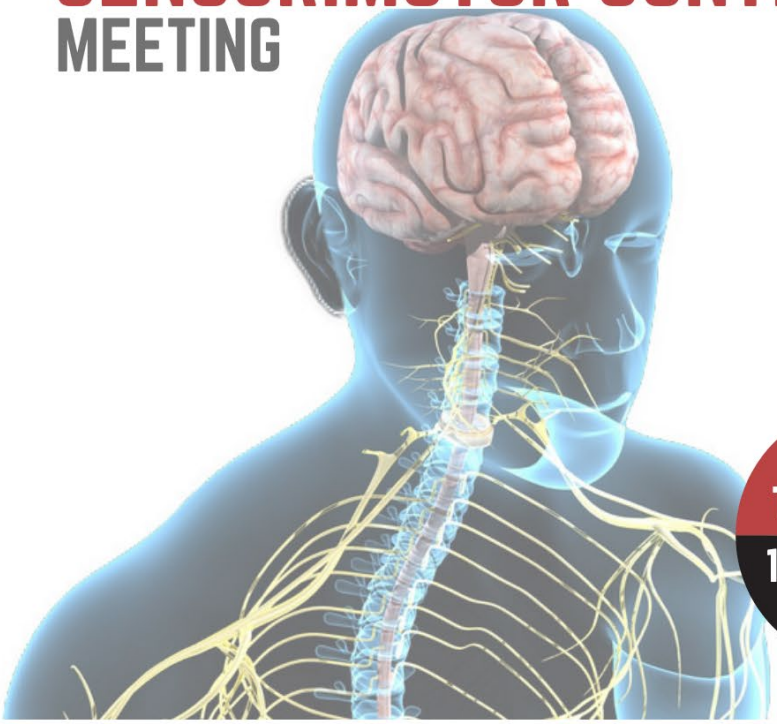
ONLINE VIA ZOOM SYDNEY 2020

SENSORIMOTOR CONTROL MEETING



THURSDAY
10 DEC 2020

PROGRAMME AND ABSTRACT BOOK

MEETING DETAILS

DATE:
THUR 10 DECEMBER 2020

TIME:
12:30PM - 5:20PM

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ONLINE 2020 SENSORIMOTOR MEETING

Thursday 10 December 2020 (via zoom)

PROGRAMME:

PLEASE NOTE: 15 minute presentation slots include 10 minutes for the talk and 5 minutes for questions

POST DOCS	**SESSION CHAIR**	Simon **GANDEVIA** *NeuRA (Neuroscience Research Australia), Sydney Australia*
12:30pm	Simon **GANDEVIA**	Opening Remarks Introduction to SESSION 1
12:35-12:50	Gregory **PEARCEY** *Northwestern University, Chicago, USA*	Antagonist tendon vibration dampens estimates of persistent inward currents in motor units of the human lower limb
12:50-1:05pm	L Eduardo **COFRÉ LIZAMA** *University of Melbourne Australia*	Sensitivity of a measure of gait stability in patients with multiple sclerosis at very early stages
1:05-1:20pm	Keonyoung **OH** *Shirley Ryan Ability Lab, Chicago USA*	Impact of sensory deficits on arm reaching performance with novel loads after stroke
1:20-1:35pm	Christopher **LATELLA** *Edith Cowan University, Perth, Australia*	Corticospinal excitability but not intracortical facilitation or inhibition is modulated with Fatigue-induced firing of quadriceps group III/IV afferents
1:35-1:50pm	Alastair **LOUTIT** *NeuRA (Neuroscience Research Australia), Sydney Australia*	Human SA-II afferents innervating the fingertip show superior torque sensitivity to other tactile afferent types
1:50-2:05pm	An **NGUYEN** *Curtin University, Perth Australia*	Is the amplitude of the error-related negativity associated with the force of an incorrect motor response?
2:05-2:20pm	Harrison **FINN** *NeuRA (Neuroscience Research Australia), Sydney Australia*	The effect of acute intermittent hypoxia on human limb motoneurone output
2:20-2:45pm	**Break**	**Break**
PHD STUDENTS	**SESSION CHAIR**	Janet **TAYLOR** *Edith Cowan University, Perth Australia*
2:45-2:50pm	Janet **TAYLOR**	Introduction to SESSION 2
2:50-3:05pm	Isabella **EPIU** *NeuRA (Neuroscience Research Australia), Sydney Australia*	Inspiratory muscle reflexes in chronic obstructive pulmonary disease
3:05-3:20pm	Taimoor **AFZAL** *Northwestern University, Chicago, USA*	Relationship between motor-unit size and recruitment threshold in the biceps brachii muscle in neurologically intact individuals

