2019 Sensorimotor Satellite Meeting

Abstract Booklet

Index

Oral Presentations

Poster Presentations

— Oral Presentations —

Session 1: Brain Stimulation in Motor Control

(Session Chair: Assoc. Prof. John Semmler)

Keynote Speaker: Prof. Ulf Ziemann

Director of the Department Neurology & Stroke, and Co-Director of the Hertie-Institute for Clinical Brain Research, University of Tübingen, Germany.

Presentation topic:

"Brain-state-dependent stimulation of human motor cortex. New windows into physiology and therapy"

Abstract:

Major advancements in neuro-technology now allow to record and analyze activity of the human brain in real-time non-invasively by EEG. This information of instantaneous brain activity can be used to trigger non-invasive brain stimulation (transcranial magnetic stimulation, TMS) brain-state-dependently. This is of immense conceptual importance. We have shown that μ-oscillations in human sensorimotor cortex determine fluctuations in corticospinal excitability, as measured by motor evoked potential (MEP) size. The positive peak of the μ-oscillation is associated with smaller MEPs (low-excitability state), whereas the negative peak of the μ-oscillation (trough) is associated with larger MEPs (high-excitability state) [Zrenner et al. 2018, Brain Stimulation 11:374-389]. If these two states are now being stimulated repetitively, in two different sessions, by high-frequency bursts (100 Hz triplets) of TMS, then the identical stimulation protocol results in long-term potentiation-like corticospinal plasticity (long-term increase in MEP size) if the high-excitability state (the negative peak of the μ-oscillation) is consistently targeted, but in a trend towards long-term depression if the low-excitability state (the positive peak of the μ-oscillation) is targeted. Therefore, the outcome of non-invasive brain stimulation depends highly significantly on the instantaneous brain state. We expect that this novel technology of EEG-informed brain-state-dependent stimulation will enable a new era of highly efficacious therapy for brain network disorders, such as stroke, Alzheimer's disease or depression.

TMS COIL ORIENTATION AND MUSCLE ACTIVATION INFLUENCE LOWER LIMB CORTICOSPINAL AND INTRACORTICAL EXCITABILITY

Brodie J Hand[1], George M Opie[1], Simranjit K Sidhu[1] and John G Semmler[1]

1. Discipline of Physiology, Adelaide Medical School, The University of Adelaide, Adelaide, Australia

Introduction: Previous research with transcranial magnetic stimulation (TMS) indicates that coil orientation (TMS current direction) and muscle state (rest or active) modify corticospinal and intracortical excitability of upper limb muscles. However, our understanding of how these factors influence the lower limb corticospinal representations remains limited. The aim of this study was to examine how variations in coil orientation and muscle activation affect corticospinal and intracortical excitability of tibialis anterior (TA), a lower leg muscle.

Methods: In 21 young (21.6 ± 3.3 years, 11 female) adults, TMS was administered to the motor cortical representation of TA in posterior-anterior (PA) and mediolateral (ML) orientations at rest and during muscle activation. Single-pulse TMS measures of motor evoked potential amplitude, in addition to resting and active motor thresholds, were used to index corticospinal output, whereas paired-pulse TMS (SICI, SICF, and LICI) was used to assess the activity of intracortical networks.

Results: For single-pulse TMS, motor thresholds and test TMS intensity were lower for ML stimulation (all $p<0.05$). In a resting muscle, ML TMS produced greater SICI ($p<0.001$) and less SICF at 1.5 and 3.0 ms (both $p<0.05$), compared with PA TMS. In contrast, when compared to PA TMS, ML TMS in an active muscle resulted in reduced SICI but increased SICF (both $p\leq0.001$).

Conclusion: ML TMS is more efficient for activation of lower limb muscles, making it a potential alternative to conventional PA TMS. Coil orientation and muscle activation influence intracortical excitability, and therefore are important considerations in TMS studies of lower limb muscles.

TEST-RETEST RELIABILITY OF SHORT-INTERVAL INTRACORTICAL INHIBITION IN THE QUADRICEPS MUSCLES

Cassio V. Ruas[1,2]; Janet L Taylor[1,2,3]; Kazunori Nosaka[1]; G. Gregory Haff[1]; Christopher Latella[1,2]

1. Centre for Exercise and Sports Science Research (CESSR), School of Medical and Health Sciences, Edith Cowan University, Joondalup, Australia
2. Neurophysiology Research Laboratory, Edith Cowan University, Joondalup, Australia
3. Neuroscience Research Australia, Randwick, Australia

Introduction: Short-interval intracortical inhibition (SICI) can be assessed using paired-pulse transcranial magnetic stimulation (TMS), and is thought to provide indices of gaba-amino-butryic-acid (GABAa) mediated inhibition. The present study investigated the reliability and variability across days of SICI measured in the quadriceps.

Methods: Fifteen participants (9M,6F; 26.6±4.4y) underwent paired-pulse TMS with a 3-ms interstimulus interval, conditioning pulses of 55-90% of active motor threshold (AMT), and a 140% AMT test pulse. Motor evoked potentials (MEPs) were recorded from the vastus lateralis (VL), rectus femoris (RF) and vastus medialis (VM) during 10% isometric contraction on two separate days. Intra-class correlation coefficient ($ICC_{2,1}$), coefficient of variation (CV%) and two-way repeated measures ANOVAs were used to determine reliability, variability and the effect of conditioning intensity across days.

Results: Maximal inhibition (conditioned:test MEP ratio: 0.66, 0.68, 0.59 for VL, RF and VM, respectively, <1 indicates inhibition) was seen at 85% AMT. Inhibition was significantly lower at 55-75% AMT (0.78-1.0, $P<0.03$) for VL, at 55-65% AMT (0.91-0.96, $P=0.002$) for RF and at 55-70% AMT (0.85-0.95, $P<0.02$) for VM. No differences were observed between days. Reliability for individual conditioning stimulus intensities ranged from poor to good ($ICC_{2,1}$=0.05-0.76, CVs=5.5-23%) for all muscles. However, SICI averaged across all intensities showed moderate reliability ($ICC_{2,1}$=0.62-0.73, CV=12.3-14.9%) for VL and VM, and poor reliability for RF ($ICC_{2,1}$=0.43, CV=12.9%).

Conclusion: SICI did not differ across days and demonstrated moderate reliability for VL and VM, but poor for RF. These factors should be considered when investigating intracortical inhibitory responses in the quadriceps.

INVESTIGATING THE NEURAL CORRELATES OF DECISION-MAKING USING TRANSCRANIAL MAGNETIC STIMULATION

Tess Nikitenko[1], Ben Sanderson[1], Rohan Puri[1], Allison Matthews[2], Andrew Heathcote[3] and Mark R. Hinder[1]

1. Sensorimotor Neuroscience and Ageing Research Laboratory, School of Medicine (Division of Psychology), College of Health and Medicine, University of Tasmania.
2. Cognitive Neuroscience Laboratory, School of Medicine (Division of Psychology), College of Health and Medicine, University of Tasmania.
3. Tasmanian Cognition Laboratory, School of Medicine (Division of Psychology), College of Health and Medicine, University of Tasmania.

Introduction: Our ability to make fast and accurate decisions is affected by prior knowledge about likelihood of possible responses, the quality of sensory evidence and efficiency of motor preparation and execution.

Methods: Fifty-one healthy adults (range: 18-47 years) responded with their left or right index fingers to rapidly decide whether a bi-colour flashing grid was comprised of more blue or orange cells. A cue indicated which response was more likely (“70% blue”; “70% orange”; 50% - neutral). Difficulty was manipulated with the dominant colour constituting 52% or 54% of the cells. Cues varied on a trial-trial basis (Exp 1; n=33) or were held constant across 160 trials (Exp 2; n=18). TMS assessed corticospinal excitability (CSE) during the cueing and decision-making period (Exp 1).

Results: Reaction times were significantly shorter in easy v. hard trials ($p<.01$) but, surprisingly, only varied between trials in which the stimulus was congruent v. incongruent to the cue in Exp 2 ($p<.01$. Accuracy was lower in hard v. easy trials, but only when stimuli were incongruent with the cue (Exp 1: $p <.001$). CSE following the cue was affected by congruency; specifically, MEPs in the hand corresponding to orange responses were elevated when an orange response was likely, compared to when a blue response was likely. However, no further CSE modulation was apparent during decision-making.

Conclusion: Behavioural results suggest that flexible cue utilisation is limited when presented with multiple concurrent alternatives, while TMS results indicate that motor pathways are mediated in expectation of a particular response.

ROLE OF EXPECTANCY IN SELECTIVE STOPPING: A BEHAVIOURAL AND NEURAL PERSPECTIVE

Rohan Puri[1] and Mark R. Hinder[1]

1. Sensorimotor Neuroscience and Ageing Laboratory, Division of Psychology, School of Medicine, College of Health and Medicine, University of Tasmania.

Introduction: Many everyday tasks require 'selective stopping', involving the rapid cancellation of one component of an action, while continuing to execute other action components, albeit in a delayed manner ('selective stop cost': SSC). However, little is known of the underlying neural mechanisms as well as the role of expectancy on selective stopping.

