

Summer School (2 ECTS): Neurorehabilitation – Recovery of Motor Function

Venue:
Aalborg University
Department of Health Science and Technology
Fredrik Bajers Vej 7A, room A4-108
9220 Aalborg

June 14 2010

9:00-9:15

Opening and introduction of speakers, Dejan Popović, Aalborg University, Denmark

9:15-10:30

The Specificity of Neuromuscular Adaptations, Roger Enoka, PhD, Professor and Chair, Department of Integrative Physiology, University of Colorado, Boulder, CO, U.S.A.

Summary: Voluntary actions involve a cascade of physiological processes that originate in the cerebral cortex and are manifested as an interaction between muscle torques and the constraints imposed by the surroundings. For at least the last century, physiologists have appreciated that all elements of the motor system are plastic. In the last few decades, however, it has become apparent that the adaptations evoked in the motor system by physical activity depend on the details of the stimulus. Classic examples of this specificity, which will be discussed in the lecture, include the adjustments that occur during fatiguing contractions and the adaptations that accompany strength training.

10:30-11:45

Motor learning, Herbert Heuer, IfADo, Germany

Summary: Techniques of rehabilitation are likely to benefit from principles of motor learning. A core problem of motor learning is to achieve mastery of novel relations between motor commands and the resulting movements. In healthy humans this kind of learning has been studied by various means such as modified vision of one's own limb, tools which implement novel kinematic transformations, and introduction of novel force fields. In this lecture the learning problem will be introduced and mechanisms involved in solving it will be described. Emphasis will be placed on situational conditions such as feedback and personal conditions such as age which modulate the functioning of these mechanisms.

12:00-13:00 *LUNCH*

13:15-14:30

Diseases and injuries of the CNS leading to sensory-motor impairment, Mario Manto,
Université Libre de Bruxelles, Belgium

Summary:Neurological disorders such as stroke, Parkinson's disease or trauma are commonly encountered worldwide. They are associated with variable deficits at the sensory-motor level. The burden of neurological disorders has been underestimated by traditional epidemiological studies taking into account only mortality, and not the disabilities. The characterization of the numerous deficits encountered in diseases and injuries of the CNS has greatly improved these last 3 decades, especially with the advent of accurate neuroimaging techniques and the integration of MRI with neurophysiological tools. This lecture will provide an overview of the neurological disorders impairing sensory-motor functions. The main diseases will be reviewed, with a focus on the pathogenesis of the sensori-motor deficits. The functional impacts on cerebral cortex, basal ganglia, cerebellum and spinal cord will be discussed.

14:30-15:45

Techniques to assess cortical and spinal cord plasticity, Natalie Mrachacz-Kersting, Aalborg University, Denmark

Summary:The human sensory and motor cortices as well as the spinal cord have the capacity to change as a result of alterations in sensory input, motor practice, or damage. Such changes are often likened with those in animal preparations termed long-term potentiation (LTP) and long-term depression (LTD). The challenge in human studies is to assess such changes using non-invasive techniques such as assessment of H-reflex, stretch reflex, motor evoked potentials etc. The limitations of these techniques for the quantification of plasticity in the intact human at both the spinal and cortical level will be described and discussed.

15:45-16:00 *COFFEE/REFRESHMENT*

16:00-17:15

Implantable devices for Neuromodulation, Ljubomir Manola, Boston Scientific Neuromodulation Europe, Brussels, Belgium

Summary:Neuromodulation is a therapy that modulates back to the normal state the output of a neural network which exhibits an abnormal behavior due to an impairment/abnormality¹. This is accomplished by supplying a neuromodulatory input to the neural network by an (implantable) neuromodulatory system. In electro-neuromodulation, the neuromodulatory input is achieved by electrical neurostimulation delivered by electrodes connected to an (implantable) pulse generator (neurostimulator)². Various parts of nervous system are targeted depending on desired effects and disorder to be treated – deep brain nuclei, parts of brain cortex, spinal cord, peripheral nerve or their endings³. To date, chronic neuropathic pain, angina, central motor disorders, epilepsy, urinary and psychiatric disorders are among well-established clinical indications¹.