PHD STUDENTS (Cont)		
3:20-3:35pm	Samuele **CONTEMORI** *University of Queensland, Brisbane, Australia*	Express visuomotor responses in humans are modulated by cognitive expectation
3:35-3:50pm	Jacob **THORSTENSEN** *Griffith University, Gold Coast, Australia*	5-HT_2 receptor antagonism reduces corticospinal-motoneuronal output in humans
3:50-4:05pm	Harry **JORDAN** *University of Auckland, New Zealand*	The modulation of short and long-latency interhemispheric inhibition during bimanually co-ordinated movements.
4:05-4:20pm	Kelly **HO** *University of Auckland, New Zealand*	The modulation of ipsilateral motor evoked potentials in a game-based context
4:25-4:35pm	Daniel **MCKEOWN** *Griffith University, Gold Coast, Australia*	Severe acute hypoxia impairs recovery of voluntary activation after a sustained submaximal isometric elbow flexion task
4:35-4:50pm	Aaron **MCINNES** *Curtin University, Perth Australia*	Premovement inhibition reflects strategy rather than necessity before movement execution
4:50-5:05pm	Muath **SHRAIM** *University of Queensland, Australia*	The effect of lumbopelvic tilt training on motor cortical mechanisms: A single and paired-pulse TMS study
5:05-5:20pm	Celine **MAES** *KU Leuven, Belgium*	PMd GABA levels are associated with the bimanual pole test in young but not older adults
5:20pm	Simon **GANDEVIA**	Closing remarks

SESSION 1: POST DOCTORAL PRESENTATIONS

Antagonist tendon vibration dampens estimates of persistent inward currents in motor units of the human lower limb

Gregory E P **PEARCEY**[1,2,3,4], Obaid U Khurram[1,2], James A Beauchamp[1,5], Francesco Negro[6], Charles J Heckman[1,2,3,4]

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Introduction: Normal motor behaviours involve complex interactions between excitatory, inhibitory, and neuromodulatory commands. We can readily estimate persistent inward currents (PICs) of motoneurons in humans by discriminating motor unit (MU) spike trains from high-density surface electromyograms. In the cat, PICs decrease when the antagonist muscle is stretched, but the effects of inhibition on PICs has not received much attention in humans. Here, we examined the effects of antagonist vibration on estimates of PICs in the human.

Methods: MU firing patterns of the tibialis anterior (TA), soleus (SOL) and medial gastrocnemius (MG) were discriminated using high-density surface electromyography and convolutive blind source separation. We estimated PICs using the paired MU analysis technique, which quantifies discharge rate hysteresis (ΔF) by comparing the onset and offset of a high-threshold MU with respect to the firing rate of a low-threshold MU, providing an estimate of neuromodulatory drive to the MU. Participants performed isometric plantarflexion and dorsiflexion triangular contractions (10 s up and down) with a peak of 30% of maximal voluntary contraction. In half of the trials, we applied vibration (128 Hz) to the distal TA tendon (plantarflexion) or Achilles tendon (dorsiflexion).

Results: ΔF decreased in the presence of antagonist vibration in all muscles, but estimates of PICs were reduced to a greater extent in the SOL than the TA and MG.

Conclusion: These findings suggest that Ia reciprocal inhibition from the antagonist muscle can reduce MU discharge rate hysteresis, providing insights about the interactions between motor commands in normal motor behaviour.

Sensitivity of a measure of gait stability in patients with multiple sclerosis at very early stages

L. Eduardo **COFRÉ LIZAMA**[1,2], Leonid Churilov[3], and Mary P. Galea[1]

[1]*Department of Medicine and Radiology, Royal Melbourne Hospital, University of Melbourne, Parkville, Australia.*
[2]*School of Allied Health, Human Services and Sports, La Trobe University, Victoria, Australia.*
[3]*Department of Medicine. Austin Health, University of Melbourne, Parkville, Australia.*

Introduction: Most people with MS (PwMS) will develop walking problems over time, resulting in persistent and progressive impairment of mobility. However, current methods of monitoring disease progression are not sufficiently sensitive to detect subtle changes in function. As a first step to develop more sensitive measures, we aimed to determine whether gait stability using the local divergence exponent (LDE) could correctly classify PwMS at early stages (EDSS <2.5).

Methods: 25 PwMS (22.5 ± 3.5 years) and 18 healthy controls (HC; 74.1 ± 1.5 years), walked on a treadmill at 1.2 m/s for 5 minutes. Gait kinematics were recorded using a 3D motion camera system at 200hz. Feet markers were used to extract data for 250 gait cycles. 3D acceleration of sacrum and cervical markers were used to calculate gait stability using the LDE. ROC was used to determine the sensitivity of LDE classification for both markers separately.

Results: ROC area under curve for the sacrum acceleration was 0.87, and 0.79 for the cervical acceleration. Furthermore, significant differences between MS and HC were found for both sacrum (p<0.01) and cervical (p<0.01) accelerations.

Conclusion: Gait stability (LDE) using cervical and sacrum markers can correctly discriminate PwMS at early stages of the disease. These results highlight the potential of the LDE as a more sensitive gait marker in MS. Further studies will explore the ability of the LDE measured using inertial sensors in clinical settings to detect changes over time and its relationship with neural damage using MRI.

Impact of sensory deficits on arm reaching performance with novel loads after stroke

Keonyoung **OH**[1,2] and William Zev Rymer[1,2]

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[2]*Department of Physical Medicine and Rehabilitation, Northwestern University, Chicago, IL, US*

Introduction: Recent studies have highlighted the adverse impact of sensory deficits on rehabilitation outcomes after stroke, but it remains unclear how such deficits affect our capability for manipulating novel loads. Thus, this study examined which type of sensory impairment most affected our subjects' motor control while interacting with novel loads after stroke.

