The Christchurch Neurotechnology Research Programme

Richard Jones
Director

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The *Christchurch Neurotechnology Research Programme* came into being in February 2001 (although its had a long informal history) as a joint venture between the Canterbury District Health Board (Medical Physics & Bioengineering, Neurology), the Christchurch School of Medicine & Health Sciences of University of Otago (Medicine), and the University of Canterbury (Electrical & Computer Engineering, Psychology). The Programme is directed by Richard Jones and receives its primary funding from FRST. In May 2004, while remaining closely linked administratively to Medical Physics & Bioengineering, the Programme's physical base moved from Christchurch Hospital to the *Van der Veer Institute for Parkinson's and Brain Research* nearby at 16 St. Asaph Street.

Following post-doctoral studies in London (UK) and Hamilton (Canada), Paul Davidson re-joined the Programme in Nov 2003 as senior neuroscientist & neuroengineer in the lapse detection research programme. He also provides valuable input into several other projects in the Institute, is involved in commercialisation initiatives, and has been appointed Associate Director of the Programme.

Jason van der Staaij, software engineer, left in June last year to pursue major travels and return to his native Netherlands. His role was taken over in November by Roger Bellamy, who is also taking over the role of IT System Administrator for the Programme and Institute. In his software engineer role, Roger is primarily focused on continuing development of the sensory-motor and cognitive tests system (*SMCTests*™) which is at the centre of the off-road driving assessment system at Burwood Hospital.

A critical long-term goal of the Neurotechnology Programme is for some of the innovative products developed within the research programme to be successfully commercialised – no small task! In August last year, a contract was signed between Canterprise (the University of Canterbury's commercialisation arm) and CDHB to spearhead the commercialisation of several products developed within the Programme. Canterprise are currently reviewing several key projects and, initially, will focus on one or two products in terms of market & competitor surveys and pathways for commercialisation.

Currently, there are four primary research areas in the Neurotechnology Programme:

Detection and characteristics of behavioural micro-sleeps

Several projects underway are in progress aimed at detection of drowsiness and lapses of consciousness/responsiveness from electrophysiological data and looking more closely at the phenomenon of 'behavioural micro-sleeps'.

We have not long completed the data collection phase of a study in which we had four expert EEG readers (2 in Christchurch, 2 in Wellington) rate multichannel EEG and EOG recorded from air-traffic controllers during night shifts (data obtained by the Sleep-Wake Research Centre in Wellington). Malik Peiris (supervised by Richard, Phil Bones, and Paul Davidson) is currently analysing this data to determine inter-rater reliability of alertness rating from EEG and EOG data and to determine to what extent human experts are able to detect the presence of lapses from such data. Malik has also investigating the ability of several advanced signal processing techniques (non-linear/complexity, wavelet analysis, etc.) to detect lapses from the EEG alone. Malik has also been quantifying the characteristics of the lapsing he recorded in his study of 15 normal subjects who carried out two 1-hour sessions of continuous performance on a tracking task and in which full-head EEG eye movements and video were recorded. An important component of the characteristics and detection projects has been considerable effort from Malik, Paul and Richard to determine a best estimate of just when a person is lapsing based on video ratings and tracking performance data – this has proven to be somewhat less than straightforward!

In addition to working with Malik on various aspects of his PhD project, Paul has continued to look at developing lapse detection logarithm based around neural networks. This has produced reasonable results and Paul is continuing to explore refinements in this area as well as investigating other promising approaches to detection of such events from the EEG.

Amol Malla (supervised by Richard, Phil, Richard Green, and Paul) has just commenced his Masters project in Electrical & Computer Engineering in which he aims apply computer-vision-based techniques to develop a video-based system for detection of drowsiness, sleep, and micro-sleeps in persons undertaking extended tasks.

Prediction of on-road driving ability from off-road tests

Carrie Innes (supervised by Richard, Tim Anderson, and John Dalrymple-Alford) completed a major clinical study in December last year in which 50 referrals to the Driving and Vehicle Assessment Service (DAVAS) at Burwood Hospital were assessed off-road on a battery of driving related sensory-motor and cognitive tests (i.e., *SMCTests*) and on-road by a driving occupational therapist blinded to the off-road results. To be included in the study, referrals had to have a brain disorder, such as stroke, traumatic brain injury, neurological degeneration, age-related cognitive decline. Sixty normal control subjects have also completed the off-road section of the study, 12 of whom were assessed on-road as well. A primary objective of the study was to determine to what extent an individual's ability to drive on-road can be predicted from performance on off-road tests. Carrie has explored several predictive techniques – discriminate analysis, logistic regression, and non-causal resource analysis – and demonstrated that on-road passes and fails can be predicted with high accuracy. Carrie is close to submitting her PhD thesis on this research and has applied for post-doctoral funding so that she can continue work in this area and carry out a clinical study to further improve the prediction and to provide independent validation of the accuracy of prediction.

Prediction of post-concussion syndrome following mild traumatic brain injury

Last year, Marcus Heitger (supervised by Tim and Richard) submitted his PhD thesis on his research project looking at eye-arm, oculomotor, and neuropsychological deficits following mild closed head injury. He is still awaiting the outcome of a prolonged examination process. In the interim, a further paper on Marcus's research has appeared in *Brain Injury*. He has also submitted a major paper on his second longitudinal study. Earlier this year, he was awarded a Post-Doctoral Fellowship from the University of Otago to continue his excellent work in this area. A major achievement of his research has been to provide a more accurate means of predicting which mild CHI patients will most likely develop debilitating post-concussion syndrome and, hence, optimal focusing of limited treatment resources.

Virtual-reality-based neuro-rehabilitation tools

Daniel Myall (supervised by Richard and Tim) has recently completed the development of a sophisticated virtual-reality and 3D multi-joint arm movement measurement system based in the Movement and Virtual Environment (MoVE) Lab at the Institute. This system is about to be used in a collaborative study with Michael MacAskill to determine whether VR can be used as a neuro-rehabilitation tool to help improve, for example, arm function in patients with Parkinson's disease. Daniel will also be using data recorded from this study to validate an improved computational model of the human brain he is developing. He will do this by determining the extent to which his model can predict complex arm movements in normal subjects and in patients with Parkinson's disease.