Methods: Twenty-eight healthy young right-handed adults (mean = 26.5 years; 19 – 41 years) responded to a bimanual 'Go' stimulus with their left and right index fingers. To assess selective stopping, a 'Stop' stimulus followed the Go stimulus on 1/3rd of the trials, requiring the cancellation of either the left, or right, response. Furthermore, to assess the role of expectancy, in some trials a pre-movement cue was provided that informed participants as to which hand would be required to stop, if indeed a stop signal was to appear. Dual-site transcranial magnetic stimulation assessed primary motor cortex (M1) corticospinal excitability (CSE) and interhemispheric inhibition (IHI) between contralateral M1s.

Results: Informative cues significantly reduced the SSC by ~ 20% (21 ms). Prior to the stop stimulus, CSE was significantly lower in the informative cue condition, but only for the dominant right hand. Following the stop stimulus, CSE was significantly lower in the left, compared to right, hand; this was accompanied by significantly greater IHI (measured at 10 ms interstimulus interval) onto the left, compared to right, hand.

Conclusion: Overall, these results suggest that expectancy influences the efficacy of selective stopping, with associated changes in motor pathways occurring in a hemisphere-specific manner.

Session 2: Brain Stimulation in Motor Activation

(Session Chair: Assoc. Prof. Kylie Tucker)

Keynote Speaker: Prof. Mark Jenkinson

Director of Structural Modelling and Analysis at the Wellcome Centre for Integrative Neuroimaging (University of Oxford) and Professor of Neuroimaging (University of Adelaide).

Presentation topic:

"Approaches for calculating biomarkers using structural and functional MRI"

Abstract:

This talk will cover widely used and newer biomarkers of changes in structure and function derived from MRI. For example, it will include, deep grey matter structural volumes, cortical thickness, VBM-style grey matter density, task-fMRI effect sizes, resting-state fMRI connectivities and fMRI spatial activation patterns. In each case the relative advantages and disadvantages will be discussed from both a statistical/image-processing and a biological perspective. Common pitfalls will be highlighted, as will the availability of standard measures and pipelines within some large, public datasets.

EFFECTS OF THE DOPAMINE D2 ANTAGONIST SULPIRIDE ON RESPONSE INHIBITION.

Dr James Coxon[1], Keri-Anne Stevens[1], Dr Patrick Cooper[1], Dr Trevor Chong[1] and Prof Mark Bellgrove[1]

1. Turner Institute for Brain and Mental Health, School of Psychological Sciences, Monash University, Melbourne, Australia.

Introduction: Cortico-basal ganglia loops and the neurotransmitter dopamine are critical for motor control, including response inhibition. In stop-signal tasks, response inhibition can be engaged proactively using advance information, or reactively, to 'slam on the brakes' following a stop-cue. Dopamine D2 receptors and the indirect cortico-basal ganglia pathway could feasibly contribute to both forms of inhibition. The aim of this study was to investigate the effect of the dopamine D2 antagonist Sulpiride on behavioural and electrophysiological signatures of proactive and reactive inhibition.

Method: In a double-blind randomised crossover study (Sulpiride/Placebo), participants (N=24) completed an anticipated response stop-signal task while electroencephalography was recorded. On each trial, advance information indicated the likelihood of a "Stop" trial (Stop 0%, Stop 25%, Stop 33%). We hypothesised that Sulpiride would increase "Go" trial response times as a function of stop-cue expectancy, and may also prolong stop-signal reaction time.

Results: There was a main effect of stop-cue expectancy ($p = .037$), but no effects that involved drug ($p > .24$). Sulpiride increased "Go" response variability ($p = .01$) and tended to prolong stop-signal reaction time ($p = .06$). A significant distinction between stop-success and stop-fail was evident in the event-related potential (P1 amplitude, $p < .001$). Drug interacted with stop-cue probability ($p = .01$), with Sulpiride decreasing P3 amplitude when stop-cues were more likely to occur (Stop 33% vs Stop 25%).

Conclusion: Although Sulpiride had subtle effects on behaviour, the electrophysiological data support a role for dopamine D2 receptors in proactive inhibition.

APPLICATION OF ONLINE TRANSCRANIAL ALTERNATING CURRENT STIMULATION SELECTIVELY MODUALTES BETA BRAIN OSCILLATIONS ASSOCIATED WITH THE RESPONSE INHIBITION NETWORK

Hakuei Fujiyama[1], Alexandra Williams[1], and Jane Tan[1]

1. Discipline of Psychology, College of Science, Health, Engineering and Education, Murdoch University, Perth, Australia

Introduction: Transcranial alternating current stimulation (tACS) is a form of non-invasive brain stimulation that uses a weak alternating electrical current to manipulate brain oscillations. When applied simultaneously to two cortical sites within a cognitive network it can potentially enhance functional connectivity between these sites. It is thought that the effectiveness of tACS is brain state-dependent, and applying a frequency targeting a particular brain oscillation that is highly relevant to a cognitive function during task performance is more beneficial than applying tACS at rest.

Methods: Here, we empirically tested the idea comparing online and offline application of dual-site tACS (1.0 mA, 20Hz) over the right inferior frontal gyrus (rIFG) and the pre-supplementary motor area (preSMA) of the response inhibition network. In a randomised double-blind sham-controlled design, 53 (21 male, age 18-35 yrs) healthy young participants performed a Stop Signal Task (SST) during (online) or after (offline) the application of tACS. Resting-state EEG was used to examine neurophysiological changes in functional connectivity.

Results: While SST performance showed no change in both active or sham stimulation, an increase in functional connectivity in the high beta frequency (21-30Hz) was observed only in the online group.

Conclusion: The results indicated that dual-site tACS has a potential to enhance functional cortical connectivity in a process specific manner, which may potentially improve relevant cortical function.

CORTICAL ACTIVATION DURING MOVEMENT PREPARATION IS ASSOCIATED WITH BOTH VOLUNTARY AND INVOLUNTARY RESPONSES DURING INTENSE ACOUSTIC STIMULATION.

An T Nguyen[1], Ottmar V Lipp[1] and Welber Marinovic[1]

1. School of Psychology, Curtin University, Perth, Australia.

Introduction: A loud acoustic stimulus (LAS) presented during movement preparation can lead to a substantial reduction in reaction time and an increase in response vigour: the StartReact effect. Although this effect was first thought to be mediated by a subcortical mechanism, empirical evidence does not allow one to rule out the involvement of cortical mechanisms. This study examined the time course of the interaction between preparatory changes in cortical areas of the brain and the manifestation of voluntary and involuntary, reflexive motor responses.

Methods: Participants (N = 23) responded to an acoustic go-signal (soft-tone or LAS) as quickly as possible in a task designed to manipulate the conditional probability of the appearance of the go-signal. The go-signal was presented paired with one out of three temporal visual cues, predictability presented 600 ms apart. The probability of the go-signal increased over time, allowing the preparatory state of the motor system for action to evolve accordingly. Electroencephalography (EEG) was recorded using a 64-channel Biosemi system.

Results: Voluntary responses were faster as the probability of the go-signal increased. EEG signals over central and auditory areas were sensitive to the conditional probability of the go-signal and, critically, the amplitude of these signals partly explains the variability of the latency of both voluntary and involuntary responses (blink-reflex) to LAS.

Conclusion: Our results indicate that movement preparation in sensorimotor areas is tuned to the conditional probability of the go-signal. These areas in turn continuously prime the circuits responsible for voluntary actions and involuntary reflexes alike.

Session 3: Neural Injury and Repair

(Session Chair: Prof. Sheila Lennon)

Keynote Speaker: Prof. Lara Boyd

Director of Brain Behaviour Laboratory, University of British Columbia, Canada.

Presentation topic:

"The Neurobiology of Recovery after Stroke: Who Responds and Why?"

Abstract:

Stroke is rapidly becoming a chronic disease. Owing to advances in acute care 80% of individuals with stroke will survive to at least 1 year. Yet advances in rehabilitation approaches have failed to keep pace. Most stroke survivors are left with significant sensorimotor deficits that impact function and quality of life. Increasing understanding of the neurobiological processes that affect recovery from stroke will lead to the development of new, effective interventions. This talk will cover what is known about neuroplastic potential after stroke with a focus on the neurophysiology of recovery. It will include a discussion of how the brain may be primed for learning and incorporate what is known about biomarkers that may be used to predict response to interventions. At the conclusion of the talk audience members will be able to:

I. Discuss potential for neuroplastic change after stroke.

II. Understand how the brain may be primed to facilitate recovery from stroke.

III. Consider which biomarkers can be used to predict recovery from, and response to interventions, after stroke.

DOES BODY AWARENESS CHANGE OVER TIME AFTER STROKE?

I. Serrada[1], B. Hordacre[1], S. L. Hillier[2]

1. School of Health Sciences, [2]Division of Health Sciences, University of South Australia

Introduction: Body awareness is formed by sensory information and is critical for motor planning. After a stroke reduced sensation is experienced by one in two individuals. However, research and rehabilitation focusing on body awareness in stroke has received little attention. We investigated whether body awareness changes over time following a stroke and if there are any relationships between body awareness and other activity and impairment-based measures.

Methods: Observational study, 96 adults (45±12.1 years) diagnosed with stroke (0-11 days) with upper (UL) or lower (LL) impairment/s in motor and/or sensory abilities. Body awareness was measured using the Body Perception Disturbance Scale (BPD-UL/LL) and Multidimensional Assessment of Interoceptive Awareness (MAIA) as well as a battery of impairment and activity-based measures to determine change in recovery over the first six months (admission, 1 month, 3 months and 6 months).

