

HUNGARIAN SPORT SCIENCE BOOKLETS - XII.

PROGRESS IN MOTOR CONTROL X.

22-25 July, 2015 | Budapest, Hungary



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Program Book



2015

**PROGRESS IN MOTOR CONTROL X.
22-25 JULY, 2015 | BUDAPEST, HUNGARY**



PROGRAM AND ABSTRACTS

International Society of Motor Control



GENERAL INFORMATION

ORGANIZING COMMITTEE

József Laczkó, Chairman

*University of Pécs & Pázmány Péter Catholic
University and Wigner Research Centre for
Physics, Hungary*

Péter Cserhádi

*National Institute for Medical Rehabilitation,
Budapest, Hungary*

Róbert Gábrriel

University of Pécs, Hungary

Grzegorz Juras

*Academy of Physical Education, Katowicze,
Poland*

Péter Lévai

MTA Wigner Research Centre for Physics, Hungary

Mindy F. Levin

McGill University, Canada

Gábor Szóts

Hungarian Society of Sport Science, Hungary

Miklós Tóth

Hungarian Society of Sport Science, Hungary

SCIENTIFIC COMMITTEE

Richard Carson

Trinity College Dublin, Ireland

Marcos Duarte

Federal University of ABC, Sao Paolo, Brasil

Anatol G. Feldman

University of Montreal, Québec, Canada

Slobodan Jaric

*Department of Kinesiology and Applied
Physiology, University of Delaware, USA
& University of Belgrade, Serbia*

József Laczkó

*University of Pécs & Pázmány Péter Catholic
University and Wigner Research Centre for
Physics, Hungary*

Mark L. Latash

The Pennsylvania State University

Mindy F. Levin

McGill University, Canada

Mike Riley

University of Cincinnati, USA

John Rothwell

University College London, UK

Gregor Schöner

University of Bochum, Germany

ACKNOWLEDGEMENTS

International Society of Motor Control

Hungarian Society of Sport Science

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University of Pécs

Pan European Regional Committee of the International Brain Research Organization

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INVITED SPEAKERS

Andrea d'Avella

University of Messina, Messina, Italy

Peter J. Beek

VU University, Amsterdam, The Netherlands

Richard Carson

Trinity College, Dublin, Ireland

Numa Dancause

University of Montreal, Canada

Anatol G. Feldman

University of Montreal, Canada

Apostolos P. Georgopoulos

University of Minnesota, USA

Joachim Hermsdörfer

Technical University of Munich, Germany

Katja Kornysheva

Institute of Cognitive Neuroscience, University College London, UK

Jozsef Laczko

University of Pécs, Pázmány Péter Catholic University, & MTA Wigner Research Centre for Physics, Hungary

Mark L. Latash

The Pennsylvania State University, USA

Mindy F. Levin

McGill University, Canada

Winfried Mayr

Medical University of Vienna, Austria

Joseph McIntyre

Tecnalia Health Research Institute, Spain

Lee Miller

Northwestern University, Chicago, USA

Vivian Mushahwar

University of Alberta, Canada

Ferdinando A. Mussa-Ivaldi

Rehabilitation Institute of Chicago, USA

Monica Perez

University of Pittsburgh, USA

John Rothwell

University College London, UK

Robert Sainburg

The Pennsylvania State University, USA

Robert Scheidt

Marquette University, Milwaukee, WI, USA

Gregor Schöner

Ruhr University, Bochum, Germany

Jeroen Smeets

VU University, Amsterdam, The Netherlands

Elizabeth Torres

Rutgers University, USA

Patrick van der Smagt

Technical University of Munich, Germany

PROGRAM OVERVIEW

WEDNESDAY, 22 JULY

19:00 – 21:00 Welcome Reception

Place: AULA

Registration: 17:30 - 20:00

THURSDAY, 23 JULY

Room: BARTÓK

Registration: 07:00 - 17:30

08:00 – 08:30 Opening session, Opening remarks

08:30 – 12:00 Symposium 1: Neurophysiological Mechanisms of Motor Control

08:30 – 09:15 Short presentations

09:15 – 10:15 Invited speakers

10:15 – 10:30 Health Break

10:30 – 11:30 Invited speakers

11:30 – 12:00 General discussion

12:00 – 14:00 Lunch and Posters

14:00 – 17:30 Symposium 2: Learning of skilled behavior

14:00 – 14:45 Short presentations

14:45 – 15:45 Invited speakers

15:45 – 16:00 Health Break

16:00 – 17:00 Invited speakers

17:00 – 17:30 General discussion

18:00 Business meeting of the International Society of Motor Control

FRIDAY, 24 JULY**Room: BARTÓK**

Registration: 08:00 - 17:00

08:30 – 12:00 Symposium 3: Theoretical Motor Control

08:30 – 09:15 Short presentations

09:15 – 10:15 Invited speakers

10:15 – 10:30 Health Break

10:30 – 11:30 Invited speakers

11:30 – 12:00 General Discussion

12:00 – 14:00 Lunch and Posters

14:00 – 17:30 Symposium 4: Fifty years of Equilibrium Point hypothesis

14:00 – 15:00 Invited speakers

15:00 – 15:15 Health Break

15:15 – 16:15 Invited speakers

16:15 – 17:00 Special short presentations for the Fiftieth anniversary of EP

17:00 – 17:30 General discussion

19:00 – 23:30 Banquet

(Lágymányosi Ökumenikus Központ, 1117 Budapest, Magyar tudósok körútja 3.)

SATURDAY, 25 JULY**Room: BARTÓK**

Registration: 08:00 - 17:00

08:30 – 12:00 Symposium 5: Human Machine Interface

08:30 – 09:15 Short presentations

09:15 – 10:15 Invited speakers

10:15 – 10:30 Health Break

10:30 – 11:30 Invited speakers

11:30 – 12:00 General discussion

12:00 – 14:00 Lunch and Posters

14:00 – 17:30 Symposium 6: Impaired Motor Control and Rehabilitation

14:00 – 14:45 Short presentations

14:45 – 15:45 Invited speakers

15:45 – 16:00 Health Break

16:00 – 17:00 Invited speakers

17:00 – 17:30 General discussion

18:00 – 19:00 Closing and Award

PROGRAM

WEDNESDAY, 22 JULY

19:00 – 21:00 **Welcome Reception**

Place name: AULA

Registration: 17:30 - 20:00

THURSDAY, 23 JULY

Room name: BARTÓK

Registration: 07:00 - 17:30

08:00 – 08:30 **Opening session**
Opening remarks

08:30 – 12:00 **SYMPOSIUM 1: NEUROPHYSIOLOGICAL MECHANISMS OF MOTOR CONTROL**
Chair: John Rothwell

SHORT PRESENTATIONS

08:30 – 08:45 **Tino Stöckel^{1,2}, Mark R. Hinder¹**
¹Human Motor Control Laboratory, School of Medicine, University of Tasmania, Hobart, Australia;
²Sport & Exercise Psychology Unit, Dept. of Sport Science, University of Rostock, Germany
INSIGHTS INTO THE MECHANISMS MEDIATING CROSS-LIMB TRANSFER
FOLLOWING UNILATERAL BALLISTIC MOTOR LEARNING

08:45 – 09:00 **Benedikt Lauber¹, Albert Gollhofer¹, Wolfgang Taube², Martin Keller²**
¹Department of Sport Science, University of Freiburg, Freiburg, Germany;
²Department of Medicine, Movement and Sport Science, Fribourg, Switzerland
MOTOR IMAGERY OF TONIC AND BALLISTIC CONTRACTIONS ACTIVATES
DIRECT AND INDIRECT CORTICOSPINAL PATHWAYS DIFFERENTLY BUT IN A
SIMILAR WAY THAN REAL TONIC AND BALLISTIC CONTRACTIONS

09:00 – 09:15 **M. Ali Akhras^{1,2}, Gabriel Baud-Bovy¹, Francesco Nori¹**
¹Istituto Italiano di Tecnologia, Genoa, Italy;
²University of Genoa, Genoa, Italy
STIFFNESS ESTIMATION OF METACARPOPHALANGEAL JOINT OF INDEX
FINGER AND ITS RELATIONSHIP TO EXTRINSIC AND INTRINSIC MUSCLES

INVITED SPEAKERS

09:15 – 09:45 **Richard Carson**
¹Trinity College Institute of Neuroscience and School of Psychology, Trinity College Dublin, Dublin, Ireland;
²School of Psychology, Queen's University Belfast, Belfast, Northern Ireland
NEURAL PATHWAYS MEDIATING CROSS EDUCATION OF HUMAN MOTOR FUNCTION

THURSDAY, 23 JULY

Room name: BARTÓK

09:45 – 10:15 **Robert L. Sainburg**

Professor of Kinesiology and Professor of Neurology, Penn State University and Penn State College of Medicine; Editor in Chief, Journal of Motor Behavior

MODELS OF HANDEDNESS AND BRAIN LATERALIZATION PROVIDE THE BASIS FOR UNDERSTANDING IPSILESIONAL MOTOR DEFICITS IN STROKE

10:15 – 10:30 **Health Break**

INVITED SPEAKERS

10:30 – 11:00 **Monica Perez**

University of Pittsburgh, USA

NEURAL CONTROL OF GRASPING AFTER SPINAL CORD INJURY

11:00 – 11:30 **Winfried Mayr**

Medical University of Vienna, Austria

EARLY AND CONTEMPORARY APPROACHES FOR APPLICATION OF FES IN MOVEMENT REHABILITATION AFTER SPINAL CORD INJURY

11:30 – 12:00 **General discussion**

12:00 – 14:00 **LUNCH AND POSTERS**

View poster group 1

View poster group 2

14:00 – 17:30 **SYMPOSIUM 2: LEARNING OF SKILLED BEHAVIOR**

Chair: Robert Scheidt

SHORT PRESENTATIONS

14:00 – 14:15 **Cosimo Della Santina¹, Matteo Bianchi^{2,1}, Manolo Garabini¹, Antonio Bicchi^{1,2}**

¹Research Center "Enrico Piaggio" - University of Pisa, Pisa, Italy;

²Department of Advanced Robotics - Istituto Italiano di Tecnologia (IIT), Genova, Italy

CONTROL ARCHITECTURE FOR HUMAN-LIKE MOTION WITH APPLICATIONS TO SOFT ROBOTICS

14:15 – 14:30 **Carla Caballero, David Barbado, Tomás Urbán, Francisco Javier Moreno Miguel Hernández**

University of Elche, (Alicante), Spain

INTERPRETATION OF MOTOR VARIABILITY DEPENDING ON FEEDBACK AVAILABILITY

14:30 – 14:45 **Tarkeshwar Singh, Kayla Goins, Christopher Perry, Troy Herter**

University of South Carolina, Columbia, SC, USA

PRACTICE-RELATED IMPROVEMENTS IN VISUOSPATIAL ATTENTION DRIVE MOTOR LEARNING IN A MOTOR TASK REQUIRING CONTINUOUS AND SIMULTANEOUS PERCEPTUAL, COGNITIVE AND MOTOR PROCESSING

THURSDAY, 23 JULY

Room name: BARTÓK

INVITED SPEAKERS

14:45 – 15:15 **Peter J. Beek**

VU University Amsterdam, The Netherlands

CURRENT INSIGHTS INTO MOTOR LEARNING AND THEIR APPLICATIONS

15:15 – 15:45 **Joachim Hermsdörfer**

*Institute of Human Movement Science, Department of Sport and Health Sciences,
Technische Universität München, Munich, Germany*

**ANTICIPATORY BEHAVIOR IN OBJECT MANIPULATION: LEARNING AND
ALTERATIONS FOLLOWING BRAIN DAMAGE**

15:45 – 16:00 **Health Break**

INVITED SPEAKERS

16:00 – 16:30 **Elizabeth Torres**

Rutgers University, New Brunswick, USA

**DISTINGUISHING INTENT AND VOLITION THROUGH STOCHASTIC
SIGNATURES OF MOTOR OUTPUT VARIABILITY**

16:30 – 17:00 **Robert A. Scheidt^{1,2,3}**

¹*Biomedical Engineering, Marquette University;*

²*Sensory Motor Performance Program, Rehabilitation Institute of Chicago;*

³*Physical Medicine and Rehabilitation, Feinberg School of Medicine, Northwestern
University, USA*

FACILITATION AND INTERFERENCE IN THE LEARNING OF MOTOR TASKS

17:00 – 17:30 **General discussion**

18:00 – **Business meeting of the International Society of Motor Control**

FRIDAY, 24 JULY

Room name: BARTÓK

REGISTRATION: 08:00 - 17:00

08:30 – 12:00 **SYMPOSIUM 3: THEORETICAL MOTOR CONTROL**

Chair: Gregor Schöner

SHORT PRESENTATIONS

08:30 – 08:45 **Hester Knol^{1,2,3}, Raoul Huys^{1,2,4}, Jean-Christophe Sarrazin³, Viktor Jirsa^{1,2,4}**

¹Aix-Marseille Université, Institut de Neurosciences des Systèmes, Marseille, France;

²INSERM, UMR_S 1106, 27 Bd Jean Moulin, 13385, Marseille Cedex 5, France;

³ONERA, Systems Control and Flight Dynamics Department, Salon de Provence, France;

⁴Centre National de la Recherche Scientifique, France

QUANTIFYING THE EBBINGHAUS FIGURE EFFECT IN PERCEPTUAL AND PERCEPTUAL-MOTOR CONTEXTS

08:45 – 09:00 **Thomas Macaluso¹, Christophe Bourdin¹, Frank Buloup¹, Bernard Gardette², Marie-Laure Mille¹, Caroline Nicol¹, Fabrice Sarlegna¹, Patrick Sainton¹, Virginie Taillebot², Jean-Louis Vercher¹, Peter Weiss², Lionel Bringoux¹ (37)**

¹Aix-Marseille Université, CNRS, ISM UMR 7287, Marseille;

²COMEX S.A., Marseille, France

IS UNDERWATER ENVIRONMENT A GOOD WAY TO SIMULATE MICROGRAVITY? SOME CUES FROM ARM REACHING AND POSTURAL CONTROL

09:00 – 09:15 **Radivoj Mandic¹, Sasa Jakovljevic¹, Slobodan Jaric^{2,3} (23)**

¹University of Belgrade, Faculty of Sport and Physical Education, The Research Center, Blagoja Parovica 156, Belgrade, Serbia;

²University of Delaware, Department of Kinesiology and Applied Physiology, USA;