Increasing our understanding of the nervous system and its disorders as well as effects of neurostimulation, better patient selection, building clinical evidence and advancements of technology are all helping to further expand indications and number of patients treated, with enormous potential for the future. Given the size of the market and potential for its expansion, it is not surprising that the number of interested commercial parties is increasing. This is necessarily accompanied by increasingly stringent regulatory requirements for commercialization of the implantable devices.

The presentation will provide overview of the electro-neuromodulatory therapies and systems as well as give an industry perspective.

References

- 1) www.neuromodulation.com
- 2) Bradley K. The technology: The anatomy of a spinal cord and nerve root stimulator - the lead and the power source. Pain Medicine 7: S27-S34, 2006
- 3) Stanton-Hicks M and Salamon J. Stimulation of the central and peripheral nervous system for the control of pain. J Clin Neurophysiol 14:46-62, 1997

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9:00-10:15

Robots for neurorehabilitation, Vittorio Sanguineti, University of Genova, Genova, Italy

Summary: During the last decade, robots have been used to promote the recovery of motor functions of stroke survivors. Robot therapy seems promising, but it is unclear which robot designs and which exercises are more effective. Similarly, it is unclear whether other pathologies may benefit from this technique. The lecture will review the available technologies and the design principles for rehabilitation robots. As regards exercises, I will argue that they should exploit the adaptive nature of the nervous system, promote active movement performance and include problem-solving aspects.

Another important aspect is the type and amount of the assistance provided by the robot. I will suggest that assistance should be kept to a minimum, should be tailored to the different degrees of impairment, and should adapt to changing performance. The notions of minimal assistance and adaptivity might also suggest how to extend robot therapy to other pathologies.

10:15-11:30

Suprathreshold stimulation for neurorehabilitation, Thierry Keller, Fatronik Technalia, San Sebastian, Spain

Summary: Stimulation above motor or sensory threshold is currently used in neurorehabilitation mainly for functional training. Nerves and muscles can be activated magnetically and electrically. For eliciting and executing motor functions transcutaneous (surface) electrical stimulation (TES) is the most frequently applied technique in clinical practice despite the huge efforts made to improve implantable technologies and some marginal efforts done in applying magnetic stimulation. Stimulation electrodes play an important role in interfacing the tissue with the stimulation unit. New techniques concentrate on multi-channel approaches and intelligent control for excitation and modulation of neural activity. Nevertheless, the systems need to be properly adapted to specific pathologies and need to take into account remaining neural properties and neuropathological changes that occur after an incidence affecting the motor-sensory system. The lecture will introduce main changes and effects affecting the functions that currently can be provided by electrical stimulation, provide a brief overview about the used technology and give some insights into new emerging technologies.

12:00-13:00 *LUNCH*

13:15-14:30

Nociceptive stimulation in neurorehabilitation, Ole Kæseler Andersen, Aalborg University, Denmark

Summary:

Painful stimulations can be used for activating spinal polysynaptic reflex pathways and thereby obtain an integrated motor response involving several muscles/joints. The primary application is gait rehabilitation after stroke or spinal cord injuries where electrical stimulation of individual muscles primarily focuses on muscles affecting the knee and ankle joints while hip flexion is problematic. Reflex pathways may also involve joint extension by proper selection of stimulation site and timing in the gait cycle. Normal muscle fiber recruitment is obtained during the reflex response opposite to artificial electrical stimulations of muscles. However, reflex habituation is a major challenge and forward propulsion is difficult to initiate and control despite evidence for activation of spinal stepping circuits by the sensory stimulus.

14:30-15:45

Methods for movement assessment, Michael Voigt, Aalborg University, Denmark

Assessment and analysis of human movement requires collection of kinematic and kinetic information in one two and/or three dimensions depending on the kind of movement in question, Eventually, in combination with other kind of physiological information like muscle activity (EMG) or oxygen consumption. For the purpose of movement analysis more or less complicated sensors, sensor systems and data acquisition systems have been developed which and the way these sensor systems are applied depends on the information need. Also, movement analysis has to be performed with proper attention to limitations and sources of error. A presentation of the stat of the art with in movement analysis will be given with relevant examples and advantages and shortcomings will be discussed.

15:45-16:15 *COFFEE/REFRESHMENT*

16:15-17:45 **TEST**