Results: For BPD-UL and LL, a significant change was found within the first month before plateauing or worsening by 6 months (p=0.000). A non-significant change/worsening was found for MAIA from one to six months (p=0.205). Further analyses showed correlations between body awareness measures, sensation, self-efficacy and upper limb impairment.

Conclusion: Change in body awareness occurs within the first month after stroke, with recovery either plateauing or worsening by 6 months. Recovery of body awareness was associated with motor impairment, sensation and self-efficacy, highlighting a need for greater insight into assessment and rehabilitation of body awareness after stroke.

MODULATION OF CORTICOSTRIATAL ACTIVITY UNDERPINS THE VOLITIONAL SUPPRESSION OF PARKINSONIAN TREMOR

Rebekah L. Blakemore[1,2], Michael R. MacAskill[1,2], Daniel J. Myall[1], and Tim J. Anderson[1,2,3,4]

1. New Zealand Brain Research Institute, Christchurch, New Zealand
2. Department of Medicine, University of Otago, Christchurch, New Zealand
3. Department of Neurology, Christchurch Hospital, Christchurch, New Zealand
4. Brain Research New Zealand Rangahau Roro Aotearoa Centre of Research Excellence, Christchurch, New Zealand

Introduction: We have previously reported that patients with Parkinson's disease (PD) can suppress their resting tremor at will, for brief periods, using conscious mental processes and muscular relaxation[1]. This volitional suppression of tremor modulated key neurophysiological characteristics of tremor without altering tonic muscle activity but the neural mechanisms underlying the phenomenon remain unclear.

Methods: Change in brain activity underlying the ability to consciously diminish tremor was examined using functional magnetic resonance neuroimaging with simultaneous accelerometry to measure tremor oscillations in the most-affected hand of 35 tremulous PD patients (on-medication). Participants completed sixteen 1-minute trials, consisting of alternating consecutive 30-second periods of resting tremor and 30-second periods of attempted tremor suppression.

Results: In 25 patients showing prominent tremor during the resting period, and in line with our previous findings, Bayesian multilevel modelling revealed that attempted tremor suppression reduced tremor amplitude (peak power) and increased the peak frequency of tremor oscillation. This suppression (contrasted with tremor at rest) was associated with increased activity of the putamen and regions in the frontal cortex including anterior cingulate (ACC) and orbitofrontal (OFC) cortices and supplementary motor area (SMA), as well as activation of the cuneus.

Conclusion: These data indicate engagement of corticostriatal circuitry during volitional suppression of tremor. Involvement of OFC and ACC, implicated in motivational processes, cognitive control, and action monitoring, together with coordinated activation of SMA[2], indicate a potentially important role for these limbic areas in top-down modulation of striatopallidal output, that may interfere with tremor circuitry[3], thereby diminishing tremor impact.

References:

1. Blakemore, R. L., MacAskill, M. R., Myall, D. J., Anderson, T. J. (2019). Volitional suppression of parkinsonian resting tremor. *Movement Disorders Clinical Practice*, *6*, 470-478.
2. Haber, S.N. (2016). Corticostriatal circuitry. *Dialogues in Clinical Neuroscience, 18,* 7-21.
3. Helmich, R.C., Hallet, M., Deuschl, G., Toni, I., & Bloem, B.R. (2012). Cerebral causes and consequences of parkinsonian resting tremor: a tale of two circuits? *Brain, 135,* 3206-3226.

BIHEMISPHERIC NEUROPLASTICITY FOLLOWING UNILATERAL ISCHAEMIC STROKE

Austin DK[1], Hordacre B[2], Brown, KE[1], McDonnell MN[2], Koblar S[3], Kleinig T[4], Graetz L[5], Greenwood RJ[1], Ridding M[2] & Rothwell JC[1].

1. Institute of Neurology, UCL, London, UK
2. Division of Health Sciences, University of South Australia, Australia
3. Adelaide Medical School, University of Adelaide
4. Robinson Research Institute, University of Adelaide
5. Department of Neurology, Royal Adelaide Hospital

Introduction: Rodent stroke models show a bihemispheric increase in dendritic sprouting and synaptogenesis over the first 10-14 days. It remains unclear whether a similar phenomenon occurs in humans and to what extend such a 'window' of plasticity corresponds to a period of enhanced recovery. We present data to support such a phenomenon in human stroke patients, using transcranial magnetic stimulation (TMS).

Methods: Data were collected at two centres, examining either ipsilesional (Adelaide) or contralesional motor cortex (London). 29 patients (average age 68.2yrs) had recording from the contralesional hemisphere at 2, 4, 6 and 26 weeks after an ischaemic stroke. 30 patients (average age 66.6yrs) had recordings from the ipsilesional hemisphere at weeks 2, 4, 8 and 26. All subjects had made a good recovery on scores of upper limb function with FMUL > 58 or ARAT > 55 after 4 weeks. Subjects received TMS in a spaced theta burst protocol to ipsilesional or contralesional M1, with change in motor evoked potentials (MEPs) over 30 minutes as a measure of neuroplastic effect. MEPs were analysed for each group separately using hierarchical linear modelling.

Results: In the ipsilesional hemisphere, there was no significant effect of WEEK or WEEK*PLASTICITY interaction. In the contralesional hemisphere there was a significant WEEK*PLASTICITY interaction ($p=0.009$ (Satterthwaite's approximation), CI 0.007 to 0.034).

Conclusions: These data represent the first neurophysiological evidence in humans for enhanced neuroplastic early (c. 4-6 weeks) post-stroke. Plasticity decreased over time in the contralesional but not ipsilesional hemisphere.

THE EFFECT OF TRANSCRANIAL DIRECT CURRENT STIMULATION ON CHRONIC NEUROPATHIC PAIN IN PATIENTS WITH MULTIPLE SCLEROSIS

Zoghi M[1], Young J[2,3], , Khan F[3], Galea MP[2,3]

1. Discipline of Physiotherapy, Department of Rehabilitation, Nutrition and Sport, School of Allied Health, La Trobe University
2. Department of Medicine, Royal Melbourne Hospital, The University of Melbourne.
3. Rehabilitation Department, Royal Melbourne Hospital, Royal Park Campus

Introduction: Patients with multiple sclerosis (MS) considered pain as one of the most important factors in their overall health-related quality of life. Pharmacologic interventions are non-specific, and at target doses may cause drowsiness and decreased capacity to carry out activities that require high executive functioning. Anodal transcranial direct current stimulation (a-tDCS) is a non-invasive technique with no or minimal side effects which can be used to decrease the pain level in this population. The aim of this study was to assess the effect of a five-day application of within-session repeated a-tDCS on neuropathic pain levels in patients with MS.

Method: A total of 30 participants were recruited in the study (n=15 in sham and active groups). A-tDCS was applied via a pair of surface electrodes (5cm x 7cm). The active and return electrodes were placed over primary motor cortex contralateral to the side of pain and the supraorbital area contralateral to the stimulated motor cortex respectively. Participants received 2 sessions of 10 minutes a-tDCS each day, 25 minutes apart for 5 consecutive days. The Visual Analogue Scale was completed at the beginning and at the end of each treatment session.

Results: The results showed that the pain level decreased significantly in active group compared to the sham group for up to 2 weeks.

Conclusion: This study shows that repeated stimulation of a-tDCS for 5 days can reduce the pain level in patients with MS. This form of non-pharmacological treatment may provide a low-risk and non-invasive option for pain relief in this population.

QUANTIFYING UPPER LIMB MOTOR IMPAIRMENT IN PEOPLE WITH PARKINSON'S DISEASE: A PHYSIOLOGICAL PROFILING APPROACH

Lewis A Ingram[1,2], Vincent Carroll[3,4], Annie A Butler[1,2], Matthew A Brodie[1,2], Simon C Gandevia[1,2] and Stephen R Lord[1,2]

1. Neuroscience Research Australia, Sydney, Australia
2. University of New South Wales, Sydney, Australia
3. NSW Health, Mid North Coast Local Health District, Australia
4. Parkinson's New South Wales, Australia

Introduction: Upper limb motor impairments, such as slowness of movement and difficulties executing sequential tasks, are common in people with Parkinson's disease (PD). However, clinical guidelines for the assessment of upper limb functioning across multiple sensorimotor domains are comparatively less developed compared to those for balance and gait in people with PD. The aim of the current study was to evaluate the validity of the upper limb Physiological Profile Assessment (PPA) as a standard clinical assessment battery in people with PD, by determining whether the tests, which encompass muscle strength, dexterity, arm stability, position sense, skin sensation and bimanual coordination can (a) distinguish people with PD from healthy controls, (b) detect differences in upper limb test domains between "off" and "on" anti-Parkinson medication states and (c) correlate with a validated measure of upper limb function.

Methods: 34 participants with PD and 68 healthy controls completed the upper limb PPA tests within a single session.

Results: People with PD exhibited impaired performance across most test domains. Based on validity, reliability and feasibility, six tests (handgrip strength, finger-press reaction time, 9-hole peg test, bimanual pole test, arm stability, and shirt buttoning) were identified as key tests for the assessment of upper limb function in people with PD.

Conclusion: The upper limb PPA provides a valid, quick and simple means of quantifying specific upper limb impairments in people with PD. It holds promise for measuring disease progression and evaluating therapies designed to improve upper limb function in people with PD.