³University of Delaware, Biomechanics and Movement Science Graduate Program, USA

PERFORMING MAXIMAL NATURAL VERTICAL JUMPS: ROLE OF THE COUNTERMOVEMENT DEPTH

INVITED SPEAKERS

09:15 – 09:45 **Andrea d'Avella^{1,2}**

¹Department of Biomedical Sciences and Morphological and Functional Images, University of Messina, Italy;

²Laboratory of Neuromotor Physiology, Santa Lucia Foundation, Rome, Italy

MODULARITY FOR MOTOR CONTROL AND MOTOR LEARNING

09:45 – 10:15 **Jeroen Smeets**

VU University Amsterdam, The Netherlands

THE BUILDING BLOCKS OF PREHENSION

10:15 – 10:45 **Health Break**

FRIDAY, 24 JULY

Room name: BARTÓK

INVITED SPEAKERS

- 10:30 – 11:00 **Katja Kornysheva**
Institute of Cognitive Neuroscience, University College London, UK
NEURAL ENCODING OF SPATIOTEMPORAL SKILLS
- 11:00 – 11:30 **Gregor Schöner**
Institute for Neural Computation, Ruhr-Universität Bochum, Germany
TOWARD AN INTEGRATED NEURAL DYNAMIC APPROACH OF OBJECT-ORIENTED MOVEMENT
- 11:30 – 12:00 **General Discussion**
- 12:00 – 14:00 **Lunch and Posters**
 View poster group 3
 View poster group 4

14:00 – 17:30 **SYMPOSIUM 4: FIFTY YEARS OF EQUILIBRIUM POINT HYPOTHESIS**
Chair: Mark Latash

INVITED SPEAKERS

- 14:00 – 14:30 **Mark L Latash**
The Pennsylvania State University, University Park, PA, USA
INTENTIONAL AND UNINTENTIONAL MOVEMENTS WITHIN THE EQUILIBRIUM-POINT HYPOTHESIS
- 14:30 – 15:00 **Mindy F. Levin**
McGill University, Canada
EXPLANATIONS OF DISORDERED MOTOR CONTROL BASED ON THE EP HYPOTHESIS

15:00 – 15:15 **Health Break**

INVITED SPEAKERS

- 15:15 – 15:45 **Anatol G. Feldman**
University of Montreal, Canada
MINIMIZATION PRINCIPLES AND REDUNDANCY PROBLEMS IN THE CONTEXT OF REFERENT CONTROL OF ACTION AND PERCEPTION
- 15:45 – 16:15 **Joseph McIntyre**
Tecnalia Health Research Institute, Spain
EP SHIFTS AS THE BASIC BUILDING BLOCK FOR HUMAN MOVEMENT
- 16:15 – 16:45 **Special short presentations for the Fiftieth anniversary of EP**
- 17:00 – 17:30 **General discussion**
- 19:00 – 23:30 **Banquet** (Address: Lágymányosi Ökumenikus Központ, 1117 Budapest, Magyar tudósok körútja 3.)



SATURDAY, 25 JULY

Room name: BARTÓK

Registration: 08:00 - 17:00

08:30 – 12:00 **SYMPOSIUM 5: HUMAN MACHINE INTERFACE**

Chair: Apostolos Georgopoulos

SHORT PRESENTATIONS

08:30 – 08:45 **Konrad Stanek^{1,2}, Hartwig R. Siebner², Steffen Angstmann², Kristoffer H. Madsen², Ole Winther¹**

¹Technical University of Denmark, DTU Compute, Cognitive Systems, Denmark;

²Danish Research Center for Magnetic Resonance, Hvidovre Hospital, Denmark

WHAT, WHEN, WHETHER - THE ELECTROPHYSIOLOGICAL CORRELATES AND CLASSIFICATION OF VOLUNTARY ACTION IN VIRTUAL ENVIRONMENT

08:45 – 09:00 **Cassie N. Borish¹, Matteo Bertucco¹, Denise J. Berger³, Andrea d'Avella³, Terence D Sanger^{1,2}**

¹University of Southern California, Los Angeles, CA, USA;

²Children's Hospital Los Angeles, Los Angeles, CA, USA;

³Santa Lucia Foundation, Rome, Italy

USING NON-NEGATIVE MATRIX FACTORIZATION AS A FILTER TO IMPROVE USABILITY OF MYOCONTROL FOR CHILDREN WITH CEREBRAL PALSY

09:00 – 09:15 **José Luis Vargas Luna^{1,2}, Matthias Krenn³, Simon M. Danner³, Ursula S. Hofstoetter³, Karen Minassian³, Winfried Mayr³, Thordur Helgason¹**

¹Health Technology Center, Reykjavik University - Landsþtali University Hospital, Reykjavik, Iceland;

²Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Monterrey, Mexico;

³Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria

COMPARISON OF CATHODIC AND ANODIC TRANSPINAL ELECTRICAL STIMULATION TO EVOKE POSTERIOR ROOT-MUSCLE REFLEXES

INVITED SPEAKERS

09:15 – 09:45 **Ferdinando A. Mussa-Ivaldi**

Northwestern University and Rehabilitation Institute of Chicago, USA

HUMAN-MACHINE INTERFACES: BRAIN AND BODY

09:45 – 10:00 **Patrick van der Smagt**

Technical University of Munich, Germany

FROM LINEAR TO NONLINEAR MOVEMENT MODELS

10:15 – 10:30 **Health Break**

SATURDAY, 25 JULY

Room name: BARTÓK

INVITED SPEAKERS

- 10:30 – 11:00 **Lee Miller**
Northwestern University, Chicago, USA
DEVELOPMENT OF AN AFFERENT NEURAL INTERFACE DESIGNED TO MIMIC NATURAL PROPRIOCEPTION
- 11:00 – 11:30 **Apostolos P. Georgopoulos**
University of Minnesota, USA
HUMAN MACHINE INTERFACE: USING CIRCUIT-BASED INFORMATION (CBI)
- 11:30 – 12:00 **General discussion**
- 12:00 – 14:00 **Lunch and Posters**
 View poster group 5
 View poster group 6

14:00 – 17:30 **SYMPOSIUM 6: IMPAIRED MOTOR CONTROL AND REHABILITATION**
Chair: Zev Rymer

SHORT PRESENTATIONS

- 14:00 – 14:15 **Henriette Steiner, Zsolt Kertesz**
Budapest University of Technology and Economics Department of Control Engineering and Information Technology, Budapest, Hungary
THE EFFECTS OF THERAPEUTIC HORSE RIDING ON THE MAIN PARAMETERS OF GAIT
- 14:15 – 14:30 **Mariusz Paweł Furmanek¹, Kajetan Słomka¹, Barbara Głuchowska², Aleksandra Żebrowska², Grzegorz Juras¹**
¹*The Jerzy Kukuczka Academy of Physical Education in Katowice, Department of Human Motor Behaviour, 72A Mikołowska St, 40-065 Katowice, Poland*
²*The Jerzy Kukuczka Academy of Physical Education in Katowice, Department of Physiological and Medical Sciences, 72A Mikołowska St, 40-065 Katowice, Poland*
THE EFFECTS OF DIFFERENT AEROBIC ACTIVITIES ON I TYPE DIABETIC SUBJECTS IN HYPOXIA CONDITION ON POSTURAL CONTROL IN QUIET STANDING
- 14:30 – 14:45 **Marcos Rodriguez^{2,4}, Andreanne K. Blanchette³, Mindy F. Levin^{1,2}**
¹*School of Physical and Occupational Therapy, McGill University, Montreal, Quebec, Canada;*
²*Feil and Oberfeld Research Center, Jewish Rehabilitation Hospital, Center for Interdisciplinary Research in Rehabilitation of the Greater Montreal (CRIR), Montreal, Quebec, Canada;*
³*Department of Rehabilitation, Laval University, Quebec, Canada;*
⁴*Faculty of Medicine, McGill University, Montreal, Quebec, Canada*
MEASUREMENT OF UPPER-LIMB COORDINATION IN CHRONIC STROKE SUBJECTS

SATURDAY, 25 JULY

Room name: BARTÓK

INVITED SPEAKERS

14:45 – 15:15 **Numa Dancause**

University of Montreal, Canada

**PLASTICITY IN THE IPSI AND CONTRALESIONAL MOTOR NETWORK
FOLLOWING STROKE IN ANIMALS MODELS**

15:15 – 15:45 **John Rothwell**

UCL Institute of Neurology, London, UK

**CAN MOTOR RECOVERY IN PATIENTS AFTER STROKE BE IMPROVED
BY NON-INVASIVE BRAIN STIMULATION? PLASTICITY IN THE IPSI AND
CONTRALESIONAL MOTOR NETWORK FOLLOWING STROKE IN ANIMALS
MODELS**

15:45 – 16:00 **Health Break**

INVITED SPEAKERS

16:00 – 16:30 **Vivian Mushahwar**

University of Alberta, Canada

**DO THE ARMS PLAY A ROLE IN THE REHABILITATION OF WALKING AFTER
SPINAL CORD INJURY?**

16:30 – 17:00 **Jozsef Laczko**

University of Pécs, Hungary;

MTA Wigner Research Centre for Physics, Budapest, Hungary;

Pázmány Péter Catholic University, Budapest, Hungary

**CONTROLLING CYCLIC LIMB MOVEMENTS IN REHABILITATION OF SPINAL
CORD INJURED INDIVIDUALS**

17:00 – 17:30 **General discussion**

18:00 – 19:00 **Closing**

POSTERS

23 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 1.

A-0004

LIGHT FINGER TOUCH ENHANCES FUNCTIONAL INTEGRATION BETWEEN POSTURAL CONTROL AND VISUAL SEARCH

Guei-Jen Lin, Jui-Hung Tu

National Pingtung University, Pingtung City, Taiwan

Topic: Neurophysiological mechanisms of motor control

A-0005

WHAT IS THE MECHANISM OF THE EFFECT OF LIGHT DIGITAL TOUCH ON POSTURAL SWAY?

Wen-Lin Liao, Fu-Chen Chen

National Pingtung University of Science & Technology, Pingtung County, Taiwan

Topic: Neurophysiological mechanisms of motor control

A-0008

ANTICIPATORY POSTURAL ADJUSTMENTS ASSOCIATED TO REACHING MOVEMENTS ARE LIKELY PROGRAMMED ACCORDING TO THE EXPECTANCY OF VISUAL INFORMATION

Roberto Esposti

Section Human Physiology of the DePT - Università degli Studi di Milano, Milan, Italy

Topic: Neurophysiological mechanisms of motor control

A-0016

LONG-RANGE CORRELATIONS IN THE FLUCTUATIONS OF STANCE, SWING AND DOUBLE-SUPPORT-TIMES IN NORMAL WALKING

Christoph Mickel¹, Gerrit Kollegger², Dietmar Schmidtbleicher¹

¹ *Institute for Sports Science, Goethe-University Frankfurt, Germany;*

² *Institute for Sport Science, TU Darmstadt, Germany*

Topic: Neurophysiological mechanisms of motor control

A-0018

ANTICIPATORY AND CARRY-OVER COARTICULATION IN EXPERIMENTS WITH TWO SEQUENTIAL SUB-MOVEMENTS

Eva Hansen¹, Britta Grimme¹, Hendrik Reimann^{1,2}, Gregor Schöner¹

¹ *Institute for Neural Computation, Ruhr-Universität Bochum, Germany;*

² *Department of Kinesiology, Temple University Philadelphia, USA*

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 1.

A-0019

LOCATION OF SOMATOSENSORY ELECTRICAL STIMULATION DOES NOT AFFECT INTERLIMB MOTOR SKILL TRANSFER

János Négyesi¹, Menno Peter Veldman², Tibor Hortobágyi^{2,3}

¹ *Semmelweis University, Budapest, Hungary;*

² *University of Groningen, University Medical Center of Groningen, Groningen, the The Netherlands;*

³ *Newcastle University, Newcastle upon Tyne, United Kingdom*

Topic: Neurophysiological mechanisms of motor control

A-0025

TACTILE GATING OPTIMIZES SENSORY INFLOW

Francisco Colino¹, Gavin Buckingham², Gordon Binsted¹

¹ *School of Health & Exercise Science, University of British Columbia, Kelowna, BC, Canada;*

² *School of Psychology, Heriot-Watt University, Edinburgh, Scotland*

Topic: Neurophysiological mechanisms of motor control

A-0028

MOTOR EQUIVALENCE DURING REACHING FROM STANDING IN HEALTHY ADULTS

Yosuke Tomita^{1,2}, Anatol G. Feldman^{2,3}, Mindy F Levin^{1,2}

¹ *McGill University, Montréal, Québec, Canada;*

² *Center for Interdisciplinary Research in Rehabilitation (CRIR)-Jewish Rehabilitation Hospital, Laval, Québec, Canada;*

³ *Université de Montréal, Département de neuroscience, Montréal, Québec, Canada*

Topic: Neurophysiological mechanisms of motor control

A-0033

VARIATIONS IN BRAIN ACTIVITY AS A FUNCTION OF HAND/TARGET VISUAL FEEDBACK AVAILABILITY

Darian Cheng¹, Krista Fjeld¹, Gordon Binsted¹

¹ *University of British Columbia, Kelowna, Canada*

Topic: Neurophysiological mechanisms of motor control

A-0034

EVALUATION OF VIDEO-BASED METHOD FOR THE MEASUREMENT OF REACTION TIME IN SPECIFIC SPORT SITUATION

Milos Mudric¹, Ivan Cuk¹, Aleksandar Nedeljkovic¹, Srecko Jovanovic¹, Slobodan Jaric²

¹ *Faculty of Sports and Physical Education, University of Belgrade, Belgrade, Serbia;*

² *Department of Kinesiology and Applied Physiology, & Biomechanics and Movement Science Graduate Program University of Delaware, Newark, USA*

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 1.

A-0041

FATIGUE- AND TRAINING-RELATED MODULATION OF “ β ” EMG-EMG COHERENCE BETWEEN SYNERGIST AGONIST MUSCLES DURING ISOMETRIC CONTRACTIONS: NEW EVIDENCE OF THE SIGNIFICANCE OF INTERMUSCULAR COUPLING IN MOTOR CONTROL.