Methods: Ten chronic hemiparetic stroke survivors (59.67 ± 5.44 years old with stroke onset of 8.67 ± 2.98 years) performed planar reaching tasks. During the reaching task, either an inertial, elastic, or viscous load was introduced virtually using a haptic robot (HapticMaster). After 15 reaching trials, each load type was replaced with another load type. Clinical measures of joint position sense (proprioception), cutaneous pressure sensation, isometric elbow extension force, and Upper Extremity Fugl-Meyer scores were then correlated with reaching performance parameters.

Results: The impaired upper limb required a larger number of reaching trials to establish consistent, stable movements, indicating a slower motor adaptation than the intact side. Interestingly, impaired proprioception best predicted reduced speed of adaptation to the novel loads. While participants without impaired proprioception showed bell-shaped reaching velocity profiles at higher velocities, the group with overtly impaired proprioception showed larger directional errors when starting movements, and inconsistent bell-shaped velocity profiles at lower velocities.

Conclusion: The results imply that the proprioceptive deficits might be responsible for the ineffective load manipulation. The inaccurate joint position sense seems to result in inaccurate joint torques and inefficient movement targeting, with inconsistent movement corrections.

Corticospinal excitability but not intracortical facilitation or inhibition is modulated with fatigue-induced firing of quadriceps group III/IV afferents

Christopher **LATELLA**[1,2], James L Nuzzo[2,3], Matheus D Pinto[1], Janet L Taylor[1,2,3]

[1]Centre for Exercise and Sports Science Research, School of Medical and Health Sciences, Edith Cowan University, Joondalup, Perth, Western Australia, Australia;
[2]Neurophysiology Research Laboratory, Edith Cowan University, Joondalup, Perth, Western Australia, Australia;
[3]Neuroscience Research Australia, Randwick, New South Wales, Australia

Introduction: Group III/IV muscle afferents evoke sensations of work and pain during exercise and contribute to central fatigue. Although effects on cortical excitability have been demonstrated in human hand muscle during post-exercise occlusion [1], it is unclear if afferent firing from a larger muscle group has similar effects.

Methods: Eighteen adults (26.2±3.8y) performed a fatiguing 2-minute sustained maximal isometric contraction of knee extensors on two separate days (OCCLUSION or CONTROL). Maximal compound action potentials (M_{MAX}) and motor evoked potentials (MEPs) were recorded from vastus lateralis pre- and post-exercise. Intracortical facilitation (ICF; 10 ms interstimulus interval) and short-interval intracortical inhibition (SICI; 2 ms interstimulus interval) were also assessed. Test pulse intensities were set and adjusted post-exercise to maintain ~0.5 mV MEP amplitude. During OCCLUSION only, a blood pressure cuff inflated around the thigh post-exercise maintained afferent firing. Muscle pain was assessed pre- and post-exercise (0-10 scale).

Results: Pain was higher for OCCLUSION (mean±SD; 9.2±1.4 vs. 2.3±2.6, $P<0.001$). For CONTROL only, the MEP (-34.1±74.7%) and MEP/M_{MAX} ratio (-32.3±69.7%) were depressed post-exercise (both $P<0.001$) despite increased test-pulse intensity (+10.3±7.0%, $P<0.001$). ICF decreased post-exercise ($P=0.020$), but no condition by time interaction was observed ($P=0.143$). SICI did not change post-exercise for either condition ($P=0.108$).

Conclusion: Greater corticospinal excitability with group III/IV afferent firing was not explained by intracortical changes. Moreover, these observations are not consistent with changes that occur in hand muscle [1]. A major difference between studies was the high level of muscle pain induced in quadriceps compared to moderate levels in the hand.

[1]Latella C, van der Groen O, Ruas CV, Taylor JL. Effect of fatigue-related group III/IV afferent firing on intracortical inhibition and facilitation in hand muscles. J Appl Physiol. 2020;128(1):149-58.

Human SA-II afferents innervating the fingertip show superior torque sensitivity to other tactile afferent types

Alastair J. **LOUTIT**[1,2], Heather E. Wheat[3], Richard M. Vickery[1,2], Antony W. Goodwin[3], Vaughan G. Macefield[4], and Ingvars Birznieks[1,2]

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[4]*Baker Heart and Diabetes Institute, Melbourne, Australia*

Introduction: Dexterous object manipulations induce torques that are encoded by tactile afferents innervating mechanoreceptors in the skin. We investigated how torque information is encoded by human tactile afferents. This study focuses on torque encoding by slowly adapting type-II (SA-II) afferents, in particular, as this afferent type distinguishes human glabrous skin from monkeys.

Methods: Torques of different magnitudes (3.5-7.5 mNm) were applied in clockwise and anticlockwise directions to a standard central site on the fingertips of 34 subjects (median age 22, range 19-54; 19 females). Torques were applied with 2 N, 3 N, or 4 N background normal force. The median nerve was exposed in awake human subjects and single unit responses recorded from fast adapting type-I (FA-I), slowly adapting type-I (SA-I), and SA-II afferents innervating the distal segments of the fingertips.

Results: During torque loading most FA-I and SA-I afferents were excited by both torque directions, whereas SA-II afferents typically showed both excitatory and inhibitory modulation depending on torque direction. Torque responses of all three afferent types were significantly influenced by the level of background normal force. Most afferents showed decreasing torque sensitivity with increasing normal force. On average, SA-II afferents were more sensitive to lower torque magnitudes (0-3.5 mNm) and showed superior torque sensitivity in this range compared to FA-I and SA-I afferents.