Session 4: Neural Injury and Repair

(Session Chair: Assoc. Prof. Gabrielle Todd)

Keynote Speaker: Professor John Rothwell

Director of Physiology and Pathophysiology of Human Motor Control Laboratory, University College London, UK.

Presentation topic:

"The importance of inhibition in movement control: clues from tics in Tourette's syndrome"

Abstract:

The defining character of tics is that they can be transiently suppressed by volitional effort of will, and at a behavioural level this has led to the concept that tics result from a failure of inhibition. However, this logic conflates the mechanism responsible for the production of tics with that employed in suppressing them. Volitional inhibition of motor output could be increased to prevent the tic from reaching the threshold for expression but so far investigations of this have yielded conflicting results. Alternatively, automatic inhibition could prevent the initial excitation of the striatal tic focus. To reconcile these competing hypotheses, we examined different types of motor inhibition in a group of 19 patients with primary tic disorders (TD) and 15 healthy volunteers. We probed proactive and reactive inhibition using the conditional stop-signal task, and applied transcranial magnetic stimulation to the motor cortex, to assess movement preparation and execution. Automatic motor inhibition was assessed with the masked priming task.

Volitional movement preparation, execution and inhibition (proactive and reactive) were not impaired in TD. We speculate that these mechanisms are recruited during volitional tic suppression, and that they prevent expression of the tic by inhibiting the nascent excitation released by the tic generator. In contrast, automatic inhibition was impaired in TD patients. In the masked priming task, positive and negative compatibility effects were found for healthy controls, whereas patients with tics exhibited strong positive compatibility effects, but no negative compatibility effect indicative of impaired automatic inhibition. Patients also made more errors on the masked priming task than healthy controls and the types of errors were consistent with impaired automatic inhibition. Finally, errors associated with impaired automatic inhibition were positively correlated with tic severity. We conclude that voluntary movement preparation/generation and volitional inhibition are normal in tic disorders, whereas automatic inhibition is impaired and may contribute to the generation of tics.

RE-WIRING OF HUMAN NEUROMUSCULAR SYSTEM USING STIMULUS-INDUCED CHANGES IN MOTOR UNIT DISCHARGE PATTERN

Kemal S Türker

School of Medicine, Koç University, Istanbul, Turkey

Introduction: Classical methods used to estimate synaptic potentials in nervous system have been claimed to contain significant errors. We have studied these claims in regularly discharging motoneurons in rat brain slice preparations (1). We have proved that the classical methods such as averaged surface electromyography and peristimulus time histogram do in fact contain significant errors, and that these errors are minimized when the same data were analysed using peristimulus frequencygram (**PSF**). Using this new method, we have now aimed to re-establish synaptic potentials in human motoneurons and hence wiring diagrams connecting receptors and motor cortex to skeletal muscles.

Methods: Consenting informed volunteers took part in this study. Depending on the pathway to be examined; electrical, mechanical, laser or magnetic stimuli were used to activate the neuronal pathways and single motor unit data from a related muscle was collected to identify stimulus-induced changes using both the classical and **PSF** analyses.

Results: In this study we have discovered that:

- H-reflex induces a long lasting excitation followed by a delayed inhibition, largely unrelated to the classical knowledge (2)
- Stretch reflex activates not five but only two neuronal pathways (3)
- Cutaneous silent period lasts much longer than previously thought (4)
- Renshaw circuitries induce much stronger inhibitions than previously thought (5)
- Transcranial magnetic brain stimulation activates long-lasting excitatory and inhibitory potentials that are largely unrelated to the classical knowledge (6)

Conclusions: Since properties of inhibitory and excitatory reflex responses are widely used for diagnosis and following treatment progress in neurological diseases, it is imperative that they are determined using dependable methods. We have used PSF technique on neuronal circuitries and found a number of errors in 'previously-established' pathways. These findings have important implications as the entire wiring of human neuromuscular system may have to be re-established before using them reliably in basic research and in clinics.

References:

1. **Trends in Neuroscience**, 2005, 28:379-386.
2. **Experimental Brain Research**, 2011, 213:73-86.
3. **Journal of Neurophysiology**, 2014, 111:602-612.
4. **Journal of Electromyography and Kinesiology**, 2016, 31:104-110.
5. **Journal of Physiology**, 2019, 597(8):2185-2199.
6. **PlosOne,** 2019, **Accepted for publication**

DISCHARGE PROPERTIES OF FLEXOR HALLUCIS BREVIS DURING MAXIMAL EFFORT RAMP CONTRACTIONS

Andrew G Cresswell[1], Jeroen Aeles[1], Luke A Kelly[1], Yasuhide Yoshitake[2]

1. School of Human Movement and Nutrition Sciences, The University of Queensland, Brisbane, Australia
2. Graduate School of Science and Technology, Shinshu University, Nagano, Japan

Introduction: During gait the human foot provides leverage for the body to apply proximally generated forces to the ground. Recent evidence has shown that the intrinsic foot muscles play an important role in actively stiffening the forefoot [1]. However, little is known about the force generating properties of these muscles.

Methods: 10 participants (age: 28 ± 6 yrs.) performed an isometric flexion task with their first-toe from 0 - 100% of MVC. A fine-wire electrode was inserted into the lateral head of flexor hallucis brevis under ultrasound guidance. Electromyographic signals were amplified x1000, bandwidth- filtered (50 Hz – 5 kHz) prior to A-D conversion at 20 kHz. Toe flexion force was simultaneously recorded from a specially constructed dynamometer.

Results: A total of 36 motor units were decomposed. A wide range of recruitment thresholds (3 – 83% of MVC) and initial and peak discharge frequencies (4.8 – 16.6 Hz and 8.6 – 29.2 Hz, respectively) within and between participants were found. Discharge frequency at recruitment was substantially varied and not related to the force at which the units were recruited (r^2 = 0.11). Later recruited units generally had lower peak discharge frequencies (r^2 = 0.29).

Conclusion: The ability of the muscle to utilise both recruitment of new units up to high forces and increase discharge frequencies over a wide range appears to be in line with the various mechanical demands placed on the foot. The relationship between recruitment and discharge rate was not uniform as typically seen in muscles when decomposed from a surface signal.

[1] Farris DJ, Kelly LA, Cresswell AG, Lichtwark GA (2019). *PNAS,* 10.1073

THE LIKELIHOOD OF BAYESIAN INTEGRATION IN MOTOR PLANNING: PRECISION AND ACCURACY IN REACHING MOVEMENTS

Brendan Keane[1], Bennette Kemp[1], Eva-Maria Reuter[1], Li-Ann Leow[1], Tim Carroll[1]

1. Centre for Sensorimotor Performance, School of Human Movement and Nutrition Sciences, University of Queensland, Brisbane, Australia

Introduction: In order to make effective goal-directed movements we must first identify the spatial location of our target. Previous research has demonstrated that goal-directed movements may be biased to reflect the characteristics of recently executed movements. This bias to repeat recent actions is exaggerated when the time available to plan our upcoming actions is limited, or the context in which we must make our movements is uncertain (e.g., there has been substantial variability in previous target locations). These findings may suggest that target location is estimated using Bayesian integration of online sensory evidence (Likelihood) and previous target locations (Prior). We aimed to establish whether humans integrate sensory evidence of target location with prior target locations consistent with Bayes' rule.

Method: We manipulated the reliability of online sensory evidence, and therefore the precision of the Likelihood distribution. We predicted that the precision of available sensory evidence would be inversely related to bias magnitude. We asked participants to reach toward targets defined by distributions of visual cues with varying precision.

Results: Consistent with previous work, participants' movements were biased to reflect their recent actions (indicating the integration of the Prior distribution of target locations). However, we found no evidence to suggest that the magnitude of this bias was sensitive to the precision of the target distribution (i.e., the Likelihood distribution).

Conclusion: These results are in conflict with a strictly Bayesian account of spatial motor planning; alternatively, they may simply reflect a failure of our paradigm to manipulate the Likelihood distribution.

INTERMUSCULAR, AND NOT CORTICOMUSCULAR, COHERENCE REFLECTS SYNERGY STRUCTURE DURING ISOMETRIC UPPER LIMB TASKS

Pablo Ortega-Auriol[1,2], Winston Byblow[1,2], Thor Besier[3], and Angus McMorland[1,2]

1. Exercise Sciences, University of Auckland, Auckland, New Zealand
2. Centre for Brain Research, University of Auckland, Auckland, New Zealand
3. Auckland Bioengineering Institute, University of Auckland, Auckland, New Zealand

Introduction: Complex EMG patterns of many muscles, during a range of tasks, can be expressed as activation of a few patterns of common co-activation known as muscle synergies (MSs). Consequently, MSs have been proposed as a mechanism for reducing motor command complexity. However, neural origins of MSs have not been identified. This study assesses coherence, a measure of common input within EMG and EEG signals, during synergy-tuned isometric upper limb tasks to further elucidate the source of neural drive producing MSs.

Methods: Fourteen healthy participants performed 3-D force matching tasks with a force instrumented handle, while recording EMG from 16 upper limb muscles and 32 channels of EEG. Participants first matched 26 targets in a sphere around the starting position, from which a number of MSs were calculated. Preferred directions for each synergy were determined from the level of activation of each synergy in the different force directions. In the second, synergy-tuned task, force targets were set in the preferred directions of the extracted MSs. From this second task, MSs and corticomuscular and intermuscular coherence (IMC) were calculated.