Camille Charissou^{1,2,3}, Laurent Vigouroux¹, Eric Berton¹, David Amarantini^{2,3}

¹ Aix-Marseille University, CNRS, ISM UMR 7287, Marseille, France;

² Inserm, Imagerie cérébrale et handicaps neurologiques UMR 825, Toulouse, France;

³ Université de Toulouse, UPS, Imagerie cérébrale et handicaps neurologiques UMR 825, Toulouse, France

Topic: Neurophysiological mechanisms of motor control

A-0042

MODULATION OF 5-30 HZ EMG-EMG COHERENCE DURING HIGH PRECISION GRIP FORCE TASKS

Robert Tibold, Simon F. Farmer, Marco Davare

Sobell Department of Motor Neuroscience and Movement Disorders, UCL Institute of Neurology, University College London, London, United Kingdom

Topic: Neurophysiological mechanisms of motor control

A-0043

THE ROLE OF ADDITIONAL ARM SUPPORT WHEN USED IN AN ACTIVE BALANCING TASK

Jernej Čamernik^{1,2}, Luka Peternel¹, Jan Babič¹

¹ Department for Automation, Biocybernetics and Robotics, Jozef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia;

² Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

Topic: Neurophysiological mechanisms of motor control

A-0049

SPIKING NEURAL CONTROL OF MUSCULOSKELETAL MOVEMENTS ABOUT THE HUMAN ANKLE

Manish Sreenivasa¹, Massimo Sartori²

¹ Optimization in Robotics & Biomechanics, Interdisciplinary Center for Scientific Computing, Universität Heidelberg, Heidelberg, Germany;

² Department of Neurorehabilitation Engineering, Bernstein Focus Neurotechnology Göttingen, Bernstein Center for Computational Neuroscience, Universitätsmedizin Göttingen, Georg-August-Universität, Göttingen, Germany

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 1.

A-0053

CROSSED RESPONSES TO STRETCH IN DISTAL MUSCLES IN THE UPPER LIMB

Demetris Soteropoulos

Institute of Neuroscience, Newcastle University, UK

Topic: Neurophysiological mechanisms of motor control

A-0131

HUNGARIAN-DEVELOPED SENSORIMOTOR-BASED POSTUROGRAPHY PLUS HEART FUNCTION EVALUATING SYSTEM (PHF) FOR CLINICAL DIAGNOSTICS, REHABILITATION AND HEAVY-DUTY EXPERIMENTAL STUDIES (A PRELIMINARY)

L. Simon¹, B. E. Toth², V. Sarkisian³, S. Garab¹, M. Endrenyi¹, L. Gevai¹, P. Nagy¹, J. Tollar⁴, F. Nagy⁴

¹*Lab.of Sensorimotor Adaptation, Semmelweis University, Budapest, Hungary;*

²*Dept.of Pharmaceutical Surveillance and Economy, University of Debrecen, Hungary;*

³*Lab.of Sensorimotor Integration, Orbeli Inst. of Physiology, NASRA, Yerevan, Armenia;*

⁴*Dept.of Neurology, M. Kaposi Teaching Hospital, Kaposvar, Hungary*

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 2.

A-0059

VARIABILITY OF THE OCCURRENCE OF PEAK MUSCLE ACTIVITY OF THE EQUINE LONGISSIMUS DORSI DURING TROT

Rebeka R. Zsoldos¹, Björn Krüger², Anna Vögele², Schröder Ulrike³, Theresia F. Licka^{4,5}

¹ University of Natural Resources and Life Sciences Vienna, Vienna, Austria;

² Multimedia, Simulation and Virtual Reality Group, Institute of Computer Science II, University of Bonn, Bonn, Germany;

³ Department for Small Animals and Horses, University of Veterinary Medicine Vienna, Vienna, Austria;

⁴ Movement Science Group, University of Veterinary Medicine Vienna, Vienna, Austria;

⁵ Royal (Dick) School of Veterinary Studies, The University of Edinburgh, Edinburgh, Scotland, United Kingdom

Topic: Neurophysiological mechanisms of motor control

A-0060

SIDEWAYS STABILISATION EFFECT OF THE EQUINE LONGISSIMUS DORSI MUSCLE IN TROT

Rebeka R. Zsoldos¹, Björn Krüger², Anna Vögele², Schröder Ulrike³, Theresia F. Licka^{4,5}

¹ University of Natural Resources and Life Sciences Vienna, Vienna, Austria;

² Multimedia, Simulation and Virtual Reality Group, Institute of Computer Science II, University of Bonn, Bonn, Germany;

³ Department for Small Animals and Horses, University of Veterinary Medicine Vienna, Vienna, Austria;

⁴ Movement Science Group, University of Veterinary Medicine Vienna, Vienna, Austria;

⁵ Royal (Dick) School of Veterinary Studies, The University of Edinburgh, Edinburgh, Scotland, United Kingdom

Topic: Neurophysiological mechanisms of motor control

A-0061

NEURAL CORRELATES OF ERROR PROCESSING IN A COMPLEX MOTOR TASK – AN EXPLORATIVE EEG-STUDY

Lisa Katharina Maurer, Heiko Maurer Hermann Müller

Neuromotor Behavior Lab, Justus-Liebig-University, Giessen, Germany

Topic: Neurophysiological mechanisms of motor control

A-0070

REFERENT ORIENTATION OF THE BODY WITH RESPECT TO GRAVITY: A GLOBAL FACTOR IN THE CONTROL OF POSTURE AND MOVEMENT

Aditi A. Mullick^{1,3}, Szu-Chen Hsu^{2,3}, Sandeep K. Subramanian^{3,4}, Nicolas Turpin⁴, Anatol G. Feldman^{3,4}, Mindy F. Levin^{1,2,3}

¹ School of Physical and Occupational Therapy, McGill University;

² Neuroscience Program, McGill University;

³ Jewish Rehabilitation Hospital (JRH) Research Site of the Center for Interdisciplinary Research in Rehabilitation (CRIR);

⁴ Department of Neuroscience, University of Montreal, Montreal, Canada

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 2.

A-0077

STABILIZATION OF DIFFERENT MECHANICAL VARIABLES BY MULTI-MUSCLE SYNERGIES DURING MARCHING IN-PLACE

Shoko Kaichida¹, Stanislaw Solnik², Mark L. Latash²

¹ Kagoshima National College of Technology, Japan;

² The Pennsylvania State University, USA

Topic: Neurophysiological mechanisms of motor control

A-0078

REACTION TIME BALLISTIC MOVEMENTS AND THEIR REGULATION ACCORDING TO MOTOR PLANNING

J.M.Castellote^{1,2}, J. Valls-Solé³

¹ Physical Medicine and Rehabilitation Department, Complutense University of Madrid;

² National School of Occupational Medicine, Instituto de Salud Carlos III Madrid, Spain;

³ Department of Neurology, Hospital Clínic, University of Barcelona, Barcelona, Spain

Topic: Neurophysiological mechanisms of motor control

A-0086

KINEMATIC AND ELECTROMYOGRAPHIC FEATURES OF UPPER-LIMB MOVEMENT PERFORMED BY HEALTHY AND POST-STROKE PATIENTS

Rosa Mariana Silva^{1,4}, Pedro Fonseca^{5,6}, Ana Rita Pinheiro³, Carolina Vila-Chã^{7,8}, Cláudia Silva³, Miguel Velhote Correia^{1,9}, Sandra Mouta^{1,2}

¹ INESC TEC, Portugal;

² Centro de Computação Gráfica, Portugal;

³ Escola Superior de Tecnologia da Saúde do Porto – Instituto Politécnico do Porto / Centro de Estudos do Movimento e Atividade Humana;

⁴ Departamento de Psicologia Básica, Escola de Psicologia, Universidade do Minho, Portugal;

⁵ Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial (INEGI), Portugal;

⁶ Laboratório de Biomecânica do Porto (LABIOME), Portugal;

ESTSP – IPP / CEMAH;

⁷ Instituto Politécnico da Guarda, Portugal;

⁸ CIDESD - Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano;

⁹ Faculdade de Engenharia da Universidade do Porto, Portugal

Topic: Neurophysiological mechanisms of motor control

A-0096

SPATIAL AND TEMPORAL REQUIREMENTS OF INSTANTANEOUS VISUAL FEEDBACK TO GUIDE ISOMETRIC FORCE PRODUCTION

Genevieve Williams¹, Amanda Chennavasin², Kristina Neely²

¹ Anglia Ruskin University, Cambridge, Uk;

² The Pennsylvania State University, PA, USA

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 2.

A-0105

CENTRAL RESETTING OF SPATIAL THRESHOLDS FOR MOTONEURONAL RECRUITMENT SUPPRESSES ACTIVATION OF MUSCLES DURING PROLONGED LENGTHENING

Nicolas A. Turpin^{1,2,4}, Rim Rahal², Sandeep K. Subramanian^{1,4}, Mindy F. Levin^{1,3,4}, Anatol G. Feldman^{1,2,4}

¹ Department of Neuroscience;

² Institute of Biomedical Engineering, University of Montreal;

³ School of Physical and Occupational Therapy, McGill University;

⁴ Center for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR), Montreal, QC, Canada

Topic: Neurophysiological mechanisms of motor control

A-0106

EFFECT OF SUBSENSORY ELECTRICAL NOISE ON KINESTHETIC PERCEPTION IN OLDER ADULTS

Diana R. Toledo¹, José A. Barela^{2,3}, André F. Kohn¹

¹ Biomedical Engineering Laboratory, University of São Paulo, EPUSP, PTC, São Paulo, Brazil;

² Institute of Physical Activity and Sport Sciences and Graduate Program in Human Movement Sciences, Cruzeiro do Sul University, São Paulo, Brazil;

³ Institute of Bioscience, São Paulo State University, Rio Claro, Brazil

Topic: Neurophysiological mechanisms of motor control

A-0111

THE INFLUENCE OF STRENGTH EXERCISE ON FORCE PERCEPTION IN VERTICAL JUMPING

Kajetan Slomka, Tomasz Skowronek, Mariusz Furmanek, Grzegorz Juras

Academy of Physical Education, Katowice, Poland

Topic: Neurophysiological mechanisms of motor control

A-0114

ACUTE AND DELAYED NEUROMECHANICAL CHANGES AFTER INTENSIVE STRETCH-SHORTENING CYCLE EXERCISE TRAINING

Márk Váczai¹, Dan Río-Rodríguez², János Négyesi³, Miguel Angel Fernández del Olmo²

¹ Institute of Sport Sciences and Physical Education, University of Pécs, Hungary;

² Facultad de Ciencias do Deporte e a Educación Física, Universidad de A Coruna, Spain;

³ Hungarian University of Physical Education, Budapest, Hungary

Topic: Neurophysiological mechanisms of motor control

A-0117

NEURAL SUBSTRATE OF THE EFFECT OF STIMULUS SALIENCY ON MOVEMENT PLANNING AND EXECUTION

Raphaël Mizzi¹, Germán Gálvez-García^{1,2}, George A. Michael¹

¹ Département de Psychologie Cognitive & Neuropsychologie, Institut de Psychologie, Université Lyon 2, Lyon, France;

² Departamento de Psicología, Universidad de La Frontera, Temuco, Chile

Topic: Neurophysiological mechanisms of motor control

23 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 2.

A-0119

EXTRACTING HEART-BEAT SIGNAL FROM FNIRS - A PRELIMINARY STUDY

Christine Langhanns¹, Hermann Müller¹

¹ Justus-Liebig-University, Giessen, Germany

Topic: Neurophysiological mechanisms of motor control

A-0120

UNINTENDED CONTRALATERAL ACTIVITY INCREASED DURING IPSILATERAL INTENDED CONTRACTIONS WITH GREATER TASK DIFFICULTY

Hironori Watanabe¹, Shobu Kurohara², Yasuhide Yoshitake²

¹ Graduate School of Physical Education, National Institute of Fitness and Sports in Kanoya, Kanoya, Japan;

² National Institute Fitness and Sports in Kanoya, Kanoya, Japan

Topic: Neurophysiological mechanisms of motor control

A-0123

VARIATION OF THE STIMULATION SITE CHANGES THE EXCITATION OF THE LUMBOSACRAL SPINAL REFLEXES

Matthias Krenn¹, Simon M. Danner², Jose L. Vargas-Luna^{3,4}, Andrea Toth¹, Ursula S. Hofstoetter¹, Karen Minassian¹, Winfried Mayr¹

¹ Center for Medical Physics and Biomedical Engineering, Medial University of Vienna, Vienna, Austria;

² Department of Neurobiology and Anatomy, Drexel University College of Medicine, Philadelphia, PA, USA;

³ Health Technology Center, Reykjavik University - Landsptiali University Hospital, Reykjavik, Iceland;

⁴ Escuela de Ingenieria y Ciencias, Tecnologico de Monterrey, Monterrey, Mexico

Topic: Neurophysiological mechanisms of motor control

A-0128

SUBCORTICAL INFLUENCES ON PAIRED-PULSE TMS-INDUCED I-WAVES IN HUMANS

John Cirillo¹, Monica A. Perez^{1,2}

¹ Department of Physical Medicine and Rehabilitation, Systems Neuroscience Institute, University of Pittsburgh, USA;

² Department of Neurological Surgery, The Miami Project to Cure Paralysis Lois Pope Life Center, University of Miami, USA

Topic: Neurophysiological mechanisms of motor control

A-0129

STRUCTURAL LEARNING MANIFESTS IN VISUOMOTOR ROTATION TASK AIMING STRATEGIES

Krista Bond¹, Jordan Taylor^{1,2}

¹ Princeton University Department of Psychology;

² Princeton Neuroscience Institute

Topic: Learning of skilled behavior

24 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 3.

A-0014

INVESTIGATION OF PHASE TRANSITION POINT PHENOMENA IN NOVICE PARTICIPANTS OVER A PERIOD OF PRACTICE: A COMPARISON WITH SKILLED BEHAVIOUR

Wan Rizal Wan Zakariah¹, Jia Yi Chow¹, Robert Rein²

¹ National Institute of Education-Nanyang Technological University, Singapore;

² German Sport University, Cologne, Germany

Topic: Learning of skilled behavior

A-0026

THE EFFECT OF BEHAVIORAL INTERFERENCE ON THE KINEMATICS OF A MOVEMENT SEQUENCE DURING MOTOR LEARNING

Jason Friedman¹, Maria Korman²

¹ Tel Aviv University, Israel;

² University of Haifa, Israel

Topic: Learning of skilled behavior

A-0027

RAMBLING AND TREMBLING DECOMPOSITION OF SWAY IN QI GONG EXPERTS DURING QUIET STANDING UNDER DIFFERENT FOCUS CONDITIONS

Martin Wünnemann, Dorothee Neuhaus

University of Paderborn, Germany

Topic: Learning of skilled behavior

A-0046

IN REWARD-BASED MOTOR SKILL LEARNING, EXPLORATORY MOVEMENTS OBEY TO A SPATIO-TEMPORAL SYMMETRY PRINCIPLE

Irene Tamagnone, Maura Casadio, Vittorio Sanguineti

Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genoa Genoa, Italy

Topic: Learning of skilled behavior

A-0050

WHOLE-BODY MOTOR STRATEGIES FOR BALANCING ON A BEAM WHEN CHANGING THE NUMBER OF AVAILABLE DEGREES OF FREEDOM

Enrico Chiovetto¹, Meghan Huber², Ludovic Righetti³, Stefan Schaal³, Dagmar Sternad⁴, Martin Giese¹

¹ Section for Computational Sensomotorics, Department of Cognitive Neurology, Hertie Institute for Clinical Brain Research, Centre for Integrative Neuroscience, University Clinic Tübingen, Tübingen, Germany;

² Department of Bioengineering, Northeastern University, Boston, Massachusetts, United States of America;

³ Autonomous Motion Department, Max Planck Institute for Intelligent Systems, Tübingen, Germany;

⁴ Departments of Biology, Electrical and Computer Engineering, and Physics, Boston, Massachusetts, United States of America

Topic: Learning of skilled behavior

24 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 3.