Conclusion: For the first time, we have demonstrated that human SA-II afferents encode torque magnitude and direction and do it with superior sensitivity to other tactile afferents.

Is the amplitude of the error-related negativity associated with the force of an incorrect motor response?

An T **NGUYEN**[1], Kara Simpson[1], Ottmar V. Lipp[1], Welber Marinovic[1]

[1]*Curtin University, School of Psychology, Perth, Western Australia.*

Introduction: The Error-Related Negativity (ERN) refers to an enhanced frontocentral negativity elicited immediately after an incorrect response. It has been traditionally implicated in internal performance monitoring and error-detection, with some evidence suggesting that ERN amplitude may be sensitive to the force of the incorrect response. However, one limitation of previous studies is that they rely largely on categorical comparisons. In our study, we sought to examine whether a continuous relationship between ERN and motor-output can be observed.

Method: We conducted three experiments, using response-inhibition tasks, and examined trials where participants failed to suppress the motor response. In Exp. 1, we used an anticipatory stop-signal task. In Exp. 2, we modified the presented feedback, so that negative feedback was only presented to more forceful responses. In Exp. 3, a go/no-go task was used.

Results: The classic ERN effect was only evident in the go/no-go task. However, there was no clear association between ERN and force across experiments. Notably, the following positivity (termed 'error positivity') was associated with motor-output (peak-force) across all experiments —less force, larger amplitude.

Discussion: ERN does not appear to be related to force and further analyses could not explain this absence. Error positivity was related to force, but it seems to reflect 'correctness' rather than 'error'. The direction of this effect is more intuitive when conceptualised as the P300 - a overlapping stimulus-locked ERP implicated in inhibitory control which is larger when inhibition is successful. The results highlight the importance of context when interpreting temporally overlapping signals.

The effect of acute intermittent hypoxia on human limb motoneurone output

Oliver Bogdanovski[1,4], Harrison **FINN**[1,4], Matthew Crawford[2], Anna Hudson[1,4], Euan McCaughey[1,4], Janet Taylor[1,3], Jane Butler[1,4], Simon Gandevia[1,4]

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[3]Edith Cowan University, Perth, WA 6027, Australia
[4]University of New South Wales, Sydney, NSW 2052, Australia

Introduction: Increases in functional performance of limb muscles has been seen in individuals with spinal cord injury after brief exposure to short periods of breathing hypoxic and normoxic gas (AIH). Animal research suggests a mechanism at the motoneurones may be responsible. Here we aimed to determine whether limb motoneurone output is facilitated after one session of AIH in healthy, able-bodied humans.

Methods: Fourteen participants completed two interventions. The intervention was either AIH, where 1-minute intervals of hypoxic ($FiO_2 \approx 0.09$) then normoxic gases ($FiO_2 = 0.21$) were inspired for 30 minutes or sham intervention where participants inspired only normoxic gas. We measured H-reflex recruitment curves in the soleus muscle, and motor-evoked potentials (MEPs) at a constant intensity in the first dorsal interosseous muscle (FDI). Measurements were made at baseline, and 0, 20, 40, and 60 min post-intervention.

Results: During AIH, oxygen saturation decreased ($P<0.001$) and ventilation increased ($P=0.028$). After AIH, there was a leftward shift in the H-reflex recruitment curve showing lower stimulation intensities needed to evoke 5%, 50%, and 99% of H-reflex max ($P<0.03$), with significant differences at 40 min and 60 min ($P<0.04$). There was no change in the maximal H-reflex or slope after AIH. MEPs were greater after AIH, with a significant difference between days at 40 min ($P=0.003$).

Conclusion: AIH increases the excitability of the limb motoneurones with most of the effects seen 40 minutes after the AIH. AIH, therefore, appears to act to enhance reflex and supraspinal drives to the motoneurones which may allow for improved functional performance.

SESSION 2: PhD STUDENT PRESENTATIONS

Inspiratory muscle reflexes in chronic obstructive pulmonary disease

Isabella **EPIU**[1,2,3], Simon C Gandevia[1,2,3], Claire L Boswell-Ruys[1,2,3], Jane E Butler[1,2], Anna L Hudson[1,2]

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Introduction: Sudden loading of inspiratory muscles produces a potent short-latency inhibitory reflex (IR) that is prolonged in conditions with chronic respiratory loading. Our aim was to determine the integrity of IR in COPD.

Methods: Reflex response to airway occlusion was recorded in 18 participants with COPD (73 ± 11 years) and 17 healthy older controls (72 ± 6 years). At mid-inspiration, the airway was occluded for 250 ms and electromyographic activity (EMG) was recorded from scalenes bilaterally and right costal diaphragm with surface electrodes.

Results: IR incidence was higher in the COPD than control group, $P = 0.010$. There is no evidence for a difference in the mean (±SD) duration of IR between the COPD (73±37ms) and control groups (90±50ms), $P = 0.344$. Compared to pre-occlusion EMG, the median (IQR) IR trough size in scalenes was 61% (50, 70) for COPD and 59% (53, 64) for controls. In the diaphragm, IR duration was 69±26.4 ms and the IR trough size was 62% (54, 65) for the COPD group, with no diaphragm IR in controls.

