



PROGRAM
SENSORIMOTOR CONTROL: THE JAW AND MORE
TUESDAY 27 JANUARY 2009
Finkel Theatre, John Curtin School of Medical Research

08:30 – 08.45 **JCSMR FOYER** **ARRIVALS**
COFFEE AND REGISTRATION

SESSION 1 : This session was designed to recognise the contribution of Professor Tim Miles to human sensorimotor control in general, and also to human jaw neurophysiology in particular.
Chair: Simon Gandevia

- 09.00 – 09.30** **Peter Svensson** (Aarhus University, Denmark)
Plasticity in corticomotor control of human tongue muscles - implications for oral rehabilitation
- 09.30 – 10.00** **Kemal Turker** (Ege University, Izmir, Turkey)
Reflex control of human mastication
- 10.00 – 10.30** **James Lund** (Faculty of Dentistry, McGill University, Canada)
Do muscle spindle afferents contribute to chronic muscle pain?

10.30 – 11.00 **JCSMR FOYER** **Morning Tea**

SESSION 2
Chair: Tim Miles

- 11.00 – 11.15** **Ingvars Birznieks** (POWMRI)
Evidence against the "vicious cycle" hypothesis of chronic pain: acute activation of muscle or skin nociceptors does not cause a reflex increase in fusimotor drive in humans
- 11.15 – 11.30** **Paul Sowman** (Macquarie University)
Modulation of an inhibitory jaw reflex and of pressure pain thresholds by experimental head pain in humans
- 11.30 – 11.45** **Leanne Hall** (University of Queensland)
Adaptive use of jaw muscles in anticipatory postural adjustments
- 11.45 – 12.00** **Kylie Tucker** (University of Queensland, Australia)
Changes in motor unit recruitment strategy during pain alters force direction
- 12.00 – 12.15** **John Rothwell** (UCL Institute of Neurology, London)
Intracortical inhibition in masseter motor cortex
- 12.15 – 12.30** **Julia Pitcher** (University of Adelaide)
Corticospinal development in children is influenced by gestation length and birth weight centile.



12.30 – 13.45	JCSMR FOYER	Lunch
----------------------	--------------------	--------------

SESSION 3

Chair: Mike Nordstrom

- | | |
|----------------------|--|
| 13.45 – 14.00 | Penelope McNulty (POWMRI)
Recruitment order of single motor units in the first dorsal interosseous muscle of the human hand |
| 14.00 – 14.15 | Anna Hudson (POWMRI)
Coupling between mechanical and neural behaviour in the human first dorsal interosseous muscle |
| 14.15 – 14.30 | John Marsden (University of Sydney)
Motor unit patterns of activation during fatiguing contractions |
| 14.30 – 14.45 | Andrew Cresswell (University of Queensland)
Central fatigue and changes in corticospinal responsiveness induced by submaximal lower limb exercise. |

14.45 – 15.15	JCSMR FOYER	Afternoon Tea
----------------------	--------------------	----------------------

SESSION 4

Chair: Kemal Turker

- | | |
|----------------------|--|
| 15.15 – 15.30 | David Burke (University of Sydney)
Pool problems and other issues in using H reflexes in motor control studies |
| 15.30 – 15.45 | Hiroshi Sasaki (RMIT University)
Dorsal neck muscle history, whole body tilt and reflex excitability of lower limb motoneurons |
| 15.45 – 16.00 | Trevor Allen (Monash University)
Elbow extensor fatigue produces unexpected errors in forearm position sense |
| 16.00 – 16.15 | Hiske van Duinen (POWMRI)
Control of single- and multi-digit tasks in flexion and extension of the human hand |
| 16.15 – 16.30 | Richard Fitzpatrick (POWMRI)
Postural control at the wrist: the effects of load on muscle and joint movement |