A-0069

ACQUISITION OF SERIAL ORDER IN SPEECH PRODUCTION: AN ULTRASOUND STUDY OF TYPICAL 4-YEAR-OLD CANADIAN FRENCH CHILDREN

Guillaume Barbier¹, Pascal Perrier¹, Lucie Ménard², Yohan Payan³, Mark K. Tiede⁴, Joseph S. Perkell^{5,6}

¹ GIPSA-lab, CNRS & Grenoble Universities, Grenoble, France;

² Laboratoire de Phonétique, Université du Québec à Montréal, Montréal, Canada;

³ TIMC-IMAG laboratory, CNRS & Grenoble Universities, Grenoble, France;

⁴ Haskins Laboratories, New Haven, Connecticut, USA;

⁵ Boston University, Boston, Massachusetts, USA;

⁶ M.I.T., Cambridge, Massachusetts, USA

Topic: Learning of skilled behavior

A-0076

STABILIZATION OF ARM CONFIGURATION AND MUSCLE ACTIVITY PATTERNS DURING CYCLING ARM MOVEMENTS AGAINST EXTERNAL RESISTANCES

Mariann Mravcsik¹, Lilla Botzheim⁴, Norbert Zentai¹, Jozsef Laczko^{1,2,3,4}

¹ Institute of Biology, University of Pécs, Hungary;

² Department of Information Technology and Biorobotics, University of Pécs, Hungary;

³ MTA Wigner Research Centre for Physics, Budapest, Hungary;

⁴ Faculty of Information Technology and Bionics, Pázmány Péter Catholic University, Budapest, Hungary;

Topic: Learning of skilled behavior

A-0081

IMPAIRED FINE MOTOR LEARNING IN WILLIAMS SYNDROME

Andrea Berencsi^{1,2}, Ilona Kovács¹

¹ Pázmány Péter Catholic University Laboratory for Psychological Research, Budapest, Hungary;

² Eötvös Loránd University Bárczi Gusztáv Faculty of Special Education, Institute for Methodology of Special Education and Rehabilitation, Budapest, Hungary

Topic: Learning of skilled behavior

A-0084

TIMING CONTROL IN CYCLING AGAINST DIFFERENT RESISTANCES

Adam Valy¹, Jozsef Laczko^{1,2,3}

¹ Pázmány Péter Catholic University, Faculty of Information Technology and Bionics, Budapest, Hungary;

² University of Pécs, Faculty of Information Technology and Biorobotics, Pécs, Hungary,

³ HAS Wigner Research Centre for Physics, Budapest, Hungary

Topic: Learning of skilled behavior

24 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 3.

A-0089

VISUALLY AIMING AT THE SCORING TARGET IN BASKETBALL: AN EXPLORATORY STUDY

Pedro T. Esteves^{1,2}, Matt Dicks³, Bruno Travassos^{2,4}, Pedro Silva⁵, Teresa Fonseca¹

¹ Polytechnic Institute of Guarda, UDI: Research Unit for Inland Development, Guarda, Portugal;

² Research Centre in Sports Sciences, Health Sciences and Human Development, CIDESD, Portugal;

³ University of Portsmouth, Portsmouth, United Kingdom;

⁴ Department of Sport Sciences, University of Beira Interior, Portugal;

⁵ Universidade do Porto, Faculdade de Desporto, Centre for Research, Education, Innovation and Intervention in Sport, Portugal

Topic: Learning of skilled behaviour

A-0091

INFLUENCE OF BREATH SYNCHRONIZATION ON AN INTERPERSONAL TASK

Naoko Yamane, Hiromichi Suenaga, Jun Nishii

Yamaguchi University, Yamaguchi, Japan

Topic: Learning of skilled behavior

A-0094

GENDER DIFFERENCES IN THE PUBERTAL TRAJECTORY OF FINE MOTOR DEVELOPMENT

Andrea Berencsi^{1,2}, Patrícia Gerván¹, Orsolya Filep¹, Ilona Kovács¹

¹ Pázmány Péter Catholic University, Laboratory for Psychological Research, Budapest, Hungary;

² Eötvös Loránd University Bárczi Gusztáv Faculty of Special Education, Institute for Methodology of Special Education and Rehabilitation, Budapest, Hungary

Topic: Learning of skilled behavior

A-0095

DOES INCREASED PRACTICE VARIABILITY MEAN INCREASED LEARNING?

Tibor Vámos^{1,2}, Kuniyasu Imanaka³

¹ National Institute for Medical Rehabilitation, Budapest, Hungary;

² Eötvös Loránd University Bárczi Gusztáv Faculty of Special Education, Institute for Methodology of Special Education and Rehabilitation, Budapest, Hungary;

³ Tokyo Metropolitan University Department of Health Promotion Science Perception and Action Laboratory, Tokyo, Japan

Topic: Learning of skilled behavior

A-0098

EFFECT OF DOG BEHAVIORAL TRAININGS ON THE ANXIETY LEVEL OF YOUNG ATHLETES

Agnes Simon

University of Physical Education, Budapest, Hungary

Topic: Learning of skilled behavior

24 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 3.

A-0107

STRETCH-SHORTENING MUSCLE CONTRACTION CYCLE AND ITS RELATION TO RUNNING ECONOMY

Edina Szabo^{1,4}, Bernadette Misovics¹, Bettina Botka¹, Mark Vaczi^{1,3,4}, Tamas Atlasz^{1,2,3}

¹ Institute of Sport Sciences and Physical Education;

² Department of Anatomy MTA-PTE PACAP „Lendulet” Research Team;

³ Janos Szentagothai Research Center;

⁴ Doctoral School of Biology and Sportbiology, Universtiy of Pecs, Pecs, Hungary

Topic: Learning of skilled behaviour

A-0108

ERRORLESS LEARNING AND MOVEMENT PATTERN

Fariba HasanBarani¹, Behrouz Abdoli², Alireza Farsi²

¹ University of Tehran, Tehran, Iran;

² Shahid Beheshti university, Tehran, Iran

Topic: Learning of skilled behavior

A-0121

NEURAL REPRESENTATION OF INTERMANUAL MOTOR SKILL TRANSFER

Ori Ossmy^{1,2}, Roy Mukamel^{1,2}

¹ School of Psychological Sciences, Tel-Aviv University, Tel-Aviv 69978, Israel;

² Sagol School of Neuroscience, Tel-Aviv University, Tel-Aviv 69978, Israel

Topic: Learning of skilled behavior

A-0126

EFFICIENT CONTROL LEARNING IN BALLISTIC-LIKE MOTION TASKS

Desislava Despotova, Petko Kiriazov

Bulgarian Academy of Sciences, Sofia, Bulgaria

Topic: Learning of skilled behavior

A-0083

TOWARDS FULL-BODY MOTION SENSOR NETWORK BASED COACHING SYSTEM: A STUDY ON GOLF PUTTING

Haisong Dong^{1,2}, Tomoyuki Yamamoto^{1,2}, Hiroshi Ishiguro²

¹ CiNet, National Institute of Communications Technology(NICT), Suita, Osaka, Japan;

² Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka, Japan

Topic: Learning of skilled behavior

A-0130

THE ROLE OF REWARD, PUNISHMENT, AND MOVEMENT DIRECTIONS ON IMPLICIT SENSORIMOTOR LEARNING

Samuel McDougale^{1,2}, Krista Bond¹, Jordan Taylor^{1,2}

¹ Princeton University Department of Psychology;

² Princeton Neuroscience Institute, USA

Topic: Learning of skilled behavior

24 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 4.

A-0020

A BAYESIAN FRAMEWORK FOR SPEECH MOTOR CONTROL

Jean-François Patri¹, Julien Diard², Jean-Luc Schwartz³, Pascal Perrier⁴

¹ GIPSA-lab, UMR 5216 CNRS Univ. Grenoble Alpes, Grenoble, France;

² Univ. Grenoble Alpes, LPNC, Grenoble, France;

³ CNRS, LPNC, Grenoble, France

⁴ GIPSA-lab, CNRS & Grenoble Universities, Grenoble, France

Topic: Theoretical motor control

A-0021

GLOBAL STABILITY INDEX – NEW PROPOSITION OF STABILITY EVALUATION MEASURE

Sobota Grzegorz, Szymańska Dominika, Juras Grzegorz, Bacik Bogdan

The Jerzy Kukuczka Academy of Physical Education in Katowice, Department of Human Motor Behavior, Katowice, Poland

Topic: Theoretical motor control

A-0024

TASK DEPENDENCY OF THE COMPLEXITY OF POSTURAL CENTER OF PRESSURE PATTERNS

Avelino Amado, Mike Busa, Richard van Emmerik

University of Massachusetts Amherst

Topic: Theoretical motor control

A-0030

TUNING OF POSTURAL RESPONSES TO INSTABILITY AND COST FUNCTION

Matteo Bertuccio¹, Amber Dunning¹, Terence D. Sanger^{1,2}

¹ University of Southern California, Los Angeles USA;

² Children's Hospital of Los Angeles, Los Angeles, USA

Topic: Theoretical motor control

A-0036

A SIMPLE NEURAL CONTROL MODEL THAT STABILIZES THE UNCONTROLLED MANIFOLD

Jun Nishii, Toru Hamamura

Yamaguchi University, Yamaguchi, Japan

Topic: Theoretical motor control

24 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 4.

A-0052

A TRADE-OFF BETWEEN REACH AND BALANCE EFFICIENCY EXPLAINS THE INTER-INDIVIDUAL DISPARITY OF POSTURE/MOVEMENT COORDINATION

Pauline Hilt¹, Bastien Berret², Thierry Pozzo^{1,3}

¹ INSERM U1093, Dijon, France;

² CIAMS Laboratory, Paris-South, France;

³ Italian Institute of Technology, Genoa, Italy

Topic: Theoretical motor control

A-0054

CAN INDIVIDUAL KINEMATICS AND BRAIN LATERALIZATION PREDICT INTERMANUAL TRANSFER OF SENSORIMOTOR ADAPTATION?

Fabrice R. Sarlegna, Alix Renault, Hannah Z. Lefumat, Lionel Bringoux, Christophe Bourdin, Jean-Louis Vercher

Institute of Movement Sciences, CNRS & Aix-Marseille University (UMR 7287), Marseille, France

Topic: Theoretical motor control

A-0058

GENERATING NATURALISTIC PLACING MOVEMENTS FROM THE ELEMENTARY MOVEMENT COMPONENTS TRANSPORT AND LIFT: A COUPLED OSCILLATOR MODEL

Jean-Stephane Jokeit Britta Grimme Gregor Schöner

Institut für Neuroinformatik, Ruhr-Universität Bochum, Germany

Topic: Theoretical motor control

A-0064

THE TUNING OF REFLEXES TO ENVIRONMENTAL RISK

Amber Dunning, Matteo Bertuccio, Terence Sanger

University of Southern California, Los Angeles, California, USA

Topic: Theoretical motor control

A-0065

WHY DO PSP PATIENTS FALL: THE ROLE OF POSTURAL GAIN, BODY SEGMENT CONTROL AND ANTEROPOSTERIOR ASYMMETRY

Kammermeier S.¹, Maierbeck K.^{1,2}, Dieterich L.^{1,3}, Plate A.¹, Lorenzl S.^{1,4}, Singh A.^{1,5}, Bötzel K.¹, Maurer C.⁶

¹ Klinikum der Universität München, Neurologische Klinik und Poliklinik, München, Germany;

² Klinikum der Universität München, Klinik für Anästhesiologie, München, Germany;

³ Kliniken Ostallgäu-Kaufbeuren, Abteilung für Allgemeinchirurgie, Kaufbeuren, Germany;

⁴ Krankenhaus Agatharied, Abteilung für Neurologie, Hausham, Germany;

⁵ Emory University, Yerkes National Primate Research Center, Atlanta, GA, USA;

⁶ Universitätsklinikum Freiburg, Klinik für Neurologie und Neuropsychologie, Freiburg, Germany

Topic: Theoretical motor control

24 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 4.

A-0071

RAMBLING-TREMBLING POSTURAL CONTROL PARADIGM: THE CONTRIBUTION OF COMPLIANT TENDONS

Davide Piovesan

Gannon University, Erie PA, USA

Topic: Theoretical motor control

A-0085

DOES INTERLIMB TRANSFER OF SENSORIMOTOR ADAPTATION RELY ON THE SAME PROCESSES AS CONSOLIDATION OF MOTOR MEMORIES?

Hannah Z. Lefumat¹, P. Mutha², R. Chris Miall³, Jean-Louis Vercher¹, Fabrice R. Sarlegna¹

¹ Aix-Marseille University, CNRS, ISM UMR 7287, 13009 Marseille, France;

² Indian Institute of Technology Gandhinagar, Ahmedabad 382424, Gujarat, India;

³ School of Psychology, University of Birmingham, Birmingham B155 2TT, UK

Topic: Theoretical motor control

A-0087

RELATIONSHIP BETWEEN THE STRUCTURE OF VARIABILITY AND INTENTIONALITY DURING A POINTING TASK

Tomás Urbán, David Barbado, Carla Caballero, Francisco J. Moreno

Sport Research Center. Miguel Hernández University of Elche, Spain

Topic: Theoretical motor control

A-0090

OPEN-LOOP CONTROL BASED ON THE MINIMUM ENERGY COST MODEL SUPPRESSES THE POSITIONAL VARIANCE AROUND THE END OF REACHING MOVEMENT

Yoshiaki Taniai¹, Tomohide Naniwa¹, Jun Nishii²

¹ University of Fukui, Fukui, Japan;

² Yamaguchi University, Yamaguchi, Japan

Topic: Theoretical motor control

A-0101

MOTOR EQUIVALENCE IN SPEECH MOTOR CONTROL: THE UNCONTROLLED MANIFOLD APPROACH

Andrew Szabados, Pascal Perrier

GIPSAIab University of Grenoble, France

Topic: Theoretical motor control

25 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 5.