Conclusion: The IR incidence was higher in COPD group than in older controls, probably due to the higher pre-occlusion EMG observed at eupnoea. This is in-line with higher neural drive required to counteract the mechanical and physiological changes in COPD. The longer IR duration in elderly COPD and control participants, compared to the duration in younger subjects from previous studies, provides further evidence that chronic loading of the respiratory muscles alters this protective inspiratory muscle reflex.

Relationship between motor-unit size and recruitment threshold in the biceps brachii muscle in neurologically intact individuals

Taimoor **AFZAL**[1], Andrew Lai[1], Nina L. Suresh[1], William Z. Rymer[1]

[1]*Department of Physical Medicine and Rehabilitation, Northwestern University, Chicago, IL, USA*

Introduction: Previous research has shown that motor-unit (MU) size in intact First Dorsal Interosseus (FDI) muscle during isometric right-index finger abduction has a linear relationship with force threshold (force at which an individual MU is recruited). However, the relationship between MU size and force threshold in Biceps Brachii (BB) muscle is unclear. The current study attempts to investigate this relationship from surface electromyography (SEMG) recording during isometric elbow flexion tasks.

Methods: Seven intact individuals performed isometric elbow flexions at 20%, 30%, 40%, 50%, and 60% of the maximum voluntary contractions with their dominant arm. SEMG signals were collected from BB muscle using a surface sensor array and decomposed. Spike-triggered averaging of the surface EMG was performed to estimate the MU sizes using the firing times of discriminated MUs as the event triggers. The force threshold of the recruited MUs was extracted from the force generated at the wrist measured with a six axis load cell.

Results: The results indicated that motor-units were recruited in an orderly manner. However, unlike the linear relationship in FDI, in BB the peak-peak amplitude of the motor-units exponentially increased with force threshold particularly at 40%, 50%, and 60% MVC levels.

Discussion: The differences in the peak-peak amplitude and force relationship between BB and FDI muscle could be due to the difference in recruitment strategies. Isometric force control in FDI depends more on the rate coding strategy compared to BB muscle which employs recruitment as the main strategy.

Express visuomotor responses in humans are modulated by cognitive expectation

Samuele **CONTEMORI**[1], Gerald E. Loeb[2], Brian D. Corneil[3,4,5], Guy Wallis[1], Timothy J.Carroll[1]

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[2]*Department of Biomedical Engineering, University of Southern California, Los Angeles, California, USA.*
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[4]*Department of Psychology, Western University, London, Ontario, Canada.*
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Introduction: Humans can generate rapid limb muscle responses that are tuned to the location of visual stimuli within 80-120ms. Given their short latency and relative inflexibility, these "express" responses may be conveyed subcortically via the tecto-reticulo-spinal pathway. Here, we tested whether cognitive expectation of the target location modifies this express visuomotor behaviour.

Methods: The pectoralis muscle activity of sixteen participants was recorded while they reached toward targets appearing randomly to the right or left of their dominant hand. The target location was unpredictable in *control* conditions, and partially predictable in *cue* conditions by extrapolating a symbolic arrow-shaped cue presented >1 second before the target and pointing toward its future location with 75% validity. Control and cue conditions were randomly intermingled.

Results: Manual reaction times were significantly shorter than control (~200ms) with valid cues (~185ms), and significantly longer when the cue was invalid (~210ms). The express muscle response prevalence and magnitude were significantly larger than control (75%, ~59μV) with valid cues (87.5%, ~65μV), and less prevalent and smaller with invalid cues (37.5%, ~50μV). Similar cue-induced consequences were observed for express response onset time (~95ms for valid cues, ~100ms for control, ~110ms for invalid cues).

Conclusion: The data show that express visuomotor responses are facilitated by cognitive expectation, and inhibited when stimuli appear at unexpected locations. This is consistent with a top-down modulation of the tecto-reticulo-spinal pathway through cortico-tectal, cortico-reticular and cortico-spinal projections. Functionally, this might subserve a priming of the express system to facilitate rapid limb movements to predictable targets.

5-HT_2 receptor antagonism reduces corticospinal-motoneuronal output in humans

Jacob R **THORSTENSEN**[1], Janet L Taylor[2,3] 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*

Introduction: Animal preparations indicate that serotonin (5-HT) release in the spinal cord facilitates motor output, particularly during strong motor activities. However, evidence for 5-HT effects during movement in humans are limited. This study examined how altering activity of 5-HT_2 receptors, which are facilitatory 5-HT receptors on motoneurons, affects human movement.

Methods: Ten healthy participants (24.2 ± 1.9 yr) ingested the 5-HT_2 antagonist cyproheptadine (8 mg) in a double-blinded, placebo-controlled, repeated-measures design. Transcranial magnetic stimulation (TMS) of the motor cortex was used to elicit motor evoked potentials (MEPs) from biceps brachii. First, stimulus-response curves (90-160% active motor threshold) were obtained during very weak contractions.. Second, to determine if 5-HT effects are scaled to the intensity of muscle contraction, TMS at a fixed intensity was applied during contractions of 20, 40, 60, 80 and 100% maximal voluntary contraction (MVC).