16.30	END OF MEETING
--------------	-----------------------

Session 1 – Chair: Simon Gandevia

Peter Svensson

Plasticity in Corticomotor Control of Human Tongue Muscles – Implications for Oral Rehabilitation

Peter Svensson, Department of Clinical Oral Physiology, School of Dentistry, Aarhus University, Denmark

There have been significant advances in the understanding of jaw motor control and training-induced changes in motor cortex excitability with several major contributions from Dr. Miles laboratory (1-8). Plasticity in the motor control of other cranial muscles has been less extensively investigated but a series of recent studies have employed similar behavioural and electrophysiological techniques and provided new insights into the characteristics of human tongue muscles and function (9-15). The human tongue plays an important role for normal mastication, swallowing, and speech; and tongue dysfunction e.g. congenital or following stroke is associated with impaired quality of life and a need for oral rehabilitation. Recently, we have shown that simple tongue-training tasks are associated with reversible and specific plasticity of corticomotor excitability related to the tongue muscles. Experimental manipulations with either painful stimulation or deprivation of sensory inputs have been tested and paired-pulse transcranial magnetic stimulation (ppTMS) has been used to assess short-interval intracortical inhibitory (SICI) and facilitatory (ICF) networks. Also functional magnetic resonance imaging has helped to understand the influence of tongue-training tasks on cortical and subcortical pathways. This talk will summarize some of these novel findings.

References

1. McDonnell MN, Hillier SL, Miles TS, Thompson PD, Ridding MC. *Neurorehabil Neural Repair* 2007;21:435-43.
2. Dartnall TJ, Jaberzadeh S, Miles TS, Nordstrom MA. *J Mot Behav* 2009;41:55-65.
3. Jaberzadeh S, Pearce SL, Miles TS, Türker KS, Nordstrom MA. *Clin Neurophysiol* 2007;118:1785-93.
4. Miles TS. *Arch Oral Biol.* 2007;52:347-52.
5. Miles TS. *J Dent Res* 2006;85:801-3.
6. Miles TS. *Clin Exp Pharmacol Physiol* 2005;32:128-31.
7. Miles TS, Flavel SC, Nordstrom MA. *Hum Mov Sci* 2004;23:337-49.
8. Uy J, Ridding MC, Hillier S, Thompson PD, Miles TS. *Neurology* 2003;61:982-4.
9. Svensson P, Romaniello A, Arendt-Nielsen L, Sessle BJ. *Exp Brain Res* 2003;152:42-51.
10. Svensson P, Romaniello A, Wang K, Arendt-Nielsen L, Sessle BJ. *Exp Brain Res* 2006;173:165-73.
11. Halkjaer L, Melsen B, McMillan AS, Svensson P. *Exp Brain Res* 2006;170:199-205.
12. Boudreau S, Romaniello A, Wang K, Svensson P, Sessle BJ, Arendt-Nielsen L. *Pain* 2007;132:169-78.
13. Baad-Hansen L, Blicher JU, Lapitskaya N, Nielsen JF, Svensson P. Submitted 2008
14. Ernberg M, Serra E, Baad-Hansen L, Svensson P. Submitted 2008
15. Arima T, Yanagi Y, Niddam DM, Ohata N, Minagi S, Arendt-Nielsen L, Sessle BJ, Svensson P. In progress 2009.

Kemal Türker

Reflex Control of Human Mastication

Kemal Türker, Center for Brain Research, Ege University, Izmir, Turkey

Mastication has two fundamental mechanisms: the *central pattern generator* (CPG) that sets the pattern of mastication and alternately sends action potentials to jaw opening and closing muscles; and the *peripheral control* that modulates the output of the CPG and jaw muscle motoneurons so that optimum bite forces are developed between the jaws. The peripheral control mechanism includes the cutaneous and mucosal receptors that innervate the lips and the oral mucosa, periodontal mechanoreceptors that innervate the support tissues of the tooth root and muscle spindles in the jaw muscles. These receptors monitor chewing forces and modify the activity of muscles in the jaw, tongue and cheeks in order to facilitate mastication and prevent damage to oral tissues.

