A behavioural and functional imaging investigation of Stroop task performance in late proficient bilinguals

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy, The University of Auckland, 2008

Abstract

In this thesis, Stroop task performance was investigated (using behavioural, electrophysiological and functional magnetic resonance imaging (fMRI) techniques) in late and proficient adult bilinguals currently living in the second language (L2) environment. Monolingual participants, matched for age and handedness, were recruited as controls. The Stroop colour-word task was considered an appropriate tool to test the general hypothesis that bilingualism might influence executive or cognitive control processes.

In Study One, a dual-task paradigm was used for assessing the lateralisation of language functions (given the linguistic nature of the Stroop paradigm used here) in the bilinguals (Macedonian-English/M-E). Bilinguals showed a more bilateral hemispheric involvement, for both languages, compared to monolinguals. These findings also provided supporting evidence for the hypothesis of greater right-hemispheric involvement for language in bilinguals.

In Study Two, two behavioural Stroop task paradigms (manual and verbal) were used in order to assess the magnitude of the Stroop effect between the groups. Bilinguals (M-E, German-English/G-E) showed a trend of smaller interference scores across both languages compared to monolinguals.

In Study Three, manual Stroop task performance with concurrent electroencephalograph (EEG) recording revealed that bilinguals had temporal shifts in the N400 component (of about 30-40 ms) for the interference comparison for both languages compared to monolinguals. Also, relative to monolinguals, M-E bilinguals (for both L1 and L2) and G-E bilinguals (for L2) had fewer electrodes over frontal and central sites with a significant amplitude difference in the interference comparison (i.e., a reduced interference effect).

In Study Four, the neural substrates engaged during Stroop task performance were investigated using fMRI. In general, monolinguals showed greater activation in regions such as the prefrontal cortex and anterior cingulate (regions associated with good executive control). This suggested that relative to bilinguals, monolinguals require more neural resources to accomplish conflict resolution.

Taken together, Stroop task performance in late and proficient bilinguals currently living in the L2 environment differed from that of monolinguals across all methods of investigation. It appears that cognitive processing changes at the executive level can be observed as a result of bilingualism. The results also provide some evidence for changes in L1 processing following late L2 acquisition, as similar results across both languages and tasks were observed for the M-E bilinguals. It is also possible

that slight modifications to cerebral laterality as a result of the late learning of (and continuous exposure to) a second language could contribute to these differences in executive functioning. The language environment might therefore be a major factor in the lateralisation of language processing and executive functioning in bilinguals. These conclusions, though tentative and require further investigation, have important implications for language and executive processing in general and for theories regarding cognitive flexibility in bilinguals.

To my Father, George

Acknowledgements

First and foremost, I would like to thank my supervisors, Dr Karen Waldie and Dr Ian Kirk, for being exceptionally supportive throughout my PhD as both supervisors and dear friends. I am extremely grateful for your constant encouragements and for making me believe in myself as a researcher.

I would like to thank all the people, my colleagues, in the department who have become my friends as well, and have helped me out in any way possible. A special thanks to Branka Milivojevic for generously giving up her time and sharing her EEG and fMRI knowledge with me.

On a personal level, the unwavering support of my family has guided me through this long process. To my husband Vane, thank you for being the voice of reason in the most difficult of times and for believing in me. To my beautiful daughter Anastasia, my mother Ubavka, my sister Dobrila, my mother-in-law Elica, and the rest of the family and friends, thank you for being there for me. Finally, to my late father, who has been my inspiration, I hope I made you proud.

The following thesis was made possible by the University of Auckland Doctoral Scholarship and all the people who unselfishly participated in my experiments.

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ACC – Anterior Cingulate Cortex

ANOVA – Analysis of Variance

BA – Brodmann Area

DLPFC – Dorsolateral Prefrontal Cortex

EEG – Electroencephalography

EHI – Edinburgh Handedness Inventory

ERP – Event Related Potential

fMRI – functional Magnetic Resonance Imaging

G-E – German-English

L1 – First Language

L2 – Second Language

LVF – Left Visual Field

M-E – Macedonian-English

PCA – Principal Components Analysis

PET – Positron Emission Tomography

QPT – Quick Placement Test

RT – Reaction Time

RVF – Right Visual Field

SPM – Statistical Parametric Mapping