Results: Cyproheptadine reduced the size of MEPs across the stimulus-response curves (p = 0.045). Notably, MEP amplitude was 22.3% smaller for the cyproheptadine condition for the strongest TMS intensity. In the second protocol, cyproheptadine reduced MVC torque (p = 0.045) and lengthened the silent period during MVCs (p = 0.037), indicating that drug-effects were evident at the highest contraction intensity.

Conclusion: This study presents novel evidence that 5-HT_2 receptors are involved in human movement. Antagonism of 5-HT_2 receptors likely reduced motoneuron excitability, such that the gain of motoneurons to ionotropic inputs declined with attenuated 5-HT activity. 5-HT effects were strongest when a large number of descending inputs activated motoneurons.

The modulation of short- and long-latency interhemispheric inhibition during bimanually coordinated movements

Harry T. **JORDAN**[1,2], Miriam Schrafl-Altermatt[2,3], Winston D. Byblow[3,4], Cathy M. Stinear[1,4]

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Introduction: Bimanual coordination is essential for the performance of many everyday tasks. There are several types of bimanually coordinated movements, classified according to whether the arms are acting to achieve a single goal (cooperative) or separate goals (independent), and whether the arms are moving symmetrically or asymmetrically. Symmetric bimanual movements are thought to facilitate corticomotor excitability (CME), while asymmetric bimanual movements are thought to recruit interhemispheric inhibition to reduce functional coupling between the M1s. The influences of both movement symmetry and goal conceptualisation on interhemispheric interactions have not previously been studied together, and not during bimanually-active dynamic tasks.

Methods: The present study used transcranial magnetic stimulation (TMS) to investigate the modulation of corticomotor excitability (CME) and short- and long-latency interhemispheric inhibition (SIHI and LIHI, respectively) during dynamic rhythmic tasks requiring different types of bimanual coordination. Twenty healthy right-handed adults performed four bimanual tasks in which they held a dumbbell in each hand or a custom device between both hands while rhythmically flexing and extending their wrists symmetrically or asymmetrically. Motor evoked potentials (MEPs) were recorded from the right extensor carpi ulnaris.

Results: We found CME was greater during asymmetric tasks than symmetric tasks, but movement symmetry did not modulate SIHI or LIHI. There was no effect of goal conceptualization nor any interaction with movement symmetry for CME, SIHI or LIHI.

Conclusion: Movement symmetry and goal conceptualization do not modulate interhemispheric inhibition during dynamic bimanual tasks. These findings contradict prevailing thinking about the role of IHI in bimanual coordination.

The modulation of ipsilateral motor evoked potentials in a game-based context

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[2]*Centre for Brain Research, The University of Auckland, Auckland, New Zealand*

Introduction. Over millions of years, humans have evolved intricate control of their upper limbs. Pathways in addition to the fast-acting, monosynaptic corticospinal tract have been implicated in bimanual control and show bilateral projection across the spinal cord. Previous studies have shown that cooperative bimanual movements engage a neural linkage between the two limbs through these pathways, one such candidate being the cortico-reticulo-priopriospinal pathway. Video gaming can drive goal-directed behaviours effectively through engagement of the hedonic system. As such, video gaming may be beneficial in facilitating homebased motor rehabilitation. The influences of bimanual coordination and goal-directed movements on ipsilateral pathways have not been studied together previously.

Methods. This study used transcranial magnetic stimulation (TMS) to investigate how the excitability of the crossed and uncrossed pathways are modulated. Crossed pathway excitability was measured with single- and double-pulse TMS to assess excitability and short-interval intracortical inhibition (SICI). Uncrossed pathway excitability was investigated with high intensity paired-pulse suprathreshold TMS. Motor evoked potentials (MEPs) were recorded from the bilateral extensor carpi ulnaris (ECU).

Results. We found an increase in excitability during cooperative tasks relative to the non-cooperative task, with no effect on intracortical inhibition. Video gaming did not modulate excitability or inhibition. Furthermore, no modulation of ipsilateral MEPs by cooperative movement or video gaming was found.

Conclusion. Consistent with literature, the results indicate that cooperative movement facilitates corticomotor excitability. Further studies are needed to elucidate ipsilateral MEP characteristics during cooperative movement.

Severe acute hypoxia impairs recovery of voluntary activation after a sustained submaximal isometric elbow flexion task.

Daniel J **MCKEOWN**[1] and Justin J Kavanagh[1]

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Introduction: Although reduced blood oxygen saturation (S_pO_2) can cause rapid changes in exercise performance, few studies have examined the direct consequence that hypoxia has on the recovery of the motor system. The purpose of this study was to examine how severe acute hypoxia affects the ability to voluntarily activate muscle during, and following, a sustained submaximal isometric elbow flexion.

Methods: Fourteen individuals (25.3 ± 3.3 yr) were exposed to a hypoxia and sham condition in separate sessions. S_pO_2 was titrated to 80% S_pO_2 over 15 min, and remained at this level during testing. The contraction task began after 2 hr of exposure, and consisted of performing a 10 min isometric elbow flexion at 20% MVC. This was followed by a 6 min recovery phase. MVC torque, resting and superimposed twitches, and voluntary activation (VA, motor point and motor-cortical) were assessed every 2 min throughout the contraction protocol, and every 1 min of the recovery phase.