A-0012

UNDER THRESHOLD POSITION CONTROL, PERIPHERAL MECHANISMS COMPENSATE EFFICIENTLY FOR SMALL PERTURBATIONS OF ARM MOVEMENTS

Lei Zhang, Andreas Straube, Thomas Eggert

Department of Neurology, Ludwig-Maximilians-University, Munich, Germany

Topic: 50 years of equilibrium point hypothesis

A-0063

POSTURAL SWAY IS REDUCED BY FINGERTIP TOUCH WHEN STANDING ON UNSTABLE SURFACES

Cristiano Rocha da Silva^{1,3}, Fernando Henrique Magalhães^{1,2}, André Fabio Kohn^{1,3}

¹*Biomedical Engineering Laboratory, University of São Paulo, São Paulo, Brazil;*

²*School of Arts, Sciences and Humanities, University of São Paulo, São Paulo, Brazil;*

³*Neuroscience Program, University of São Paulo, São Paulo, Brazil*

Topic: 50 years of equilibrium point hypothesis

A-0115

REGULATION OF MUSCLE ACTIVITIES FOR FAST, ACCURATE, AND SMOOTH MOVEMENTS: EVOLUTION OF VIRTUAL TRAJECTORY VIA COUPLING OF DIRECTIONAL MECHANICAL IMPEDANCES

Hiroaki Hirai, Keitaro Koba, Kanna Uno, Takanori Oku, Mitsunori Uemura, Fumio Miyazaki

Graduate School of Engineering Science, Osaka University, Osaka, Japan

Topic: 50 years of equilibrium point hypothesis

A-0109

ACCELEROMETRY BASED HUMAN-MACHINE INTERFACE FOR ROBOTIC APPLICATIONS

Attila Répai, György Cserey

Pázmány Péter Catholic University, Budapest, Hungary

Topic: Human-machine interface

A-0110

GAIT RECOGNITION WITH DEPTH CAMERA FROM A MOVING PLATFORM

Kevin Leyden¹, Krisztián Gergely², Miklós Koller², György Cserey²

¹ *University of Notre Dame, Notre Dame, IN, USA;*

² *Pázmány Péter Catholic University, Budapest, Hungary*

Topic: Human-machine interface

25 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 5.

A-0112

IMPROVING BALANCING ABILITY TO MITIGATE SIMULATOR ADAPTATION SYNDROME

Germán Gálvez-García^{1,2,3}, Lucio Rehbein¹, Leonardo Lagos¹, Miriam León¹

¹ Departamento de Psicología, Universidad de La Frontera, Temuco, Chile;

² Departamento de Psicología Experimental, Granada, Spain;

³ Département de Psychologie Cognitive & Neuropsychologie, Institut de Psychologie, Université Lyon 2, Lyon, France

Topic: Human-machine interface

A-0116

ATTENTIONAL SHIFT BETWEEN MOTOR EFFECTORS; ERGONOMIC APPLICATIONS

Germán Gálvez-García^{1,2}, Lucio Rehbein¹, Miriam León¹, Leonardo Lagos¹

¹ Departamento de Psicología, Universidad de La Frontera, Temuco, Chile;

² Département de Psychologie Cognitive & Neuropsychologie, Institut de Psychologie, Université Lyon 2, Lyon, France

Topic: Human-machine interface

A-0006

EFFECT OF ADDITIONAL SENSORY INFORMATION ON GAIT SPEED OF FALLERS ELDERLY

Isabela Feitosa de Carvalho¹, Marcos Eduardo Scheicher^{1,2}

¹ Biosciences Institute, Paulista State University, Rio Claro, Sao Paulo, Brazil;

² Department of Physical Therapy and Occupational Therapy, Paulista State University, Marília, Sao Paulo, Brazil

Topic: Impaired motor control and rehabilitation

A-0022

VARIATIONS IN BIMANUAL CONTROL DURING A FUNCTIONAL BIMANUAL BOX OPENING TASK IN CHILDREN WITH UNILATERAL CEREBRAL PALSY

Julian Rudisch¹, Ingar Zielinski², Pauline Aarts^{2,3}, Jenny Butler¹, Deirdre Birtles⁴, Bert Steenbergen^{2,5}, Dido Green¹

¹ Oxford Brookes University, Oxford, UK;

² Radboud University, Nijmegen, The Netherlands;

³ Sint Maartenskliniek, Nijmegen, The Netherlands;

⁴ University of East London, London, UK;

⁵ Australian Catholic University, School of Psychology, Melbourne, Australia

Topic: Impaired motor control and rehabilitation

25 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 5.

A-0038

MOTOR CONTROL DURING DUAL-TASK SITUATIONS IN WILLIAMS SYNDROME

Kati Wuebbenhorst¹, Norman Holl²

¹ Department of Physiotherapeutical Research (PIN.FOR) Faculty of Applied Public Health, EUFH MED Rostock, Germany;

² University Medicine Rostock, Germany

Topic: Impaired motor control and rehabilitation

A-0039

EMG ANALYSIS OF HIP AND TRUNK MUSCLES AMONG PEOPLE WITH CHRONIC LOW BACK PAIN

Regina Finta, Peter Katona, Rudolf Mihalik

University of Physical Education, Budapest, Hungary

Topic: Impaired motor control and rehabilitation

A-0051

THE FINGER FORCE MANIPULANDUM: A NOVEL DEVICE FOR MEASUREMENT OF MANUAL DEXTERITY AFTER STROKE

Maxime Térémetz¹, Florence Colle^{2,3}, Marc Maier^{1,4}, Pålvel Lindberg^{1,3}

¹ Université Paris Descartes, FR3636 CNRS, Paris, France;

² Hôpital Sainte-Anne, Paris, France;

³ Centre de Psychiatrie et Neurosciences, Inserm U894, Paris, France;

⁴ Université Paris Diderot, Sorbonne Paris Cité, Paris, France

Topic: Impaired motor control and rehabilitation

A-0055

FORCE CONTROL AND INTEGRATION OF PROPRIOCEPTIVE FEEDBACK IN CERVICAL DYSTONIA

Loïc Carment¹, Jean Pierre Bleton^{2,3}, Sophie Sangla³, Serge Mesure⁴, Marc A Maier^{1,5}, Pavel G Lindberg^{1,6}

¹ Université Paris Descartes, FR3636 CNRS, Sorbonne Paris Cité, 75006, Paris, France;

² INSERM U894, Université Paris Descartes, Service de Neurologie, Hôpital Sainte-Anne, Paris, France;

³ Fondation ophtalmologique Rothschild, Paris, France;

⁴ CNRS UMR 7287, Aix-Marseille Université, Marseille, France;

⁵ Université Paris Diderot, Sorbonne Paris Cité, 75012, Paris, France;

⁶ Centre de Psychiatrie et Neurosciences, Inserm U894, 75014 Paris, France

Topic: Impaired motor control and rehabilitation

25 JULY 2015 – 12:00 – 13:00 | POSTER GROUP 5.

A-0056

THE EFFECT OF FES-ASSISTED CYCLING ON THE CARDIOPULMONARY SYSTEM OF CNS INJURED INDIVIDUALS

Peter Katona², Krisztina Uto¹, Emese Trajer², Edit Bosnyak², Anna Protzner², Jozsef Laczko³, Miklos Toth²

¹ *Semmelweis University, Budapest, Hungary;*

² *University of Physical Education, Budapest, Hungary;*

³ *University of Pécs, Pécs, Hungary*

Topic: Impaired motor control and rehabilitation

25 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 6.

A-0009

LATENCY OF ANTICIPATORY POSTURAL ADJUSTMENTS DEPENDS ON THE INTENDED, NOT ON THE ACTUAL MOVEMENT VELOCITY

Carlo Bruttini, Roberto Esposti, Francesco Bolzoni, Paolo Cavallari

Section Human Physiology of the DePT - Università degli Studi di Milano, Milan, Italy

Topic: Neurophysiological mechanisms of motor control

A-0057

EFFECTS OF MOTOR STROKE RECOVERY ON FINGER TAPPING-RELATED DYNAMICS OF BRAIN OSCILLATIONS: A CASE STUDY BASED ON HIGH-POWER EEG

Béla Weiss¹, János Körmendi^{2,3}, Anikó Papp², Zoltán Nagy^{2,3,4}

¹ Brain Imaging Centre, Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary;

² National Institute of Clinical Neurosciences, Budapest, Hungary;

³ University of Pannonia, Veszprém, Hungary;

⁴ Department-Section of Vascular Neurology, Semmelweis University, Budapest, Hungary

Topic: Impaired motor control and rehabilitation

A-0075

DOES OLDER AGE AFFECT ACTION SELECTION?

Elizabeth Mallia, Sven Bestmann, John Rothwell

Sobell Department of Motor Neuroscience and Movement Disorders, Institute of Neurology, University College London, London, UK

Topic: Impaired motor control and rehabilitation

A-0079

VISUAL CONTRIBUTION TO WALKING: HOW IS IT IN CHILDREN WITH A RISK OF MOTOR COORDINATION DISORDER?

Miriam Palomo, Rudolf Psotta, Reza Abdollahipour, Adrian Agricola, Ludvik Valtr

Palacky University, Olomouc, Czech Republic

Topic: Impaired motor control and rehabilitation

A-0080

POSTURAL ASYMMETRY, MUSCULAR DEMANDS AND ENERGETIC COST IN YOUNG AND ELDERLY INDIVIDUALS DURING UPRIGHT STANDING

Janina M. Prado-Rico¹, Rafael R. Garcia¹, Marcos Duarte²

¹ Curso de Fisioterapia, Universidade Presbiteriana Mackenzie, São Paulo, SP, Brasil;

² Engenharia Biomédica, Universidade Federal do ABC, Santo André, SP, Brasil

Topic: Impaired motor control and rehabilitation

25 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 6.

A-0082

PROPORTIONAL MYOELECTRIC CONTROL FROM MOTOR UNIT BEHAVIOUR

Tamas Kapelner, Ning Jiang, Dario Farina

Department Neurorehabilitation Engineering, University Medical Center Göttingen, Georg-August University, Göttingen, Germany

Topic: Impaired motor control and rehabilitation

A-0088

NORMATIVE NEUROFLEXOR DATA FOR EARLY DETECTION OF SPASTICITY AFTER STROKE

Gaia Valentina Pennati¹, Jeanette Plantin^{1,2}, Jörgen Borg^{1,2}, Pålvel Lindberg^{2,3}

¹ *Department of Rehabilitation Medicine, Danderyd University Hospital, Stockholm, Sweden;*

² *Department of Clinical Sciences, Karolinska Institutet, Stockholm, Sweden;*

³ *Université Paris Descartes, FR3636 CNRS, Sorbonne Paris Cité, 75006, Paris, France*

Topic: Impaired motor control and rehabilitation

A-0092

SECONDARY HYDROCEPHALUS ASSOCIATED WITH SEVERE BRAIN INJURY, CEREBRAL SHUNT IMPLANTATION AND OUTCOME OF REHABILITATION: THE ESSENTIAL ROLE OF MOTOR CONTROL

Szilvia Tarjanyi, Helga Nagy, Galina Belinszkaja, Zoltan Denes

National Institute for Medical Rehabilitation Budapest Hungary

Topic: Impaired motor control and rehabilitation

A-0093

SUPPORTING REHABILITATION OF PATIENTS POST-STROKE WITH APPLICATION OF TASK-SPECIFIC EXERCISES IN HIGH REPETITION NUMBER

Ibolya Tavaszi¹, Gabor Fazekas^{1,2}, Beata Karlik¹, Rahel Lukacs¹, Renata Steigervald¹, Ferenc Szerencses¹

¹ *National Institute for Medical Rehabilitation, Budapest, Hungary;*

² *Szent Janos Hospital, Budapest, Hungary*

Topic: Impaired motor control and rehabilitation

A-0100

DECLINES OF PERFORMANCE IN TRAIL MAKING TESTS ACROSS ADULTHOOD AND FOLLOWING STROKE REFLECT MULTIFACETED DEFICITS IN VISUAL SEARCH, WORKING MEMORY AND MOVEMENT SPEED

Tarkeshwar Singh, Angela Ross, Christopher Perry, Troy Herter

Department of Exercise Science, University of South Carolina, Columbia, SC

Topic: Impaired motor control and rehabilitation

25 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 6.