To investigate their connections to motoneurons that innervate jaw muscles, we stimulate these receptors electrically and/or mechanically in adult volunteers. The responses of the jaw muscles to these stimuli are then recorded using intramuscular fine-wire and surface electrodes.

Our experiments over the last 25 years indicate the following: Periodontal mechanoreceptors not only actively contribute to chewing but also protect the teeth and supporting tissues against unexpected stimuli. Muscle spindles not only help develop bite force but with strong modulation during chewing they also allow jaws to move smoothly. Low-threshold mechanoreceptors reduce their sensitivity during chewing and hence gate out their reflex responses to weak and unimportant mechanical stimuli to allow mastication to continue smoothly. In contrast, high-threshold mechanoreceptors generate strong inhibitory effect on the jaw closers and hence protect the jaws and supporting tissues especially when jaws are coming together. These studies contribute to a better understanding of the neuronal circuitry of the masticatory system which forms a scientific base for future clinical applications.

KST holds the Marie Curie Chair of the European Union. This study is supported by NHMRC of Australia; Marie Curie Chair project (GenderReflex; MEX-CT-2006-040317) and Turkish Scientific and Technological Research Organization (Tübitak-107S029- SBAG-3556).

James Lund

Do Muscle Spindle Afferents Contribute to Chronic Muscle Pain?

James Lund and Arlette Kolta

Faculty of Dentistry, McGill University and Centre de Recherche en Sciences Neurologiques, Université de Montréal.

Ectopic firing of large-diameter sensory afferents has been linked to neuropathic pain. Spikes can arise from neuromas, but spontaneous somatic action potentials are also generated because of an injury-induced increase in the amplitude of high frequency membrane oscillations.

We postulated that similar changes occur in “non-neuropathic” forms of chronic pain. Proske and his collaborators produced evidence that muscle spindles may contribute to Delayed Onset Muscle Soreness (DOMS) in humans. They noted that spindle activation decreased pressure-induced pain in control muscles, but increased it during DOMS.

Saline of pH 5.2 mimics the pain associated with tissue acidosis and DOMS. We compared effects of acidic and normal saline injections into rat masseter muscles on retrogradely-labeled muscle spindle somata studied in brainstem slices. Thresholds for firing, membrane oscillations, and bursting were shifted to more hyperpolarized values in the experimental group. Amplitude of oscillations was also increased, and spontaneous ectopic firing occurred only in the experimental group. Changes appeared within one day after the first injection and lasted as long as the nocifensive behaviour (≈ 5 weeks).

Ectopic firing in primary afferents leads to long-term changes in the dorsal horn, but these spikes also travel antidromically. Annulo-spiral endings of muscle spindles are enriched in glutamate and express the VGLUT1 glutamate transporter, so antidromic spikes could increase glutamate release. We used immunofluorescence and lectin binding to show that small-calibre fibres containing known nociceptor markers and glutamate receptors are found close to masseter annulo-spiral endings, suggesting that glutamate released from spindle end-organs could activate adjacent nociceptors. We also showed that injections of glutamate antagonists blocked nocifensive responses caused by acidic saline.

Session 2 – Chair: Tim Miles

Ingvars Birznieks

Evidence against the "Vicious Cycle" Hypothesis of Chronic Pain: Acute Activation of Muscle or Skin Nociceptors Does Not Cause a Reflex Increase in Fusimotor Drive in Humans.

Ingvars Birznieks, Alexander Burton and Vaughan Macefield
Prince of Wales Medical Research Institute and School of Medicine, University of Western Sydney

Animal studies demonstrating that muscle pain can reflexly excite gamma motor neurones have lead to the “vicious cycle” hypothesis explaining development of chronic pain by reciprocal aggravation of muscle tone and pain. In contrast, our data obtained in humans contradicts this notion and casts doubt on whether this model is applicable in clinical settings.