Results: No corticomuscular coherence was observed in any condition. Above-chance IMC levels in the 10 Hz (alpha) range were found between muscles with high weights within individual synergies during both the force-ramp and hold phases of each trial. IMC levels between high-synergy-weight muscles were higher than IMC levels between a high and a low muscle synergy contributor.

Conclusion: Coherence results suggest a subcortical origin of MSs under these task conditions.

— Poster Presentations —

MODULATION OF CEREBELLAR BRAIN INHIBITION DURING ADAPTIVE LEARNING IN COINCIDENT TIMING TASK

Shinya Tanaka[1] and Kozo Funase[1]

1. Graduate School of Integrated Arts and Sciences, Hiroshima University, Hiroshima, Japan

Introduction: Role of cerebellum during adaptive learning in visuomotor task has been reported[3,4]. Meanwhile, some previous studies have showed the poor performance in patients with cerebellum disease compared to healthy subjects in interception task[1,2]. In this study, we examined the role of cerebellum during adaptive learning in coincident timing task.

Methods: We used a custom-made PC program presenting the coincident timing task similar as a baseball batting. Subjects were required to hit a ball to a given range in the center field. The bat swing was triggered by a mouse click. In pre and post sessions, a standard bat swing speed as a baseline condition was adopted. In the adaptation session, the swing speed was abruptly changed faster or slower (F or S condition), thus, subjects had to change the click timing to compensate the coincident timing errors. In the randomized condition (R condition), the swing speed unpredictably changed to one of 3 conditions described above. Using paired transcranial magnetic stimulations, we measured the cerebellar brain inhibition (CBI) at pre, during, and post adaptation. Feedback of bat swing movement was given only practice session.

Results: In both F and S conditions, subjects adapted to the temporal perturbations, and their CBI was decreased, i.e., disinhibition. No change of CBI was confirmed in R condition.

Conclusion: In the present study, we showed the disinhibition of CBI as the result of cerebellum plasticity in the temporal adaptation, as well as that in the spatial adaptation which has previously reported[4].

References:

1. Bareš M, Lungu OV, Husárová I, Gescheidt T, Predictive motor timing performance dissociates. Cerebellum 9: 124-135, 2010
2. Bares M, Lungu O, Liu T, Waechter T, Gomez CM, Ashe J, Impaired predictive motor timing in patients with cerebellar disorders. Exp Brain Res 180: 355-365, 2007
3. Galea JM, Vazquez A, Pasricha N, Orban de Xivry JJ, Celnik P, Dissociating the roles of the cerebellum and motor cortex during adaptive learning: the motor cortex retains what the cerebellum learns. Cereb Cortex 21: 1761-1771, 2011
4. Schlerf JE, Galea JM, Bastian AJ, Celnik PA, Dynamic modulation of cerebellar excitability for abrupt, but not gradual, visuomotor adaptation. J. Neurosci 32: 11610-1617, 2012

ACUTE HYPOXIC EXPOSURE INCREASES PERCEPTION OF FATIGUE PRIOR TO AFFECTING VOLUNTARY ACTIVATION DURING MAXIMAL CONTRACTIONS

Daniel J Mckeown[1] and Justin J Kavanagh[1]

1. Menzies Health Institute Queensland, Griffith University, Gold Coast, Queensland, Australia

Introduction: Although reducing blood oxygen saturation (S_pO_2) can cause rapid changes in exercise performance, few studies have examined the direct consequences hypoxia has on the development of fatigue in the motor system. The purpose of this study was to examine how severe acute hypoxia affects an individual's ability to voluntarily activate muscle, as well as the individual's perception of fatigue during maximal elbow flexions.

Methods: Fourteen individuals (23 ± 2.2 yr) were exposed to a hypoxia and a sham intervention. S_pO_2 was titrated over 15 min and remained at 80% S_pO_2 during testing. Motor performance was assessed before titration (Pre), 0 hr, 1 hr, and 2 hr after titration. At each time point brief unfatigued elbow flexor MVCs were performed, followed by sustained 20 s MVCs to induced fatigue. Motor point superimposed and resting twitches were obtained from the biceps brachii to calculate level of voluntary activation (VA), and ratings of perceived fatigue were obtained with a modified CR-10 Borg scale.

Results: In fresh muscle there was no difference in VA between sham and hypoxia. During fatiguing contractions, the perception of fatigue was significantly greater for the hypoxia condition at 0 hr ($p = 0.04$), 1 hr ($p = 0.007$), and 2 hr ($p < 0.001$) compared to sham. VA remained unaffected by hypoxia until the 2 hr timepoint, where VA in the fatigued muscle decreased by 7% compared to sham ($p = 0.002$).

Conclusion: Our results suggest that acute hypoxia alters an individual's perception of fatigue compared to their actual ability to activate muscle during fatiguing maximal contractions.

AGE-RELATED CHANGES IN GABA-MEDIATED INHIBITION WITH FATIGUING SINGLE JOINT EXERCISE

Lavender A Otieno[1], John G Semmler[1] and Simranjit K Sidhu[1].

2. Discipline of Physiology, Adelaide Medical School, The University of Adelaide, Adelaide, Australia

Introduction: Fatiguing intermittent single-joint exercise reduces short- (SICI) and long-(LICI) interval intracortical inhibition in young adults. Furthermore, age-related differences between SICI and LICI have been reported previously. However, age-related changes in SICI and LICI with fatigue is yet to be established and forms the primary aim of this study.

Methods: In 15 young (22.8 ± 3.5 years) and 15 older (69 ± 5.3 years) adults, SICI (2 ms interstimulus interval; ISI) and LICI (100 ms ISI) was measured in a resting first dorsal interosseous muscle before and after a 15 min sustained submaximal contraction at 25% EMG.

Results: There was no change in SICI post fatigue compared to baseline in both young and older adults ($P = 0.4$). Although there was no change in LICI post fatigue in younger adults ($P = 1.0$), LICI was reduced in older adults post fatigue ($P < 0.05$).

Conclusion: Contrary to studies that have implemented intermittent fatiguing contractions, there was no change in SICI and LICI in the current study in young adults following a sustained submaximal contraction. This suggests that GABA modulation may be task dependent. Furthermore, a greater reduction in LICI in older adults suggests a possible age-related compensatory mechanism in order to maximise force output during fatigue.

ENHANCED AVAILABILITY OF SEROTONIN INCREASES PERCEIVED FATIGUE AND MODULATES THE CORTICAL SILENT PERIOD DURING SUSTAINED LOW-INTENSITY ELBOW FLEXIONS

Jacob R Thorstensen[1], Janet L Taylor[2,3], Murray G Tucker[4], and Justin J Kavanagh[1]

1. Menzies Health Institute Queensland, Griffith University, Gold Coast, Australia
2. School of Medical and Health Sciences, Edith Cowan University, Perth, Australia
3. Neuroscience Research Australia, Sydney, Australia
4. Mental Health, Drugs and Alcohol Service, Barwon Health, University Hospital Geelong, Geelong, Victoria, Australia

Introduction: Enhanced availability of serotonin exacerbates central fatigue that occurs during fatiguing maximal effort contractions. However, it is not known if serotonin release has a pronounced effect on central fatigue during submaximal contractions over longer time periods. Hence, the current study assessed the effect that enhanced availability of serotonin has on prolonged low-intensity contractions.

Methods: Fifteen individuals (22.3 ± 2.1 yr) ingested the serotonin reuptake inhibitor paroxetine in a double-blinded, placebo-controlled, repeated-measures design. Participants performed a low-intensity (15% of maximal voluntary contraction, MVC) isometric elbow flexion for 30 min. Throughout the protocol, brief MVCs were performed and muscle responses to transcranial magnetic stimulation (TMS) of the motor cortex, electrical stimulation of the brachial plexus, and electrical stimulation of the elbow flexors were obtained. Ratings of perceived elbow flexor fatigue (CR-10 scale) were also obtained throughout the sustained submaximal elbow flexion.

Results: Paroxetine did not influence maximal torque or voluntary activation of the biceps brachii during brief MVCs performed throughout the 30 min low-intensity contraction. However, enhanced availability of serotonin progressively increased the perception of fatigue throughout the contraction (p = 0.005), and shortened the biceps silent period elicited via motor cortical stimulation during brief MVCs (p = 0.011) and during the 15% MVC contraction (p = 0.003).

Conclusion: Although motor performance was unaffected, perceived fatigue was greater and intracortical inhibitory activity was reduced following the enhancement of serotonin availability. Rather than directly influencing motor pathways, serotoninergic activity during low-intensity contractions may indirectly affect motor performance via changes in cortical activity.

DOSE DEPENDENCY AND RELIABILITY OF THE ONLINE EFFECT OF TRANSCRANIAL DIRECT CURRENT STIMULATION ON CORTICOSPINAL EXCITABILITY

Carolyn Berryman[1], Brenton Hordacre[2], Mitchell Goldsworthy[1], Michael C Ridding[2]

1. School of Medicine, The University of Adelaide, Adelaide, Australia
2. School of Health Sciences, University of South Australia, Adelaide, Australia

Introduction: The after effect of transcranial direct current stimulation (tDCS), is extremely variable both between and within individuals and remains a barrier to greater uptake of tDCS use [1, 2]. To help reduce the variability in after effects, we may need a greater understanding of the online effects of tDCS on corticospinal excitability. This study aimed to establish whether the online effects of tDCS on corticospinal excitability are: (1) influenced by tDCS intensity; (2) reliable between sessions.