A-0104

REGULAR VOLUNTARY RUNNING IMPROVES COGNITIVE FUNCTIONS IN AN ANIMAL MODEL OF ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

Klára Felszeghy¹, Anikó Posa², Csaba Varga², Csaba Nyakas¹

¹ University of Physical Education, Institute of Sport Sciences, Budapest, Hungary;

² University of Szeged, Department of Physiology, Morphology and Neurobiology, Szeged, Hungary

Topic: Impaired motor control and rehabilitation

A-0113

MOTOR ADAPTATION IN CHRONIC STROKE: THE INFLUENCE OF SPASTICITY ZONES

Mindy F Levin^{1,2}, Sandeep K Subramanian^{3,2}, Rhona Guberek², Anatol G Feldman^{3,2}

¹ School of Physical and Occupational Therapy, McGill University, Montreal, QC, Canada;

² Feil and Oberfeld JRH/CRIR Research Centre, Jewish Rehabilitation Hospital site of the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal, Laval, QC, Canada;

³ Département de Neurosciences, Université de Montréal, Montreal, QC, Canada

Topic: Impaired motor control and rehabilitation

A-0118

POWER OUTPUT OF SPINAL CORD INJURED INDIVIDUALS DURING FUNCTIONAL ELECTRICAL STIMULATION DRIVEN BICYCLING LOWER LIMB MOVEMENT

Mariann Mravcsik¹, Andras Klauber², Jozsef Laczko^{1,3,4,5}

¹ Institute of Biology, University of Pecs, Hungary;

² National Institute for Medical Rehabilitation, Budapest, Hungary;

³ Department of Information Technology and Biorobotics, University of Pecs, Hungary;

⁴ MTA Wigner Research Centre for Physics, Budapest, Hungary;

⁵ Faculty of Information Technology and Bionics, Pazmany Peter Catholic University, Budapest, Hungary

Topic: Impaired motor control and rehabilitation

A-0122

EFFECTS OF NORDIC WALKING AND FREE GAIT TRAINING ON CLINICAL, FUNCTIONAL AND BIOMECHANICAL PARAMETERS IN SUBJECTS WITH PARKINSON'S DISEASE: RANDOMIZED CONTROLLED TRIAL

Flávia Gomes Martinez¹, Elren Passos Monteiro¹, Leandro Tolfo Franzoni¹, Giane Liedke¹, Patrícia Dias Pantoja¹, Leonardo Alexandre Peyré-Tartaruga¹

¹ Federal University of Rio Grande do Sul, Porto Alegre, Brazil

Topic: Impaired motor control and rehabilitation

25 JULY 2015 – 13:00 – 14:00 | POSTER GROUP 6.

A-0124

PHYSIOLOGICAL AND PATHOLOGICAL FACTORS INFLUENCING THE SCAPULOTHORACI MOBILITY

Alexandra Roren^{1,2}, Marie-Martine Lefevre-Colau^{1,2}, Sessi Acapo¹, Serge Poiraudau^{1,2}, Agnes Roby-Brami^{1,2,3}

¹ Department of Physical Medicine and Rehabilitation, Cochin Hospital (AP-HP), Paris Descartes University, Paris, France;

² Institut fédératif de Recherche sur le Handicap, INSERM, Paris, France;

³ ISIR (Institute of Intelligent Systems and Robotics), CNRS UMR 7222, AGATHE INSERM U 1150, Sorbonne Université, UPMC University Paris 06, Paris, France

Topic: Impaired motor control and rehabilitation

A-0125

THE ASYMMETRY OF FAST AND SLOW COMPONENTS OF DECOMPOSED COP SIGNAL IN PD PATIENTS

Grzegorz Juras¹, Kajetan Slomka¹, Bogdan Bacik¹, Janusz Blaszczyk¹, Joanna Siuda², Justyna Szefer³, Monika Rudzinska²

¹ Department of Motor Behavior, Academy of Physical Education, Katowice, Poland;

² School of Medicine, Medical University of Silesia, Katowice, Poland;

³ Department of Neurology, Central Clinic of Medical University of Silesia, Katowice, Poland

Topic: Impaired motor control and rehabilitation

A-0127

ACQUISITION OF MOTOR ACTIONS IN CHILDREN WITH MOTOR DIFFICULTIES

Roberto Gimenez^{1,4}, Dalton Lustosa de Oliveira^{2,4}, Raquel Simoni Pires², Edison de Jesus Manoel³

¹ Universidade Cidade de São Paulo - Master program in education - São Paulo- Brazil;

² Universidade Cidade de São Paulo - Doctoral program in physical therapy - São Paulo- Brazil;

³ Universidade de São Paulo - São Paulo- Brazil ⁴ Universidade Nove de Julho - São Paulo- Brazil

Topic: Impaired motor control and rehabilitation

ABSTRACTS OF THE INVITED SPEAKERS

NEURAL PATHWAYS MEDIATING CROSS EDUCATION OF HUMAN MOTOR FUNCTION**Richard G. Carson***Trinity College, Dublin, Ireland*

The potential for significant improvement of upper limb function during the post-acute phase following stroke is often dismissed. Yet it is now well accepted that in older adults – the group most likely to suffer a stroke, there remains the facility for the brain to undergo adaptive change and functional reorganisation. Cross-education is defined as an improvement in the performance of the untrained limb following unilateral training. In a number of recent studies (including randomised controlled trials) that dispel conventional assumptions regarding the utility of this phenomenon in stroke rehabilitation, it has been demonstrated for individuals in the chronic phase of recovery, there is positive transfer of motor skill learning from the healthy limb to the paretic limb. The broad aim of our research program is to establish the manner in which cross education may best be exploited in the service of rehabilitation.

While the behavioural expressions of cross-education have been documented thoroughly, the underlying physiological mechanisms remain poorly understood. We have shown previously that (at least in ballistic movement tasks) interlimb transfer of performance is not accompanied by changes in the excitability - as assessed by single-pulse transcranial magnetic stimulation (TMS), of circuits in the primary motor cortex (M1) that innervate corticospinal neurons projecting (via spinal motoneurons) to the muscles of the untrained limb. The acute neural adaptations that mediate bilateral performance gains are however associated with changes in muscle activation dynamics, of a character that suggests the mediation of brain networks functionally upstream of the elements within M1 that are recruited by single-pulse TMS.

Using analyses based on resting-state functional Magnetic Resonance Imaging (rs-fMRI) we obtained evidence that: following training undertaken by the left arm that gave rise to substantial interlimb transfer (and retention) of performance gains, functional connectivity was elevated within the resting motor network - between left and right supplementary motor area (SMA), and between left anterior cingulate cortex (ACC) and right posterior primary motor area (M1p). These changes were not however correlated with or predictive of individual levels of transfer.

In the same group of participants, analysis of the Diffusion Weighted Imaging (DWI) data using Constrained Spherical Deconvolution (CSD) based tractography indicated that the apparent fibre density (AFD) of the fibre bundles connecting left and right SMA was negatively correlated with and predictive of the extent of interlimb transfer, both when this was assessed acutely following the training performed by the left limb, and one week later. A replication including only the structural connectivity measures was conducted for

a separate group of individuals, wherein AFD in the tracts connecting bilateral SMA was again negatively correlated with and predictive of the degree of interlimb transfer.

The findings suggest that, at least for this motor task, interhemispheric interactions between bilateral SMA play an instrumental role in relation to cross education, and that the structural organisation of the intercalating white matter pathways is related to the level of transfer that is realised through unilateral training.

**MODELS OF HANDEDNESS AND BRAIN LATERALIZATION PROVIDE THE BASIS FOR
UNDERSTANDING IPSILESIONAL MOTOR DEFICITS IN STROKE****Robert L. Sainburg***Pennsylvania State University, USA*

The pervasive nature of handedness across human history and cultures is a salient consequence of brain lateralization. I will review evidence that provides a structure for understanding the motor control processes that give rise to handedness. According to the Dynamic Dominance Model, the left hemisphere (in right handers) is proficient for processes that predict the effects of body and environmental dynamics, while the right hemisphere is proficient at impedance control processes that can minimize potential errors when faced with unexpected mechanical conditions, and can achieve accurate steady-state positions. This model can be viewed as a motor component for the paradigm of brain lateralization that has been proposed by Rogers et al. (MacNeilage et al., 2009) that is based upon evidence from a wide range of behaviors across many vertebrate species. We have exploited the unilateral nature of stroke to test our hypothesis in patients with right and left hemisphere lesions. In addition to verifying our model of motor lateralization, these studies have elaborated and quantified the motor deficits that can occur in the ipsilesional arm of stroke patients. In many cases, ipsilesional deficits are substantial and functionally limiting, indicating that motor function in the non-paretic arm should be both assessed and often remediated in clinical rehabilitation

NEURAL CONTROL OF GRASPING AFTER SPINAL CORD INJURY**Monica A. Perez***University of Pittsburgh, USA*

The primary motor cortex and the corticospinal system contribute to the control of a precision grip between the thumb and index finger. Using noninvasive brain and peripheral nerve stimulation we provided evidence that the control of precision grip in humans involves premotoneuronal subcortical mechanisms, likely di-or polysynaptic spinal pathways, which are impaired after cervical spinal cord injury (SCI) and can be recovered by long-term baclofen use. We propose that spinal GABA_B-ergic interneuronal circuits, which are sensitive to baclofen, are part of the subcortical premotoneuronal network shaping corticospinal output during human precision grip. Typically, a cervical SCI leads to asymmetric functional impairments in the arms. We demonstrated that the more impaired arm has a detrimental influence on the grasping ability of the less impaired arm, which at least in part relates to abnormal control of EMG activity of the hand muscles. We propose that extrinsic (object) and intrinsic (speed) variables provide avenues to distinctly modulate grasping function after human SCI.

**EARLY AND CONTEMPORARY APPROACHES FOR APPLICATION OF FES IN MOVEMENT
REHABILITATION AFTER SPINAL CORD INJURY****Winfried Mayr***Medical University of Vienna, Austria*

Functional Electrical Stimulation (FES) can be a versatile tool for support of movement rehabilitation. On basis of non-invasive (electrodes at the skin surface) or invasive (implanted electrodes) techniques there are 3 options for reactivation of lost muscle functions:

- 1) Stimulation of efferent nerves - neuromuscular stimulation - as established method,
- 2) Direct activation of muscle fibers - muscle stimulation - in absence of the motor nerve, which can lead to similar contraction responses, and
- 3) Stimulation of afferent nerve structures, which can lead to improvement in impaired movement patterns by artificially substitution of missing neural inputs to central neuronal networks in the spinal cord - movement pattern generators.

Applications of electrical stimulation for restoration of movement reach back in the 18th century. At this time stimulators based on electrostatic discharge became available and were applied for treatment of post-stroke movement disorders. Though over the years we see a constant growth in the knowledge on physiology and pathophysiology of movement, technically supported rehabilitation methods and associated equipment progress was limited till the invention of the bipolar transistor mid 20th century that suddenly enabled the construction of compact battery-powered stimulators. Numerous non-invasive and implantable devices for a variety of applications were developed since, for experimental and clinical research, only few got transferred to market and permanent availability for patients in need.

Earlier concepts focused on stimulation of efferent motor nerves for direct reactivation of paralysed muscles or muscle groups to make FES induced muscle contractions act as kind of biological braces. Extension of these concepts to multiple channels and inclusion of biosignal and sensor feedbacks led to closed-loop approaches with the intention to come to more physiological execution of complex "more natural" movement patterns. Many difficulties were experienced regarding handling of equipment, costs and achievable stability of control.

In the recent past new developments started to rely more in taking advantage from remaining intact neural structures in and below the lesion zone in the spinal cord. There are promising developments in using non-invasive stimulation of posterior roots at the lumbar spinal cord level to assess, in combination with multi-channel EMG and sensor recordings, functional injury profiles. These can be of value for primary assessment and intervention planning as well as for monitoring of applied protocols and biological developments with time. Similar setups can act as neuroprosthesis for enabling, augmenting or modifying movements by influencing altered central control mechanisms via non-invasively or epidurally placed electrode arrangements.

CURRENT INSIGHTS INTO MOTOR LEARNING AND THEIR APPLICATIONS**Peter J. Beek***VU University, Amsterdam, The Netherlands*

During the last three decades or so much behavioral research on motor learning has been motivated from conceptual dichotomies reflecting different theoretical orientations. Dichotomies that figure prominently in the literature are internal versus external focus of attention, implicit versus explicit learning, “errorless” versus trial and error learning, variable versus repetitive practice (e.g., differential (or “differencial”) learning versus traditional learning) and self-controlled versus externally-controlled practice. The general picture that emerges from this large body of work is that motor learning is most effective (in terms of performance improvement, transfer and retention) when (i) an external rather than an internal focus of attention is adopted, (ii) implicit learning methods such as analogy learning and “errorless” learning are employed, (iii) practice is highly variable instead of repetitive and (iv) practice is self-controlled rather than imposed. However, the available evidence for each of these statements varies in volume, strength and consistency, and several exceptions to the general picture have been reported. There may be two reasons for the diversity of research findings. On the one hand, relevant factors such as the skill level of the participants, the nature of the to-be-learned task and individual differences in information processing and learning styles, as well as the interactions between these, have not been systematically investigated. On the other hand, it might be an intrinsic feature of motor learning that it can take many forms, implying that the dichotomies in question are in fact much less categorical than suggested by their either-or framing. More research is needed to determine how task-specific changes in motor control and coordination support behavioral outcomes, as a function of skill level and individual characteristics. In addition, future research should focus on the effectiveness of blended forms of learning, in which different methods of learning are combined so as to identify the most effective learning protocol. The latter endeavor may also allow for a potentially more productive form of interaction with professionals in relevant applied fields like physical education, sports, dance, music and rehabilitation. As it stands, the currently prevailing insights into motor learning are often at odds with conventional wisdom and common practice. Within the aforementioned fields there is an increasing recognition of this fact as well as a preparedness to modernize more traditional learning practices on the basis of current insights. Examples of recent developments drawing from elite sports and rehabilitation will be presented, followed by a discussion of how, conversely, research on motor learning might benefit from the experience and expertise of professionals in these domains.

**ANTICIPATORY BEHAVIOR IN OBJECT MANIPULATION: LEARNING AND ALTERATIONS
FOLLOWING BRAIN DAMAGE****Joachim Hermsdörfer***Technical University of Munich, Germany*

Interacting with objects in our environment would be terribly slow if we solely rely on feedback information about the objects' characteristics. Rather we predict the relevant object properties and scale our motor output according to our prediction. During the manipulation of grasped objects, this anticipatory behavior can be inferred from the time course of the grip force increase during the first instances after contact with the object before relevant sensory feedback information is available.

Knowledge about object properties can be acquired by developmental learning, such as knowing that a larger object is heavier than a smaller object of the same material, or can be learned by associative learning, if for example the different colors of two novel objects indicate differences in weight.

We have compared the precision of anticipating objects' weight on the basis of size information with newly learned color information. Both cues effectively modulated the time course of the grip force increase (steeper increase for the larger object or the heavier object according to the color code). Size however induced a stronger effect. Interestingly, when associative learning of the color code was combined with an unrelated working memory task, anticipation developed slower and was less distinct for the two objects.

In a second line of experiments we tested the hypothesis that damage to the motor-dominant brain deteriorates the precision of anticipating object properties. Accordingly we asked patients with stroke of the left or the right hemisphere to grasp and lift objects with different properties using the ipsilesional "non-paretic" hand. When the effect of object size information was tested, most of the patients and control subjects scaled the grip force according to size. Since material information may be less rigidly implemented in the nervous system than size information, we next compared expanded polystyrene and metal-looking objects. Again patients performed largely similar to control subject and scaled their grip force according to the different materials. If however the relevant object properties were only accessible by object identity and not by overt physical characteristics such as size and material, the patients failed to scale the grip force according to weight. Thus patients' grasped a light package of biscuits with the same early grip force rate as a similar-sized but much heavier book. This deficit was more obvious in patients with left brain damage compared to right brain damage.

In conclusion, our results on associative learning of anticipatory grip force control in healthy subject and on the effects of different cues in brain damaged patients indicate that different cues are differently represented in the central nervous system. Physical cues seem to be very rigidly implemented and anatomically distributed, while cues that have to be learned by associations are more vulnerable to resource limitations during learning and to damage of the central nervous system.