Paul Sowman

Modulation of an Inhibitory Jaw Reflex and of Pressure Pain Thresholds by Experimental Head Pain in Humans

Paul Sowman, Kelun Wang and Lars Arendt-Neilsen
Macquarie Centre for Cognitive Science (MACCS), Macquarie University, Australia
Center for Sensory-Motor Interaction (SMI), Department of Health Science & Technology, Aalborg University, Denmark

In this study we used a novel device to experimentally create acute head pain. During the period of head pain, subjects’ pressure pain threshold was increased on the face, arm and leg. Additionally, there was a decrease in the size of masseteric reflex inhibition evoked by noxious electrical lip stimulation.

Leanne Hall

Adaptive Use of Jaw Muscles in Anticipatory Postural Adjustments

Leanne Hall, Sandra Brauer, and Paul Hodges
NHMRC Centre of Clinical Research Excellence in Spinal Pain, Injury and Health, School of Health and Rehabilitation Sciences, The University of Queensland

Anticipatory postural adjustments (APAs) were compared between tasks in which novel (jaw) and familiar (hand) postural supports were available. APAs changed immediately upon presentation of a new task regardless of familiarity with available supports. Further adaptation of postural strategy after the initial repetition occurred only in the novel jaw task.

Kylie Tucker

Changes in Motor Unit Recruitment Strategy during Pain Alters Force Direction

Kylie Tucker and Paul Hodges
Human Neuroscience Unit, School of Health and Rehabilitation Sciences, University of Queensland

It was hypothesised that altered motor unit (MU) recruitment would change the force vector generated by quadriceps during experimental knee pain. When force amplitude was matched, MU discharge changes were associated with ~5° angle change. When force amplitude and angle was

matched, MU discharge changes were less prevalent.

John Rothwell

Intracortical Inhibition in Masseter Motor Cortex

John Rothwell, Franca Deriu & V Ortu

UCL Institute of Neurology, Queen Square, London

Because of the difficulty in eliciting MEPs in masseter muscles at rest, it has only been possible to study short interval intracortical inhibition (SICI) during active contraction. Examined in this way, masseter SICI appear to be weak, at least compared with “standard” SICI evoked in hand muscles at rest. This forced us to re-examine SICI during contraction of hand muscles to reveal a complex interaction between inhibitory and facilitatory effects that are differentially sensitive to effects of voluntary contraction.

Julia Pitcher

Corticospinal Development in Children is influenced by Gestation Length and Birthweight Centile.

Julia Pitcher, Ryan Higgins, Ashleigh Smith, John Drysdale, Luke Schneider, Nick Burns, Ross Haslam and Jeffrey Robinson

Robinson Institute and School of Paediatrics & Reproductive Health, University of Adelaide

Preliminary findings from this study of motor cortical development in a cohort of 11-12 year old children born 25-41 weeks gestation indicate that even mildly preterm children have delayed or permanently altered cortical development. This altered development is exacerbated in children whose *in utero* growth was sub-optimal.

Session 3 – Chair: Mike Nordstrom

Penelope McNulty

Recruitment Order of Single Motor Units in the First Dorsal Interosseous Muscle of the Human Hand

Penelope McNulty, Jane Butler and Simon Gandevia
Prince of Wales Medical Research Institute

We investigated whether exceptions to the orderly recruitment of motor units during voluntary contractions could be demonstrated for single motor units in the first dorsal interosseous muscle. Intramuscular EMG was recorded for between 3-10 motor units simultaneously active during seven different tasks. Variability in the recruitment order was quantified using the shuffle index.