Results: MVC torque, twitch responses, and VA decreased similarly for the sham and hypoxia sessions during the submaximal contraction. However, during the recovery phase motor-point and TMS-evoked superimposed twitches were greater during the hypoxia session (p's < 0.05). Consequently, motor-point and TMS-based measurements of VA were lower during the recovery phase of the hypoxia session (p's < 0.05).

Conclusion: Severe acute hypoxia impairs the ability of the motor system to recover after performing sustained submaximal elbow flexions. This finding prompts further investigation into not just exercise, but exercise recovery, after exposure to hypoxic environments.

Premovement inhibition reflects strategy rather than necessity before movement execution

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Introduction: During movement preparation, corticospinal excitability is transiently reduced before movement initiation. This phenomenon has been ubiquitously observed across a range of motor tasks and as such, has been suggested to be a necessary component of movement preparation. We hypothesised that when urgency to perform a motor action is high, and there is little time to engage in normal preparatory processes, the motor system may not undergo such inhibition, whilst leaving the initiation of the motor response unchanged.

Methods: We increased the urgency of an impending motor action by shortening the foreperiod length in an anticipatory timing task. Transcranial magnetic stimulation (TMS; experiment one) or a loud acoustic stimulus (LAS; experiment two) were used to assess how corticospinal and startle-related subcortical excitability may be modulated during movement preparation.

Results: Preparatory inhibition of the corticospinal tract was absent when movement urgency was increased. Inhibition of subcortical circuits was similarly impaired by increased movement urgency. Interestingly, movement force and vigour were reduced by both TMS and the LAS when movement urgency was high, and conversely, enhanced when movement urgency was low.

Conclusion: Our findings indicate that preparatory inhibition may not be a necessary component of motor preparation. The behavioural effects we observed in the absence of preparatory inhibition were induced by both TMS and the LAS, and as such, may be attributed to the accessory stimulation provided by the coil discharge. We conclude that preparatory inhibition can be a strategy which serves to protect the prepared motor action from external interference.

The effect of lumbopelvic tilt training on motor cortical mechanisms: a single and paired-pulse TMS study

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Introduction: Evidence suggests changes in excitability of the motor cortex in response to motor skill learning. This has been mostly investigated in the upper limb. There has been limited investigation of whether corticospinal excitability and intra-cortical mechanisms change following a single session of motor learning in the lower back. In addition, it remains unclear which transcranial magnetic stimulation (TMS) methods are suited for exploring cortical changes in this region. This study aimed to: (1) compare corticospinal excitability and intra-cortical mechanisms related to activation of lumbar muscles before and after a single session of learning a precise lumbopelvic tilt motor task in healthy people; and (2) compare these measures when assessed with two types of TMS coil.

Methods: Thirty-two young participants (23.6(4.6) years) completed a single session of lumbopelvic motor learning task involving (3 blocks, 5 minutes). Single-pulse TMS measures (recruitment curve from 70%-150% of active motor threshold) and paired-pulse TMS measures (ICF, SICF, and SICI) were made before (using 2 coils: figure-of-8 and double cone) and after (double cone coil only) training.

Results: A repeated measures ANOVA showed a significant increase in corticospinal excitability after training as measured by recruitment curve intensities. However, no significant differences were found for paired-pulse measures (ICF, SICF, SICI) after training. There was no significant differences of recruitment curve parameters between measures made using the two different TMS coils

Conclusion: Increased corticospinal excitability after a single session of lumbopelvic motor learning task is observed; however, this change is not explained by changes in intra-cortical mechanisms.

PMd GABA levels are associated with the bimanual pole test in young but not older adults

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Introduction: Emerging literature points towards a role for age-related alterations in the neurochemical properties of the brain in degraded motor performance. Whereas GABAergic neurotransmission is well-studied using transcranial magnetic stimulation, little is known about the importance of baseline GABA levels for efficient motor functioning as derived from magnetic resonance spectroscopy (MRS).

Methods: In this study including 29 young (24.5 ± 4.1 years) and 30 older (67.8 ± 4.9 years) adults, bimanual performance was assessed using the bimanual pole test[1]. Furthermore, MRS-derived GABA levels were acquired from the key hubs of the motor network and dorsolateral prefrontal cortex. Finally, the correlation between GABA levels and motor performance was investigated.

Results: On a behavioural level, older adults performed significantly poorer on the bimanual pole test as compared to their younger counterparts. On a neural level, GABA levels were lower in older as compared to young adults for the primary sensorimotor cortex only. Furthermore, age affected the association between bilateral dorsal premotor cortex (PMd) GABA levels and bimanual motor performance such that in young adults only, higher GABA levels related to poorer performance.

Conclusion: The present study revealed a region-specific decrease in GABA levels in older as compared to young adults. Furthermore, the association between motor network GABA levels and motor performance was affected by age. Specifically, our results pointed towards a designated association between PMd and bimanual pole performance in young adults only. Together, these results advance our understanding of age-related alterations in GABA levels and their implications for motor performance.

[1]Ingram LA, Butler AA, Walsh LD, Brodie MA, Lord SR, Gandevia SC. The upper limb Physiological Profile Assessment : Description , reliability , normative values and criterion validity. *PLoS One*. 2019;14(6):e0218553. doi: https://doi.org/ 10.1371/journal.pone.0218553

SUPPLEMENTARY ABSTRACTS

Potency of an illusion of body ownership and body representation depends on the interaction between interoceptive awareness and attention

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Introduction Passively grasping an unseen artificial finger induces ownership over this finger and an illusory coming together of one's index fingers: a grasp illusion. Here we determine how attention and interoceptive awareness influence this illusion.