DISTINGUISHING INTENT AND VOLITION THROUGH STOCHASTIC SIGNATURES OF MOTOR OUTPUT VARIABILITY**Elizabeth B Torres***Rutgers University, USA*

As an athlete masters new skillful motions the unfolding trajectories of his movements vary from moment to moment. The variability inherently present in the trajectories of his body segments automatically reveals movement classes that distinguish deliberate portions of purposeful motions from spontaneous transitional portions that are incidental to the goals and occur largely beneath awareness. During the athlete's practice, the interplay between these movement classes can be monitored and various perturbations introduced to distinguish intent from volition. Intent in this context refers to a disembodied conceptualization of a desirable trajectory, whereas volition refers to the physical realization of that trajectory to fulfill the task's overall purpose. Intended motions do not necessarily match willfully executed physical motions all the time. The mismatch may occur even in situations when the physical trajectory reaches the goal at will. For example we may intend to move the hand along a straight-line path to a visual target but our physical realization of the intended hand trajectories may have excess curvature due to internally generated after effects from movement practice (i.e. after effects that are not caused by the imposition of external forces.) In such cases there is control at will of the physical motion and the goal may be attained, but a mismatch between the intended and the physically realized motion trajectory may persist. A simple way to probe the system and assess the alignment or misalignment between intention and volition can be through manipulations in the movement dynamics. When changes in speed do not alter the geometrical aspects of the deliberate motions the intended action is aligned to its physical execution. In the case of misalignment, various geometric ratios break down and the physical trajectories accomplishing the desired end goal do not match the athlete's intended ones.

In marked contrast to the intended trajectories that unfold under tight volitional control, are the spontaneous transitional segments of natural motions occurring largely beneath awareness. These incidental motion segments are much easier to identify as they do change the shape of their trajectories with changes in speed. Various characterizations of the stochastic signatures of motor output variability of the deliberate and spontaneous motions reveal fundamental differences between these movement classes that can help us further differentiate intent and volition. Besides clearly distinguishing between deliberate and transitional movement segments, the stochastic signatures of various trajectory parameters can also blindly predict the context and situation where the movements most likely took place. We present examples of these general phenomena in simple routines of martial arts and the tennis serve. We also present various new methods to study sports and ballet training under a new statistical framework that has helped us better characterize various underexplored kinesthetic re-afferent aspects of volitional movements. These empirical findings pose new questions and invite new theoretical conceptualizations to use the distinction between intent and volition in clinical settings

FACILITATION AND INTERFERENCE IN THE LEARNING OF MOTOR TASKS

Robert A. Scheidt*Marquette University, Milwaukee, WI, USA*

Skill is the ability to bring about some end result with maximum certainty and minimum outlay of time and energy. In acquiring skill, previously learned tasks can profoundly influence learning. Transfer of skill between tasks can be positive (facilitation) or negative (interference). Traditional accounts of skill transfer depend on notions of task similarity such as the “theory of identical elements”, “stimulus response compatibility” and the “structural learning hypothesis”. Here I describe experiments designed to elucidate: 1) how people form new patterns of coordination when learning a skill *de novo*, and 2) which specific task characteristics need to be “similar” or “dissimilar” for positive or negative transfer to occur between motor tasks. Participants wore a data glove and learned to control the two-dimensional $\{x,y\}$ motions of a virtual object (a cursor) by finger motions (Mosier et al., 2005). In support of structural learning, subjects gradually identified a subset of finger motions that influenced task performance and restricted exploration to stay within this subspace of control; we refer to this subspace as the “task space”. Subjects also learned to avoid finger motions that did not affect performance; we refer to this second subspace as the task’s “null space”. We then required subjects to learn two tasks, which we called the “prior task” and the “criterion task.” We manipulated the mapping between finger and cursor motions so that the task space of the prior task either shared or did not share task space dimensions (x - y axes) of the criterion task. We observed positive transfer when the two tasks shared task space dimensions and negative transfer when they did not. Thus, similarity in task space dimensions between two tasks is a critical variable influencing whether prior learning of one skill facilitates or interferes with the learning of a second skill. Moreover, the data suggest that this transfer is caused by preferential exploration along previously learned task spaces.

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MODULARITY FOR MOTOR CONTROL AND MOTOR LEARNING

Andrea d'Avella*University of Messina, Messina, Italy*

How the central nervous system (CNS) overcomes the complexity of multi-muscle and multi-joint control and how the CNS acquires and adapts motor skills are fundamental and open questions in motor neuroscience. Knowledge of the dynamics of a multi-DOF system and of the requirements and constraints of specific tasks may simplify control. For example, in robotics, knowledge of the robot motion equations allows computing the torques necessary to generate a desired motion. As it is unlikely that the CNS stores explicit analytical internal models of the musculoskeletal system and of the tasks, such knowledge may be implicitly incorporated in the organization of modules used to construct motor commands. A modular control architecture can generate motor commands for a variety of tasks and task conditions by flexibly combining shared modules embedding features of both the system dynamics and the tasks. If a small number of modules is sufficient to generate adequate motor commands, the complexity of control is reduced by directly mapping task goals into a small number of module combination parameters. Several investigations of the electromyographic activity recorded from many muscles during the performance of different motor skills have shown that motor commands are generated by the combination of a small number of muscle synergies, coordinated recruitment of groups of muscles with specific amplitude balances or activation waveforms, thus supporting a modular organization of motor control. Modularity may also help understanding skill learning. If a new skill can be performed using existing modules, learning can be achieved by acquiring a new low-dimensional mapping of goals into combination parameters. However, a skill may require new modules and learning new modules is likely slower than learning new mappings. Thus, compatibility of the modules required for a new skill with the modules for existing skills may affect learning difficulty. A recent study in which human subjects used myoelectric control to move a mass in a virtual environment has shown that the difficulty in adapting to a perturbation depends on the compatibility of the perturbation with the muscle synergies used to generate hand force. By altering the mapping between recorded muscle activity and simulated force applied on the mass, as in a complex surgical rearrangement of the tendons, it has been possible to show that it is easier to adapt to a perturbation that is compatible with the existing muscle synergies than to a similar but incompatible perturbation. These results suggest that motor learning relies on two adaptive processes: a fast learning of module combinations and a slow learning of module structure.

THE BUILDING BLOCKS OF PREHENSION**Jeroen Smeets***VU University, Amsterdam, The Netherlands*

Prehension is a prototype of human movement coordination. Since the pioneering work of Marc Jeannerod, this movement is generally considered to be a coordinated combination of hand transport and grip formation. One of the main theoretical reasons for choosing transport and grip as building blocks is that they are anatomically independent: one can determine for each muscle, joint or brain area whether it belongs to transport or grip. We propose a different view on grasping, in which the coordination problem is formulated as one related to the movements of the digits. According to this view, both the transport of the hand and the formation of the grip emerge from the combination of independent digits' movements towards the objects' surface. This independency of the digits might seem counterintuitive, as the muscles that are used to move the thumb to the object are to a large extent the same as those that are used to move the other digits. However, we propose that the independency of the digits is not anatomically defined but is defined at a more abstract level. It resembles the independence of synergies (as discussed by d'Avella in this session). A synergy is a set of muscles that is activated in a coordinated way. Different synergies are activated independently, but a single muscle can be part of several synergies. In this talk I will present a selection of the experimental evidence (including data on visuomotor adaptation) that we collected to support this view that the digits' movements are the building blocks of prehension.

NEURAL ENCODING OF SPATIOTEMPORAL SKILLS**Katja Kornysheva***Institute of Cognitive Neuroscience, University College London, UK*

In order to reliably produce intelligible speech or fluently play a melody on a piano we need to learn how to successively activate our muscles following a specific temporal pattern. Surprisingly, the fundamental question of how memories of complex temporal dynamics of movement are stored across the brain is still unresolved. The dynamical systems view holds that the spatiotemporal evolution of an action is encoded in the intrinsic dynamics of a pattern generator with the muscle commands inseparably represented from their timing. In contrast, our results from behavioural experiments and representational neuroimaging analyses in humans suggest that premotor areas in the neocortex automatically parse skilled movement sequences into two separate representations: the spatial (the order of movements in space) and the temporal (the timing of these movement in a sequence) features. This corresponds to recent findings in songbirds. Such a modular representation of sequential features allows the learner to efficiently generate new combinations of spatiotemporal sequences without the necessity of forming execution-related representations *de novo*.

**TOWARD AN INTEGRATED NEURAL DYNAMIC APPROACH OF OBJECT-ORIENTED
MOVEMENT****Gregor Schöner***Ruhr University, Bochum, Germany*

Reaching to grasp an object requires a tight integration of at least five processes:

1) scene perception that includes the segmentation of an object and an estimation of its pose; 2) preparing the movement, taking into account the location of the object relative to that of the effector; 3) behavioral organization that includes minimally the initiation and then termination of the movement, but may also involve sequences of actions; 4) generating the time course of the movement that is coordinated across effectors and with any perceived motion of the object; 5) generating the physical movement including distributing the spatio-temporal movement commands to the degrees of freedom and to the muscle systems. What characterizes human movement (as compared to much robotic movement, for instance) is the seamless integration of all these processes. In response to perturbations or changes of the scene, for instance, all processes can be continuously updated online in a coordinated fashion. I will review neural and behavioral evidence that narrows down the range of possible theoretical accounts and will propose neural dynamics as a framework for understanding all the component processes and their integration. I will report on progress on several fronts toward such an integrated approach, using robotic demonstrations to illustrate that a true process understanding has been achieved. I will also point to open issues that need to be addressed before a fully integrated neural process account of object-oriented movement is achieved.

INTENTIONAL AND UNINTENTIONAL MOVEMENTS WITHIN THE EQUILIBRIUM-POINT HYPOTHESIS

Mark L. Latash*The Pennsylvania State University, USA*

One of the crucial assumptions within the equilibrium-point hypothesis is that the neural control of action can be adequately described as time shifts of neural variables resulting in trajectories of spatial referent coordinates for the involved effectors. At the single-muscle level, the referent coordinate is equivalent to the threshold of the tonic stretch reflex, λ . For multi-muscle actions, a hierarchical scheme has been suggested with a low-dimensional, task-specific input representing referent trajectories for salient variables, and a sequence of few-to-many mappings ultimately resulting in λ values for all the muscles. The mappings are assumed to be organized in a synergic way, which means that the high-dimensional output can show high variance as long as it is compatible with low variance of its salient action defined by the input. This scheme predicts equifinality (returning to a state or to a trajectory following a transient perturbation) in the space of task-specific variables and its violation in the spaces of elemental variables at different levels of the assumed hierarchy. This prediction has been confirmed experimentally in multi-digit, multi-joint, and multi-muscle spaces. A series of recent experiments, however, also provided examples of violations of equifinality at the task level. When a person is asked to perform a steady-state action and “not to interfere” with effects of perturbations, the application of a transient mechanical perturbation leads to a different final steady state if the perturbation involves a dwell time between its application and removal. In experiments with multi-joint hand movements, a drift of the referent hand coordinate has been demonstrated with the characteristic time of about 1 s. There was also a simultaneous drift in the arm apparent stiffness, which allowed the hand to stay at a steady position during the dwell time. The observed violations of equifinality have been interpreted as reflections of an unintentional drift of the hand referent coordinate towards its actual coordinate. This phenomenon, addressed as RC-back-coupling, can be viewed as a reflection of the natural property of physical systems to move towards states with low potential energy. The RC-back-coupling hypothesis allows offering an interpretation for other phenomena including, in particular, the unintentional force drift in tasks with constant force production observed after turning the visual feedback off. The time constant of the force drift in those studies, however, was much longer, on the order of 10-15 s. Currently we are exploring a scheme involving slow drifts of abundant systems along the uncontrolled manifold (UCM, space of no changes in a performance variable) and fast drifts orthogonal to the UCM. To summarize, the equilibrium-point hypothesis and its recent developments have provided a very fruitful framework for analysis of a range of phenomena characterizing biological movements. It has been a very important step towards developing a truly scientific approach to motor control, that is, physics of biological movement.

EXPLANATIONS OF DISORDERED MOTOR CONTROL BASED ON THE EP HYPOTHESIS

Mindy F. Levin*McGill University, Canada*

Recovery of voluntary control of movement is the main goal of rehabilitation. Despite numerous studies aimed at identifying the most effective rehabilitation interventions, attempts to improve post-stroke upper limb recovery remain disappointing: sensorimotor deficits of the arm and hand persist in a large proportion of stroke survivors (up to 62%). Indeed, efforts to improve upper limb recovery have been hampered by the lack of understanding of the neural mechanisms underlying spasticity, muscle weakness and altered kinematic redundancy. Spasticity refers to the presence of hyperactive velocity-dependent stretch reflexes and is associated with disorders of upper motor neurons following central nervous system (CNS) injury such as stroke. Since it is associated with disruption of upper motor neuron function, those with spasticity typically also have weakness and decreased control of voluntary movements. Despite intensive research into these phenomena however, the nature of the relationship and neural mechanisms underlying spasticity, weakness and voluntary control remains unclear. This relationship may be understood within the context of the equilibrium-point theory of motor control. The theory describes how central regulation of reflexes, including the stretch reflex, results in different motor actions, in particular, muscle relaxation, motion, and isometric torque production in single- or multi-joint systems. Research in animals and in healthy subjects suggests that the tonic stretch reflex threshold (TSRT) may be altered by descending systems mediating both direct and indirect influences on motoneurons. The TSRT also depends on the velocity of change in the muscle length. How deficits in agonist-antagonist muscle activation at the elbow and ankle in patients with spastic hemiparesis are related to limitations in the range of regulation of the TSRTs will be discussed. The discussion will extend to deficits in multi-joint control in subjects with spasticity and to the ability of a measure of TSRT to discriminate between different types of hypertonic disorders. Limitations in the regulation of TSRTs result in a subdivision of all-possible elbow or shoulder-elbow arm configurations into different spatial zones in which spasticity, weakness, the ability to make intentional movements by producing a reciprocal activation of agonist and antagonist muscles, or only coactivation of antagonist muscles can occur. The implications for motor learning and recovery will be discussed.