Methods: Twenty seven adults (26.07 +/- 8.03 years) underwent two sessions of brain stimulation. Motor evoked potentials (MEPs) were measured during tDCS at nine different intensities (400 microamperes (μA) to 2000 μA, in 200 μA steps), and a sham condition, delivered in randomised order. Baseline corticospinal excitability was measured at the beginning and the end of each session.

Results: There was a significant effect of intensity $F(9,6251) = 5.31$, $p < .000$ on corticospinal excitability. The largest excitatory effects were found at 400, 1800 and 2000 μA. There was a significant effect of the order of intensity delivery $F(9, 6251) = 1.99$, $p = .036$ with higher corticospinal excitability at order 5 and 6. There was no effect of session.

Conclusion: Our results provide moderate evidence of an excitatory online effect of anodal tDCS that is related to the intensity of stimulation. Furthermore, we found evidence for the effect of the order of intensity delivery, raising the possibility that priming factors or temporal factors may influence excitability changes resulting from tDCS application.

References

1. Nitsche, M.A. and W. Paulus, *Excitability changes in duced in the human motor cortex by weak transcranial direct current stimulation.* Journal of Physiology, 2000. **527**(3): p. 633-639.
2. Nitsche, M., et al., *Modulating parameters of excitablity during and after transcranial direct current stimulaton of the human motor cortex.* Journal of Physiology, 2005. **568**: p. 291-303

USE OF TRANSCRANIAL MAGNETIC STIMULATION TO TEST VOLUNTARY ACTIVATION OF THE KNEE EXTENSOR MUSCLES

James L. Nuzzo[1,2], David S. Kennedy[3], Harrison T. Finn[1], Janet L. Taylor[1,4]

1. Neuroscience Research Australia, Randwick, Australia

2. School of Medical Sciences, University of New South Wales, Sydney, Australia
3. Graduate School of Health, University of Technology Sydney, Sydney, Australia
4. School of Medical and Health Sciences, Edith Cowan University, Perth, Australia

Introduction: Transcranial magnetic stimulation (TMS) has been used to examine changes in voluntary activation (VA) of knee extensor muscles with fatigue. However, the validity of this technique remains uncertain. The degree to which TMS might inadvertently activate the antagonist hamstrings (HS) motor area and reduce the superimposed twitch of the knee extensors has not been properly evaluated.

Methods: In 13 healthy individuals, electrical stimulation of sciatic nerve branches was used to evoke maximal M-waves (Mmax) of medial HS. Electrical stimulation of the femoral nerve was used to evoke Mmax of vastus lateralis (VL) and superimposed twitches of knee extensors. TMS with a double-cone coil was used to evoke motor evoked potentials (MEPs) of HS and VL and superimposed twitches of knee extensors at various contraction levels and TMS intensities. Participants were seated upright with hips and knees at 90°.

Results: We obtained HS Mmax in 12 of 13 participants (mean [SD]: 9.8 [2.8] mV). Commonly, HS MEPs during maximal contractions were too big (16.5 [10.3] %Mmax) and/or VL MEPs during moderate-level contractions were too small (51.4 [11.9] %Mmax) for TMS to provide a valid estimate of the resting twitch (107.9 [37.3] Nm) compared to the resting twitch from femoral nerve stimulation (178.9 [34.9] Nm).

Conclusion: In many individuals, TMS is not a valid technique for assessing VA of knee extensor muscles. It activates too many antagonist motoneurones and/or too few agonist motoneurones to accurately estimate the resting twitch. Nevertheless, rigorous inclusion criteria might render the technique valid in select individuals.

CORTICAL EXCITABILITY FOR RESTING MUSCLE AND ACTIVE MUSCLE IS ENHANCED WITH THE BLOCKADE OF MUSCARINIC RECEPTORS

Lisa Dempsey[1] and Justin J Kavanagh[1]

1. Menzies Health Institute Queensland, Griffith University, Gold Coast, Australia

Introduction: The cholinergic system plays a critical role in human movement, where the blockade of muscarinic receptors in the CNS affects the excitability of motor cortical networks [1]. However, it is unknown if muscle activation influences these TMS responses, and if spinal motoneurone excitability contributes to altered responses.

Methods: Ten healthy individuals (22 ± 2 yr) were randomly administered a placebo, or 20 mg promethazine (Phenergan), in 2 testing sessions. Single pulse transcranial magnetic stimulation (TMS) was applied to the motor representation of abductor digiti minimi (ADM) to obtain motor evoked potentials (MEP). F-waves were obtained from the ADM via electrical stimulation of the ulnar nerve (30 stimulations at 0.5 Hz). Normalised MEPs and F-waves were obtained from resting muscle, after a 10 s 50% MVC, and after a 10 s MVC.

Results: A main effect of drug was identified for MEP area ($p < 0.001$) where the MEP was significantly greater for the antimuscarinic condition compared to the placebo condition. A main effect of contraction intensity was also identified for MEP area ($p = 0.008$) where the MEP was greater for the 50% MVC intensity compared to the 0% MVC and MVC intensity. No drug by contraction interaction was identified for MEP area, and no differences were found for F-wave persistence or area for any condition.

Conclusion: Antimuscarinic effects were only observed for the cortical TMS measures. Cholinergic pathways modulate cortical inhibition, and the antimuscarinic drug used in this study potentially suppressed inhibitory mechanisms in the motor cortex.

References

1. Di Lazzaro, V., et al. (2000). Muscarinic receptor blockade has differential effects on the excitability of intracortical circuits in the human motor cortex. Experimental Brain Research. 135(4):455-61.

A PROPOSAL TO INVESTIGATE THE CONTRIBUTION OF PERIPHERAL IMMUNE ACTIVATION TO CORTICOMOTOR EXCITABILITY.

Carolyn Berryman[1], G. Lorimer Moseley[2], Mitchell Goldsworthy[1], Michael C Ridding[2], John Semmler[3], Nigel Rogasch[1], Mark Hutchinson[4]

1. School of Medicine, The University of Adelaide, Adelaide, Australia
2. School of Health Sciences, University of South Australia, Adelaide, Australia
3. School of Physiology, The University of Adelaide, Adelaide, Australia
4. Centre for Nanoscale Biophotonics, The University of Adelaide, Adelaide, Australia

Introduction: Transcranial magnetic stimulation (TMS) is widely used in clinical and research settings. It has direct effects on neuronal excitability, but the overall effects are also likely to be due to other factors. One factor is the contribution that glial cell activation makes to neuronal excitability. Glial cell activation is not routinely considered in the outcomes of TMS studies because there is no manner of reliably measuring their activity. We aim to use a general immune challenge to investigate whether there are differences in corticomotor excitability and intracortical inhibition during an immune challenge and whether these differences are correlated to cognitive function.

Methods: A randomised, 2 way crossover, double-blind, placebo-controlled trial is planned. Healthy participants will complete a demographic survey, cognitive tests, baseline blood tests, a pain history and be baseline tested for hyperalgesia, and response to single and double pulsed TMS (short interval intracortical inhibition (SICI) and intracortical facilitation (ICF)). Participants will then be injected with either the influenza vaccination or saline. Sixteen to twenty four hours later (time of peak immune activation), the participant will return for repeat measures and a plasticity induction procedure (continuous theta burst stimulation (cTBS)). After a three week washout period, participants will return for the opposite condition.

Results: A linear mixed model with fixed effects of group (saline and vaccine) and time (4 levels) will be used to compare differences in corticomotor excitability and intracortical inhibition between groups. Correlation between cognitive function and intracortical inhibition will be assessed using a correlation matrix.

A COMPARISON OF CORTICOSPINAL TRACT INTEGRITY METRICS AS A BIOMARKER OF UPPER LIMB BEHAVIOUR IN CHRONIC STROKE

Ian Kakoschke[1] and Brenton Hordacre[1]

1. School of Health Sciences, University of South Australia, Adelaide, Australia

Introduction: Stroke is a leading cause of disability. Neurophysiological biomarkers have substantial value in guiding selection of appropriate rehabilitative therapy to ensure maximal recovery. For the upper-limb, corticospinal tract (CST) integrity is associated with impairment and recovery potential. However, there are several metrics used to quantify CST integrity. Therefore, the purpose of this study was to compare magnetic resonance imaging and transcranial magnetic stimulation markers of CST integrity and determine their association with upper-limb behaviour in chronic stroke.

Methods: In 41 chronic stroke survivors (30 male; age 64.7±10.7 years; time since stroke 4.1±3.2 years) participated. Transcranial magnetic stimulation of the ipsilesional motor cortex was performed to obtain motor evoked potential (MEP) status. Structural and diffusion magnetic resonance imaging were performed to obtain measures of CST lesion load, weighted-CST lesion load, maximal cross-sectional lesion overlap and fractional anisotropy of the CST. Upper-limb behaviour was assessed using the Fugl-Meyer, Action Research Arm Test and grip strength. A principle component analysis was performed to obtain a primary behavioural measure.

