THE DEVELOPMENT AND APPLICATION OF QUANTITATIVE APPROACHES TO INVESTIGATE SPATIAL PROCESSING IMPROVEMENT AND COGNITIVE CONTROL

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B. Psychology (Hons)

This thesis is submitted for the degree of Doctor of Philosophy

University of Newcastle, NSW, Australia

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Statements by the candidate

Statement of originality

The thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University’s Digital Repository**, subject to the provisions of the Copyright Act 1968. **Unless an Embargo has been approved for a determined period.

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I hereby certify that the work embodied in this thesis contains a published paper/s/scholarly work of which I am a joint author. I have included as part of the thesis a written statement, endorsed by my supervisor, attesting to my contribution to the joint publication/s.

Alexander Provost

Date: 26th November 2014
Acknowledgements

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Dedication

I dedicate this thesis to my wife and daughter; our little family means the world to me.
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Abstract

This thesis uses quantitative approaches to process behavioural and neural data in order to understand spatial cognition learning and cognitive control. Quantitative measurement was used to clearly identify two distinct strategies for improvement in the mental rotation task, one a departure from mental transformation, the other improvement of mental rotation. Using data from an experiment on learning in mental rotation, a quantitative model of mental rotation was developed. The model was able to account for the RT distribution and error rates using an LBA decision model and a scale adjusted gamma distribution to account for rotation time.

The following two chapters apply a modified version of a previously established signal processing technique to model the change in cued task-switching ERPs as a function of RT. Using this approach we modeled a switch-specific ERP component that increases with RT prior to target onset, providing evidence for switch-specific proactive control. We then used the same approach to investigate how interference following target onset is dealt with, reporting ERPs that suggest reactive control is actively used to resolve both target conflict and cue related processing.

The final chapter extends the modeling approach used in the previous two chapters, by making modifications to the algorithm. This new method was evaluated on a simulated dataset, and then applied to neural data from the mental rotation experiment to demonstrate its utility. Although results were encouraging, more testing and development is necessary to optimise this new technique.
Publications and Conferences

Publications arising from this thesis


Conference presentations arising from this thesis


Abstracts of 2010 Australian Psychology Conferences (pp. 33). Melbourne, Vic: The Australian Psychological Society.


Other conference presentations


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Statement of Contribution

I attest that Research Higher Degree candidate Alexander Lawson Provost made the following contributions to each of the papers that are submitted as part of his PhD thesis. Papers are listed below in the order they appear in this thesis, followed by an outline of co-author contribution.

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A. Provost collected the data, analysed the behavioral and neural data. He also presented the data and took a lead role in manuscript presentation. B. Johnson contributed to research design, supervised data collection on site at Macquarie University, contributed to neural data processing and contributed to manuscript preparation. S. Brown and F. Karayanidis contributed to research design and manuscript preparation. A. Heathcote contributed to research design, data analysis and manuscript preparation.


A. Provost collected the data, analysed behavioral data, presented findings and contributed to prepared manuscript. A. Heathcote and A. Provost designed and fit models and prepared manuscript.


A. Provost reprocessed and analysed the neural data, presented findings and contributed to manuscript preparation. F. Karayanidis contributed to research design, analysed behavioural data and took the lead role in manuscript preparation. S. Brown and B Paton were involved in research design and manuscript preparation and A. Heathcote contributed to research design, data analysis and manuscript preparation.


A. Provost reprocessed and analysed the neural data and behavioral data, presented findings and took a lead role in manuscript preparation. S. Jamadar contributed to analysis and manuscript preparation. S. Brown and A. Heathcote were involved in research design and manuscript preparation and F. Karayanidis contributed to research design, data analysis and manuscript preparation.
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List of Abbreviations

EEG - Electroencephalogram
ERP – Event related potential
RRN- Rotation Related Negativity
FFT – Fast Fourier transform
OPTA- Orthogonal Polynomial Trend analysis
WOPTA – Wavelet Orthogonal Polynomial Trend analysis
SNR – Signal-to-noise ratio
LBA- Linear Ballistic Accumulator
fMRI – functional Magnetic Resonance Imaging