Anna Hudson

Coupling Between Mechanical and Neural Behaviour in the Human First Dorsal Interosseous Muscle

Anna Hudson, Janet Taylor, Simon Gandevia and Jane Butler
Prince of Wales Medical Research Institute and University of New South Wales

The neural drive to a muscle and its biomechanical properties determine the force at a joint. We hypothesised that if two muscles can contribute to force production around a joint, then the proportion of neural drive sent to each muscle would reflect the muscles' ability to produce force, i.e. its mechanical effectiveness. We tested this for index flexion force around the metacarpophalangeal joint.

John Marsden

Motor Unit Activation Strategies in Fatigue and Recovery

John Marsden, Ron Balnave and Chris Balnave.
NSW Institute of Sport and University of Sydney

We used sEMG to examine MU recruitment and rate coding strategies during fatigue and recovery from repeated dynamic contractions to a fatigue resistant level of force. The protocol identifies three pools of MU's responsible for force generation. Recruitment recovery appears complete within 4min. MVC force and firing rate remained depressed at 60min.

Andrew Cresswell

Central Fatigue and Changes in Corticospinal Responsiveness Induced by Submaximal Lower Limb Exercise.

Andrew Cresswell, BW Hoffman, Simranjit Sidhu, Tomomichi Oya, and Tim Carroll
University of Queensland, School of Human Movement Studies

In separate studies, corticospinal responsiveness was measured during sustained submaximal contractions of the triceps surae and during brief and sustained knee extensor contractions after locomotor exercise. Corticospinal responsiveness increased progressively during the sustained contractions, and locomotor exercise caused a long-lasting impairment in the capacity of the motor cortex to drive the knee extensors.

Session 4 – Chair: Kemal Türker

David Burke

Pool Problems and other Issues in using H Reflexes in Motor Control Studies

David Burke and Penelope McNulty

Institute of Clinical Neurosciences, Royal Prince Alfred Hospital, University of Sydney, and Prince of Wales Medical Research Institute, University of New South Wales

Five issues limit the use of H reflexes (i) disynaptic inhibition from Ib afferents in the test volley, (ii) homosynaptic depression at the Ia-motoneurone synapse, (iii) non-linearity of the input-output relationship for the pool, (iv) non-homogeneity in the distribution of inputs across the pool, and (v) a change in reflex gain.

Hiroshi Sasaki

Dorsal Neck Muscle History, Whole Body Tilt and Reflex Excitability of Lower Limb Motoneurons

Hiroshi Sasaki and Barbara Polus

Division of Chiropractic, School of Health Sciences, RMIT University

The influence of dorsal neck muscle length and contraction history on reflex excitability of lower limb motoneurons with and without static head-up whole body tilt was studied. A change in amplitude of the tendon jerk and H-reflex after systematically altering muscle history was only evident when the body was tilted.

Trevor Allen

Elbow Extensor Fatigue Produces Position Errors in an Unexpected Direction

Trevor Allen and Uwe Proske

Department of Physiology, Monash University.

After fatigue of elbow flexors subjects showed errors of position sense in the direction of elbow extension. Fatigue of extensors was expected to produce errors in the opposite direction. However subjects still perceived their fatigued arm to be more extended.

Hiske van Duinen

Control of Single- and Multi-Digit Tasks in Flexion and Extension of the Human Hand

Hiske van Duinen, Wei Shin Yu, Simon Gandevia

Prince of Wales Medical Research Institute

Digits of the hand cannot be controlled completely independently. This study of single- and multi-digit maximal contractions showed increased ‘spread’ of force to non-instructed digits during extension tasks but an increased ‘deficit’ in force during flexion tasks. These patterns may reflect the distribution of inhibition at motor cortical level.

Richard Fitzpatrick

Postural Control at the Wrist: The Effects of Load on Muscle and Joint Movement

John Chew and Richard Fitzpatrick

Prince of Wales Medical Research Institute

Loads with different levels of elastic stiffness were held still using the same wrist force. Ultrasound measurements of the length of the contractile and tendon elements of flexor carpi radialis show that contractile length does not reflect wrist movement and load stiffness alters the relationship between angle and tendon length.