Results: Fractional anisotropy asymmetry index of the contralesional and ipsilesional CST was strongly associated with upper-limb behaviour (rho=-0.622, $p<0.001$), as was MEP status (U=67, $p=0.002$). CST lesion load ($p=0.201$), weighted-lesion load ($p=0.171$) and maximal cross-sectional lesion overlap ($p=0.107$) were not significantly associated with upper-limb behaviour.

Conclusion: Our results suggest that the strongest markers of upper-limb behaviour in chronic stroke are Fractional anisotropy of the CST and MEP status. These neurophysiological markers of CST integrity may have clinical value in understanding upper-limb recovery following stroke.

THE HIDDEN HAND IS PERCEIVED CLOSER TO MIDLINE: A PERCEPTUAL ERROR THAT DOES NOT DRIFT OVER TIME

Martin E Héroux[1], Hassan G Qureshi[1], Alex Rana[1], Graham K Kerr[2], Annie Butler[1] and Simon C Gandevia[1]

1. Neuroscience Research Australia, Randwick, Australia
2. Queensland University of Technology, Brisbane, Australia

Introduction: To date, no study has systematically assessed errors in perceived hand location across the horizontal workspace and over time (sometimes termed 'proprioceptive drift') using purely proprioceptive-based measures (i.e. no pointing or reaching).

Methods: In Experiment 1 (n=30, mean age 29 years), participants reported perceived location of their right index finger when placed 10, 20 or 30 cm on either side of the body midline (3 trials each, order randomised). In Experiment 2 (n=30, mean age 27 years), participants reported perceived location of their right index finger when placed 10 cm on either side of midline with either no delay between *pre* and *post* periods or a 3 min delay (5 measures in each period).

Results: Participants perceived their right hand closer to the body midline than it actually was, and this error increased linearly with distance from midline [slope 0.77 (0.74 to 0.81), mean (95% CI)]. Participants made smaller errors when the right hand was in the contralateral workspace [mean difference 2.13 cm (1.57 to 2.69)]. Over 3 min, there was little to no proprioceptive drift on the ipsilateral (-0.47 cm [-1.11 to 0.17]) or contralateral side (-0.44 cm [- 1.12 to 0.24]).

Conclusion: Participants made systematic perceptual errors immediately after hand placement. Because of their magnitude, these errors may contribute to errors in motor planning when visual feedback is not available. However, errors do not drift over time, suggesting a relatively stable (but distorted) representation of where our limbs are located in the horizontal workspace.

REMOTE VOLUNTARY CONTRACTION AND MENTAL STRESS INCREASE SUSTAINED FORCE OUTPUT AND ACTIVITY OF MOTONEURONES

Christopher Latella[1,2], Matheus D Pinto[1,2], Janet L Taylor[1,2,3]

1. Centre for Exercise and Sports Science Research (CESSR), School of Health and Medical Sciences, Edith Cowan University, Joondalup, Australia
2. Neurophysiology Research Laboratory, Edith Cowan University, Joondalup, Australia
3. Neuroscience Research Australia, Randwick, Australia

Introduction: Following tendon vibration, sustained muscle forces (tendon vibration reflex) may indicate the activation of persistent inward currents (PICs) in motoneurones. In particular, PICs promote repetitive motoneurone firing and are thought to be modulated by serotonin and noradrenaline. We investigated PIC activity with simultaneous remote voluntary contraction (serotonin), or mental stress (noradrenaline) of knee extensors (KE).

Methods: Healthy adults (n=12 [exp 1], n=11 [exp 2]) received vibration (100 Hz, 33 s) with superimposed muscle stimulation (20 Hz, 5×2-s) of KE. In experiment one, vibration and stimulation were applied during control, handgrip, or ankle dorsiflexion at 35% maximal force. In experiment two, participants read random numbers aloud (control) or performed mental arithmetic (stress; counting backwards by 13). Mean force and surface electromyography (EMG; vastus lateralis) over 0.5 s immediately (T0), and 3 s (T3) after the end of vibration were analysed.

Results: In experiment one, sustained force was greater at T0 (3.5%-4.6% of maximum, $p=0.006$) and T3 (3.3%-3.7%, $p=0.008$) with remote contraction (hand or ankle) compared to control. EMG was also higher with remote contraction (all $p<0.005$) at both T0 (3.2%-4.5% of maximum) and T3 (3.1%-3.4%). In experiment two, force was greater with mental stress than control at T0 (1.5%, $p=0.023$) and T3 (0.9%, $p=0.022$), as was EMG (T0: 1.8%, $p=0.002$; T3: 1.1%, $p=0.012$).

Conclusion: Remote voluntary contraction and mental stress increase the sustained force and EMG in KE muscles. This increase suggests that PIC activity is modulated by both serotonin and noradrenaline release onto motoneurones during different tasks.

THE CONTRIBUTION OF NECK PROPRIOCEPTIVE INPUTS TO CARDIOVASCULAR RESPONSES DURING ORTHOSTASIS.

Nobuhiro Watanabe[1] and Barbara I Polus[2,3]

1. Research Scientist, Department of Autonomic Neuroscience, Tokyo Metropolitan Institute of Gerontology
2. College of Science Engineering and Health, RMIT University
   Corresponding Author: bipolus11@gmail.com

Introduction: Vestibulo-sympathetic reflexes contribute to stable cardiovascular conditions during changing postures. The central nervous system (CNS) must differentiate between movements of the head only and whole-body movements [1] [2]. Here we report on the contribution of neck proprioceptive inputs on cardiovascular responses during orthostasis testing the hypothesis that an alteration in rate of resting discharge of dorsal neck muscle spindle afferents impacts the vestibulo-sympathetic reflex response during orthostasis.

Methods: Blindfolded participants lay supine on a tilt table. Dorsal neck muscles were conditioned to putatively leave dorsal neck muscle spindles mechanically sensitive or not, increasing or decreasing spindle afferent resting discharge respectively. The table was then tilted up 20 degrees (HUT). Beat-to-beat blood pressure (BP), heart rate (HR) and finger blood flow were continuously measured.
Results: In response to HUT following flexion conditioning (low spindle afferent discharge), HR did not change while BP decreased by 10% at 10 ($p<0.001$) and 15 ($p<0.002$) seconds. Following extension conditioning (high spindle afferent discharge) HR increased by 10% at 5 ($p<0.001$), 10 ($p<0.002$) and 15 ($p<0.004$) seconds and BP did not change. Finger blood flow reduced immediately after HUT for both forms of muscle conditioning.

Conclusion: Immediate responses (within 15 seconds) of HR and BP to HUT depended on the relative level of spindle afferent discharge - high levels associated with appropriate cardiovascular adjustments. In this same time frame, the vestibulo-sympathetic reflex contributes to blood pressure control during orthostasis [3]. We conclude that neck proprioceptive inputs participate synergistically with the vestibulo-sympathetic reflex during orthostasis.

References:

1. Gdowski, G.T. and R.A. McCrea, *Neck proprioceptive inputs to primate vestibular nucleus neurons.* Experimental brain research, 2000. 135(4): p. 511-526.
2. Bolton, P.S., E. Hammam, and V.G. Macefield, *Neck proprioceptors contribute to the modulation of muscle sympathetic nerve activity to the lower limbs of humans.* Experimental brain research, 2014. 232(7): p. 2263-2271.
3. Tanaka, K., Abe, C., Sakaida, Y., Aoki, M., Iwata, C., Morita, H, *Subsensory galvanic vestibular stimulation augments arterial pressure control upon head-up tilt in human subjects.* Autonomic neuroscience: basic & clinical, 2012. 166(1-2): p. 66-71.

THE ROLE OF NECK MUSCLES IN THE BRAIN'S PERCEPTION OF THE DIRECTION OF MOVEMENT OF THE BODY RELATIVE TO THE HEAD-NECK

Samantha Harman[1], Matthew Wong[3], Dein Vindigni[1] and Barbara I Polus[2,3]

1. Discipline of Chiropractic, School of Health and Biomedical Sciences, RMIT University
2. Corresponding author: samantha.harman@rmit.edu.au
3.College of Science Engineering and Health, RMIT University

Introduction: Our previous research demonstrated that when dorsal neck muscle spindles are experimentally slackened correct perception of movement direction of the trunk relative to the fixed head occurs with increased speed of trunk motion relative to the speed required when dorsal neck muscle spindles were tight. This study tested the hypothesis that proprioceptive input from agonist-antagonist pairs of neck muscles is required to accurately perceive movement-direction of the body relative to the head-neck.

Methods: Seven young healthy adults lay on their side on a motorised table with their head fixed firmly. The trunk section of the table rotated about the stationary head.

The length and activation history of dorsal or ventral muscles was altered putatively leaving muscle spindles mechanically sensitive or not, thus altering the resting discharge of neck muscle spindles[i]. Table movement into flexion or extension then commenced with increasing speed. Participants indicated when they perceived their body moving and in which direction it moved.

Results: The mean speed, when motion in the correct direction was perceived, was significantly lower under conditions where the dorsal or ventral neck muscle spindles were mechanically sensitive ($p<0.001$) when compared to when either muscle's spindles were mechanically insensitive.

Conclusion: Muscle conditioning and direction of table movement that results in mechanically insensitive muscle spindles of agonist or antagonist neck muscles requires higher speed for perception of movement in the correct direction. Agonist-antagonist neck muscle pairs work cooperatively to provide ongoing proprioceptive input to the CNS to assist in updating the internal body schema.