Methods: Participants passively grasped, for 3 min, an unseen artificial finger with their left index and thumb while their right index finger, located 12 cm below, was lightly clamped. Experiment 1 (n=30) investigated whether the strength of the grasp illusion (perceived index finger spacing and perceived ownership) is related to a person's level of interoceptive awareness (heartbeat perception and body sensations questionnaire). Experiment 2 (n=30) investigated the effect of attentional cueing on the grasp illusion in three conditions: (1) verbal cueing, (2) tactile cueing, and (3) watching a silent video (control).

Results: On their own, interoceptive awareness as well as verbal and tactile cueing had little to no effect on the strength of the grasp illusion. However, when we consider interoceptive awareness of individuals, verbal cueing increases the strength of the grasp illusion in those with lower interoceptive awareness. This was not a trivial effect. Across the range of interoceptive awareness in study participants, verbal cueing decreased perceived index spacing by, on average, 5.6 cm, and perceived ownership by, on average, 3 points on a 7-point Likert scale.

Conclusion: Verbally guiding a person to attend to their upper limbs increases the strength of a body ownership illusion in a way that is inversely proportioned to their level of interoceptive awareness. More broadly, these results indicate that a person's attentional focus and their interoceptive awareness influence the strength of proprioceptive illusions of body ownership and body representation.

Neuromuscular characteristics of eccentric in comparison to concentric and isometric contractions

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Introduction: Muscle can generate greater force with lower muscle activation during eccentric (ECC) than isometric (ISO) and concentric contractions (CON). However, the neuromuscular mechanisms underpinning these contractions are not fully understood. The present study compared responses to transcranial magnetic stimulation (TMS), twitch forces and voluntary drive across ECC, ISO and CON.

Methods: Sixteen participants (20-33y) performed submaximal and maximal voluntary contractions (MVCs) for ISO and isokinetic (30˚/s) CON and ECC of knee extensors. EMG was recorded from vastus lateralis. Supramaximal femoral nerve stimulation during and after MVCs evoked superimposed (ST) and resting twitches (RT) to calculate voluntary activation (VA). Maximal M-waves (M_{MAX}) were recorded. During 30% MVCs, single- and paired-pulse TMS elicited motor-evoked potentials (MEPs) and assessed short-interval intracortical inhibition (SICI). All stimuli were delivered at 75° knee flexion.

Results: MVC torque was greater ($P<0.01$) during ECC (302.6±90.0 Nm) than ISO (10.0±12.6%) and CON (22.0±14.6%). EMG during MVC was lower ($P<0.01$) for ECC than ISO (-16.5±23.2%) and CON (-43.0±33.4%). VA was lower ($P<0.01$) for ECC than ISO (-16.3±18.1%) and CON (-19.5±22.0%). ST was greater ($P<0.01$) for ECC than ISO (34.0±28.0%) and CON (48.9±22.2%). RT was greater ($P<0.02$) for ECC than CON (7.3±12%). During 30% contraction, EMG was lower ($P<0.01$) for ECC than ISO (-27.1±16.3%) and CON (-63.6±24.8%), but MEP/M_{MAX} and SICI showed no differences among ECC, ISO and CON.

Conclusion: MVC torque was greater despite lower voluntary drive for ECC than CON and ISO. Reduced muscle activation during ECC was not explained by increased intracortical inhibition or reduced corticospinal excitability.

Does spinal neuromuscular function differ between adolescents with and without idiopathic scoliosis? A review of surface EMG studies.

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Introduction: Adolescent Idiopathic Scoliosis (AIS) is a three-dimensional spinal deformity occurring between ages of 10 to 18 years. Asymmetrical spinal muscle activation may also exist in AIS. We aimed to determine the level of published evidence for asymmetrical spinal muscle activation in AIS.

Methods: PubMed and Embase databases were searched using terms: adolescent idiopathic scoliosis AND electromyography (EMG). Identified studies (n=77) were then screened for eligibility. We identified 14 studies, from which 88 EMG onset and amplitude outcomes met our inclusion/exclusion criteria. To compare EMG amplitude, between studies an EMG ratio [$(convex_{EMG})/(convex_{EMG}+concave_{EMG})$] was calculated.

Results: For EMG onset, one of two studies provided evidence of earlier muscle activation on the convex compared to concave side, particularly in progressive AIS. For EMG amplitude, 41 outcomes provided evidence of convex > concave activation (i.e. ratio >0.55), 43 outcomes supported no difference between sides, and 4 outcomes supported concave > convex activation (i.e. ratio <0.44). Sub analysis of data demonstrated that greater convex side activity was more common in single right thoracic curves (26/62 outcomes), during postural tasks (26/50), at the scoliosis curve apex (10/16) or the vertebrae below (6/12), and in progressive curves (6/7).

Conclusion: This review identified that asymmetry in muscle activity was not consistent among people with AIS. Asymmetry in spinal muscle activity appears to depend on curve type, motor task tested, recording region and curve progression status. Recommendations are provided to improve methodological quality for studies of spinal neuromuscular function in AIS.