanisms to compensate for the limited resource system. It was interesting to find discrepancy in performance as a function of language, thus L1 showed more errors as well as lack of desired effect as compared to L2. These results support our previous findings with respect to the involvement of the two modes of control for L1 and L2. Thus, brain damage in individuals with bilingual aphasia showed greater impairment of general purpose cognitive control resulting in more deficient performance in L1 as compared to L2. Experimental data based on the performance of bilingual aphasics also highlighted the transient nature of inhibition, as the sustained inhibition effect was found to be compromised with intact ability for conflict resolution in the current trial. Control processes such as selection, inhibition and conflict monitoring particularly sustained inhibitory control may serve as the underlying resource system for language control in representing and using the languages as a function of parallel recovery among bilingual aphasics.

Findings of the current study provide insight into the theoretical debate of whether bilingual language control is subsidiary to general purpose cognitive control. The current study demonstrates that bLC and GPCC are dissociable yet interactive systems. The methodological variations described above, namely considering language proficiency as a continuous variable, use of linguistic and non-linguistic stimuli, use of reaction times and ERP latency/amplitudes and the use of pathological
data (bilingual aphasia), altogether present a uniform finding about the relationship between bilingualism and cognitive control. Such a consistent pattern of findings across experimental tasks, paradigms, and methodologies demonstrate that language proficiency as a measure of bilingualism is an important factor which determines the nature of the influence of bilingualism on control processes of selection and inhibition. Considering language proficiency as a continuous variable not only resolves the issue of selection bias particularly in bilingual research but also helps in understanding one’s performance on experimental tasks as determined by L1 and L2 proficiency. In a country like India, where there are no strict patterns of language learning, considering L1 as a default language of use or dominance may not be a wise assumption and thus relying only on L2 proficiency may not provide a complete picture with respect to the cognitive effects of bilingualism.