References:

1. PROSKE, U., MORGAN, D. L. & GREGORY, J. E. 1993. Thixotropy in skeletal muscle and in muscle spindles: a review. *Prog Neurobiol,* 41**,** 705-21

BALANCING MUSCLE FORCE IN ADOLESCENT PATELLOFEMORAL PAIN

Kylie Tucker[1], Marion Crouzier[2,] Natalie Collins[3] and Francois Hug[1,2]

1. School of Biomedical Sciences, The University of Queensland, Brisbane, Australia
2. Faculty of Sport Sciences, University of Nantes, Nantes 44000, France
3. School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Australia

Introduction: We aim to determine if the balance of vastus lateralis (VL) and medialis (VM) muscle force differs in adolescents with Patellofemoral Pain (PFP) compared to healthy controls, and if this balance of force is altered during a wall-squat with force directed through the toes vs the heels.

Methods: Twenty adolescents with PFP and 20 age/sex matched controls (15±2 years) participated. Muscle force was estimated from muscle physiological cross sectional area (PCSA; volume/fascicle length) * muscle activation, where muscle activation was normalised to that obtained during maximal contractions (MVC). Muscle activation was recorded during isometric knee extension (10, 20 and 40% MVC, knee angle 60^{o}), and during wall squat with force through the toes or heels.

Results: Isometric contractions: the balance of muscle force did not differ between groups, at any contraction level (P all > 0.05). In both groups, and at all contraction levels, VL contributed approximately 66% of the total vastii muscle force. Wall-squat: the balance of muscle force did not differ between groups or between the heel and toe condition (all P > 0.6). In both groups, and both conditions, VL contributed approximately 53% of the total vastii muscle force.

Conclusion: We provide no evidence that the (im)balance of VL and VM muscle forces differ between adolescents with PFP compared to controls. The wall squat appears to balance the force generation of VM and VL compared to the isometric knee extension task, irrespective of if force is guided through the toes or heels.

ALTERED SPINE CONTROL IN ACUTE LOW BACK PAIN REVEALED USING AN UNSTABLE SITTING PARADIGM: COHERENCE BETWEEN LUMBAR SEGMENTS AND SEAT ORIENTATION

Wolbert van den Hoorn[1], Mansour Abdullah Alshehri[1,2], David M Klyne[1], Paul W Hodges[1]

1. NHMRC Centre of Clinical Research Excellence in Spinal Pain, Injury and Health, School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Australia

2. Physiotherapy Department, Faculty of Applied Medical Sciences, Umm Al-Qura University, Mecca, Saudi Arabia

Introduction: Spine control is altered in chronic low back pain (LBP). If and how control is altered during early-acute LBP is unclear. We explored this using an unstable sitting paradigm.

Methods: 130 individuals (67 females, age/height/weight: 29±8 years, 1.73±0.09m, 72.6±14.8kg) with acute LBP (<2 weeks since onset; pain-level: 5/10±2) and 72 pain-free controls (28 females, 27±7years, 1.69±0.10m, 65.1±15.3kg) participated. Participants sat as still as possible on an unstable seat fixed to a hemisphere (250mm radius) with eyes open or closed for 30-s, three times. Seat orientation, left thigh, L5-S1, L3, T12-L1, and T1 was measured with motion capture. Relative orientation was determined between the thigh and L5-S1 (Hip), L5-S1 and L3 (Lower-lumber), L5-S1 and T12-L1 (Lumbar), L3 and T12-L1 (Higher-lumbar), and T12 and L1-T1 (Thorax). Sagittal plane coordination between seat and relative segments were assessed using coherence between: 0-0.5Hz, 0.5-1Hz, 1-1.5Hz. Coherence was modelled using generalized estimating equations with BMI as a covariate, and full factorial design for Group, Segment, Vision and Frequency. Alpha level: $P<0.05$ or $P<0.01$ for post-hoc.

Results: There was a significant Group×Segment×Frequency interaction ($P>0.03$). LBP participants showed lower coherence between the Seat-Hip and Seat-Lumbar (1-1.5Hz), and Seat and Higher-lumbar (0.5-1Hz; $P<0.010$) than controls, with/without vision. Highest segmental coherence with the seat was observed for the hip (~0.6).

Conclusion: As coherence provides a coupling measure of motion between the seat and body, our data provide evidence that this is less tightly constrained in acute LBP. Pain might interfere with finer control of these segments and impact recovery.

BENEFIT OF INTENSE ACOUSTIC STIMULATION ON RESPONSE FORCE AND VIGOUR IS ENHANCED BY A PREPARATORY CONTRACTION

Aaron N McInnes[1], Ottmar V Lipp[1], Welber Marinovic[1]

1. School of Psychology, Curtin University, Perth, Australia.

Introduction: Loud acoustic stimuli supress corticospinal excitability when movement preparation is low, and increase excitability when preparation is high. The StartReact effect – characterised by early triggering and enhanced force of movements elicited by an intense sensory stimulus, may be associated with this increased excitability induced by acoustic stimuli when preparation is high. In order to determine the involvement of cortical mechanisms in the StartReact effect, we examined whether isometric preparatory contractions may increase, or decrease, the StartReact effect.

Method: Ballistic wrist flexion responses were made with and without isometric preparatory contractions in a forewarned reaction time (RT) task in Experiment 1 and an anticipatory timing task in Experiment 2. A LAS was presented simultaneously with the imperative stimulus in 20% of trials. In Experiment 1, preparatory contractions were wrist flexion of the left hand at increasing force levels. In Experiment 2, preparatory contractions were wrist flexion or extension at 10% of maximum voluntary contraction.

Results: Results show no effect of preparatory contraction force on RT, but a larger benefit in peak force and peak rate of force development by the LAS at the 10% MVC preparatory contraction condition. Preliminary EEG analyses show differences in the lateralised readiness potential between contraction conditions, and an increased inter-hemispheric phase coherence during the flexion preparatory contraction.

Conclusion: A preparatory contraction can increase preparatory activity throughout motor areas, which subsequently results in an increased engagement of motor neurons by the LAS and hence, a larger enhancement of response force and vigour by the intense stimulus.

ALPHA AND THETA OSCILLATORS DURING PHOTIC DRIVING IN MEG-EEG SIGNALS DIFFERENTIATED USING COUPLED CP DECOMPOSITION

Stephan Lau[1-3], Kristina Naskovska[4], Alexey A Korobkov[4-5], Jens Haueisen[1] and Martin Haardt[4]

1. Institute of Biomedical Engineering and Informatics, Ilmenau University of Technology, Ilmenau, Germany
2. Australian Institute for Machine Learning, School of Computer Science, The University of Adelaide, Adelaide, Australia
3. Neuroimaging and Neurostimulation Group, South Australian Health and Medical Research Institute, Adelaide, Australia
4. Communications Research Laboratory, Ilmenau University of Technology, Ilmenau, Germany
5. Institute of Radio Electronics and Telecommunications, Kazan National Research Technical University n.a. A.N Tupolev-KAI, Kazan, Republic of Tatarstan, Russia

Introduction: Brain oscillations in the alpha and theta bands and their interactions can be investigated with intermittent photic stimulation (IPS). Simultaneously acquired magnetoencephalography (MEG) and electroencephalography (EEG) data capture oscillatory signals, but are inherently multi-dimensional and exhibit coupling. This study uses a coupled tensor decomposition to extract the signal sources from MEG-EEG during IPS [1].

Methods: MEG-EEG recordings of 12 healthy participants during IPS with 13 fractions of the individual alpha frequency between 0.4 and 1.3 were performed. Each stimulation frequency was performed in 30 trains of 40 periods each, separated by 4 seconds of rest. After averaging of trains and wavelet transformation, the frequency-time-channel tensors are decomposed using the Coupled SEmi-Algebraic framework for approximate CP decomposition via SImultaneous matrix diagonalization (C-SECSI) [2-3].

Results: The component field-maps allow us to separate physiologically meaningful oscillations of visually evoked brain activity in the occipital cortex from background signals. The response amplitude resonates for stimulation frequencies in the alpha and theta bands. The frequency signatures of the components identify either an entrainment to the respective stimulation frequency or its first harmonic, or an oscillation in the alpha band or theta band. In the group analysis of both, MEG and EEG data, we observe a reciprocal relationship between alpha and theta band oscillations [3].

Conclusion: Alpha and theta band oscillators are connected, reciprocal and can be driven with IPS. The unsupervised coupled tensor decomposition using C-SECSI is a robust method for differentiating brain oscillations that can be utilised in clinical diagnostics and brain-computer-interfaces.

References:

1. Salchow C, Strohmeier D, Klee S, Jannek D, Schiecke K, Witte H, et al. (2016). Rod driven frequency entrainment and resonance phenomena. Front. Hum. Neurosci. 10, 413.
2. Naskovska K, Lau S, Aboughazala A, Haardt M, and Haueisen J. (2017). Joint MEG-EEG signal decomposition using the coupled SECSI framework: Validation on a controlled experiment. In Proc. 2017 IEEE 7th Int. Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP). 360–364.
3. Naskovska K, Lau S, Korobkov A, Haardt M, Haueisen J. Coupled CP decomposition of simultaneous MEG-EEG signals for differentiating oscillators during photic driving. In review, Frontiers in Neuroscience, 2019.