MINIMIZATION PRINCIPLES AND REDUNDANCY PROBLEMS IN THE CONTEXT OF REFERENT CONTROL OF ACTION AND PERCEPTION**Anatol G. Feldman***University of Montreal, Canada*

Bernstein (1967) emphasized the necessity of solving the redundancy problem by answering the question of how the nervous system chooses a specific combination of degrees of freedom from many possible combinations each time a goal-directed movement is made. According to the equilibrium-point theory, control levels of the nervous system do not dictate which and how degrees of freedom or muscles should participate in reaching a motor outcome. Instead, these levels change specific neuro-mechanical parameters that only narrow the set of possible motor actions whereas a particular motor action from that set emerges due to the interaction between the organism and environment. These parameters pre-determine where, in spatial coordinates or frames of reference, the neuromuscular periphery should work, rather than how it should work. This *modus operandi* is called "referent control". Referent control is associated with a global minimization process: the neuromuscular periphery tends to minimize, in the limits of internal and external constraints, the difference between the emergent, actual biomechanical variables and their referent values specified by neural control levels. A minimum is associated with reaching an equilibrium state in the interaction between the organism and the environment. The minimization process always yields a unique motor action. However, the uniqueness of the motor action is not defined by the nervous system *per se*: it results from the interaction between the organism and the environment. If the emergent action does not meet the motor goal, the system modifies referent control until the goal is reached. Referent control thus opens a new perspective in approaches to redundancy problems in biological systems by emphasizing the role of the environment in solving these problems. How referent control may be used to produce reach-to-grasp and other movements will be discussed.

EP SHIFTS AS THE BASIC BUILDING BLOCK FOR HUMAN MOVEMENT**Joseph McIntyre***Tecnalia Health Research Institute, Spain*

Since its inception the Equilibrium Point (EP) hypothesis in its various forms has inspired any number of empirical and theoretical studies of human motor behavior. A key principle of this theory is that the movement of the limb and/or the force that it produces are dependent not only on the motor commands sent by the CNS to the muscle but also on the characteristics of the physical environment in which this motor program is played. In this talk I will describe a set of experiments in which we showed that what humans internalize when asked to reproduce a remembered force is in fact a representation of the shift in the equilibrium configuration used to generate that force. These experiments support the notion that EP control forms the basic building block of human movement control. Then, in the spirit of the 50th anniversary of the EP hypothesis I will describe how EP principles in fact underlie more recent theories of motor control principles, demonstrating how the CNS might assure stable and robust behavior when constructing motor commands based on multi-layered cortical and sub-cortical control loops.

HUMAN-MACHINE INTERFACES: BRAIN AND BODY

Ferdinando A. Mussa-Ivaldi

Rehabilitation Institute of Chicago, USA

Since the beginning of the millennium (and well before then) the fancy of lay people, writers and scientists has been captured by the dream of extracting human intentions from neural activities and translating these in commands to robots and other devices. The frontier in brain-machine interfaces now is the establishment of adaptive bi-directional, closed loop interactions between neural and artificial systems, where decoding motor intention is coupled with encoding the state of the external system in patterns of stimuli, as a form of artificial proprioception. The promise that so much fascinates the media is the possibility of “controlling by thought.” But is this a biologically and clinically meaningful goal? I will present a different perspective, where the external devices are controlled not by brain activities but by overt motions of the body. In this body/machine interface paradigm many of the encoding/decoding issues are identical to those encountered in the brain/machine communication. But the body-machine interface aims not only at controlling devices, but also at empowering paralyzed people to use their intact body skills, at recovering lost mobility and at developing new forms of motor dexterity.

I will present an overview of four key challenges in the current development of human-machine interfaces based on the reorganization of body motions that remain available to their paralyzed users:

- 1) The identification of mapping systems for the optimizing the human/machine interactions. In particular, I will describe the use of methods for embedding the space of machine controls within the space of signals generated by body motions.
- 2) Programming the interface for combining assistive a rehabilitation goals. These are effectively opposing goals. While assistive devices are normally interfaced with their users so as to require minimum control effort, rehabilitation exercises are designed to encourage engagement in challenging activities.
- 3) Concurrent human/machine learning for adapting the interface to the improving or degrading skills of their users. The adaptation of a human machine interface is likely to take place in parallel with human learning. How should the machine learning parameters be adapted to the user’s learning dynamics?
- 4) Integration of artificial proprioception to provide direct feedback of the controlled devices. I will briefly review some issues concerning the use of vibrotactile stimuli to facilitate human motor control and learning.

FROM LINEAR TO NONLINEAR MOVEMENT MODELS**Patrick van der Smagt***Technical University of Munich, Germany*

Combining neuroprosthetic with biomechanical data, a number of arguments can be put forward suggesting that our brain really has an easy job controlling our limbs. Movement analysis suggests that our central nervous system is based on a robustly modellable underlying neuromuscular structure---while at the same time the musculoskeletal system is quite nonlinear.

Yet movement involves more than moving a point in space: in principle, the complete impedance problem must be solved. Measuring human strategies to this effect is almost prohibitively complex. How do these issues affect brain-machine interfaces? In this talk I will explain the development and use of recurrent deep neural networks used as generative models of the peripheral neuromuscular system. With these we can close the control loop for impaired individuals while learning about human motor control. Some patient-centred examples demonstrate the viability of the approach.

DEVELOPMENT OF AN AFFERENT NEURAL INTERFACE DESIGNED TO MIMIC NATURAL PROPRIOCEPTION**Lee Miller***Northwestern University, Chicago, USA*

We have developed an efferent brain machine interface (BMI) that allows monkey subjects to grasp objects despite a peripheral nerve block causing complete paralysis of the flexor muscles below the elbow. We anticipate that such a system might ultimately provide spinal cord injured patients with control of arm and hand movements through normal cognitive processes, and greatly enhance their independence and well-being. However, a major issue to be addressed in the development of more effective BMIs is the need to provide somatosensory feedback. Proprioception is essential for normal movement. Its loss largely eliminates the ability to plan movement dynamics or to make rapid corrections to limb perturbations. Existing BMIs rely exclusively on visual feedback, which may account in part, for their relatively limited performance. The representation of proprioceptive signals within the cortex has been far less studied than has touch, and while some progress has been made toward restoring touch through intracortical microstimulation of somatosensory cortex (S1), there has been as yet, very little corresponding success for proprioception.

We have completed a series of multi-electrode recording experiments designed to study the way limb movements are encoded by neurons in area 2 of S1. These neurons signal limb movement, whether generated actively by the monkey or as the result of a passive limb displacement. The discharge of most neurons is tuned to the direction of hand movement, and can be summarized reasonably accurately by a single "preferred direction" (PD). Much as in motor cortex, there is a roughly sinusoidal modulation of firing rate for movement directions away from this PD. Many of these neurons are also influenced by external forces that oppose movement. Furthermore, there is evidence of an efference copy component of S1 activity that precedes the onset of active movement, and is well aligned spatially with the later, afferent component. The representation of movement direction by populations of neurons is linearly separable, as is the brain state representing active and passive movements. The latter is likely due to the interaction of kinematic and force representation.

We have now begun a new series of experiments, the goal of which is to use our knowledge of the representation of limb state by S1, to evoke a sensation of directed limb movement by stimulating electrodes within S1 to recreate natural patterns of cortical activity. We have shown that stimulation of multiple electrodes, each with subliminal currents, yields an effect greater than the theoretical linear combination of the individual electrodes. By stimulating small groups of electrodes with similar PDs, we have succeeded in inducing perceptions of limb motion that appear to be similar to those caused by actual movement. We are working to develop a neuroprosthesis based on continuously varying stimulation of many electrodes, in order to restore a sense of limb state to patients with high-level spinal cord injury.

HUMAN MACHINE INTERFACE: USING CIRCUIT-BASED INFORMATION (CBI)

Apostolos P. Georgopoulos

Department of Neuroscience, University of Minnesota, Minneapolis, USA

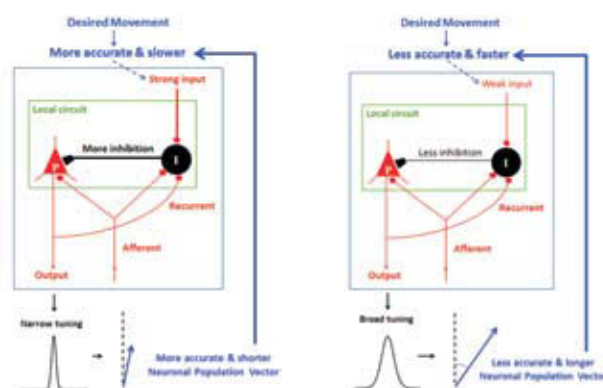
The use of multielectrode recordings from the motor cortex to control prosthetic devices or paralyzed limbs is now at the forefront of brain-machine interface research, development and applications to primates and humans. The field encompasses multiple coordinated domains, including, but not limited to, motor behavior, neurophysiology, materials sciences, engineering, computer science, modeling, robotics, and neurosurgery. This confluence of multiple disciplines towards a single goal to restore motor functional capability using neural signals to control artificial or paralyzed limbs has revolutionized the field of motor control and has opened new vistas in understanding brain function as well as in intervening to modulate it. Most importantly, recordings in humans have confirmed basic principles derived from previous experiments in monkeys, notably the directional tuning of motor cortical cells and the utility of the neuronal population vector to yield a control signal for prosthetic arm motion in space. The extraction of useful information from recorded brain activity has become increasingly sophisticated to include control signals for hand motion, in addition to arm movement, although much is left to be accomplished to achieve fluid control of coordinated and independent finger movements, a hallmark of human hand function. In a way, information extracted from recordings might be approaching an asymptote, and, indeed, time has come to try new means to move forward in neuroprosthetic control. Such approaches include electrical microstimulation from multiple motor cortical sites and the addition of somatosensory (or other) feedback to optimize prosthetic control.

A different, yet unexplored, approach would operate at the level of the neural circuit to extract Circuit-Based Information (CBI) that could be used in at least two different ways: first, to enhance the decoding range and accuracy of ensemble neural activity, and second to enable successful intervention on the circuit operation by various methods, such as electrical microstimulation, local infusion of chemicals, and/or optogenetic selective interference (temporary activation and/or elimination) with specific elements of the circuit. (a) The decoding range and accuracy could be enhanced by taking into account the interactions among circuit elements, both along a cortical column and across neighboring columns. This time-varying interaction matrix could be further refined by identifying the location and neuronal species of the elements of the circuit constituting the matrix, e.g. their layer, whether they are pyramidal cells (and if so, of what kind of discharge pattern), other kind of projection cells (e.g. Martinotti cells), excitatory interneurons, or inhibitory interneurons (and if so, of what kind). An adequate time-varying CBI would then consist of the ongoing individual cell activities in the circuit and the interactions among those activities (neutral; or excitatory, inhibitory, and their lags, using crosscorrelation analysis). The next step would be to associate the CBI with peripheral motor variables, including global movement parameters as well as state of motoneuronal pool activation, using a multivariate modeling approach. This knowledge would then be used to better control prosthetic devices and/or better define parameters of intervention, e.g. multisite stimulation. (b) The design of any intervention on the circuit (e.g. electrical stimulation or optogenetic stimulation) would profit greatly from CBI, which would provide the dynamic framework within which the intervention would operate. For example, selectively turning on or off inhibitory interneurons of a specific kind at the proper time and for the proper duration could be crucial in improving the specificity of the effect of the intervention. We proposed recently that local inhibitory mechanisms may be intimately involved in controlling the directional accuracy and speed of the reaching movement [1, 2]. Specifically, we hypothesized that the width of the directional tuning curve could be the key factor governing the directional accuracy of the population vector and its instantaneous length (and, hence, movement speed). This hypothesis was first tested using modeling, as follows [1]. We varied systematically the width of the directional tuning curve and determined the direction and length of population

vectors calculated from sets of tuning curves of different widths. These results of the modeling studies were confirmed by applying the same analyses to experimental data from previous motor cortical recordings [3]. In addition, it was found from the latter analyses that the rate of cell discharge during a control period (during which the monkey was exerting a constant load) was significantly and positively associated with the width of the tuning curve. This implies, in turn, that this “resting” discharge rate could specify the directional accuracy and speed of reaching. Since it is very likely that the resting discharge rate would be the outcome of a varying strength of inhibition, it follows that this could be the neural mechanism by which variable inhibitory drive would control coding of key movement parameters and, hence, could be a target for intervention. This idea is illustrated for the two cases of more accurate (and slower) vs. less accurate (and faster) movements in the figure below.

In summary, it is clear that neuroprosthetics is the arena for the ultimate testing of the utility of movement coding schemes in the motor cortex. Unlike pure theory or speculation, neuroprosthetics is the real-world platform where coding schemes can be tested. The fact that the population vector decoding has been very successful in motor cortical prosthetic control [4] is itself evidence for its utility, and the utility of the foundation upon which the calculation of the population vector is based, namely directional tuning of motor cortical cell activity. Further advances in neuroprosthetics may help clarify many open questions in systems neuroscience, including how sensory feedback modifies motor signals, mechanisms of motor skill learning and memory, cognitive motor functions, and the role of oscillatory/synchronous neural activity in neural codes. CBI would be gradually enhanced by enlarging the scope of the active circuit to include other, interacting brain structures, such as the somatosensory cortex and the thalamus. Finally, manipulating local inhibitory drive might prove a useful and effective tool in improving voluntary control of prosthetic limb movements. All of these are challenging objectives but, I believe, very feasible given the current status of technological sophistication and tools.

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4. Collinger JL, et al. (2013) High-performance neuroprosthetic control by an individual with tetraplegia. *Lancet* 381:557-564



Schematic diagram to illustrate the hypothesis of directional accuracy via a variably tuned inhibitory drive. Left panel: Strong inhibitory drive leads to accurate and slower movement by reducing the directional tuning width and producing an accurate and short population vector. Right panel: Weak inhibitory drive leads to less accurate and faster movement by increasing the directional tuning width and producing a less accurate and longer population vector. (See abstract for details.) Red and black terminals indicate

**PLASTICITY IN THE IPSI AND CONTRALESIONAL MOTOR NETWORK FOLLOWING STROKE
IN ANIMALS MODELS****Numa Dancause***University of Montreal, Canada*

After a middle cerebral artery occlusion (MCAo), the most common site of occlusion leading to stroke, there is often damage to the primary motor cortex (M1). These lesions cause deep functional deficits, mainly to the contralateral limbs. Some recovery occurs in the weeks and months that follow the lesion and is associated with reorganization of distant cortical areas of the ipsi and contralesional hemispheres. In the ipsilesional premotor areas, there are changes of neuroanatomical projections and of cortical motor maps that are sensitive to the size of injury. In a recent series of experiments in rats, we found that the reorganization of contralesional premotor cortex is also affected by lesion size. In contrast, cortical injury had little effect on the motor maps in the contralesional M1. These data suggest that the contralesional premotor cortex may play a greater role in the recovery of the paretic forelimb following large lesions. In another series of experiments, we used pharmacological methods to study the effects of inactivation of the contralesional M1 on recovery. We found that contralesional inactivation initiated within hours after a cortical lesion can improve recovery of the paretic forelimb. Increasing the duration of the inactivation improved motor outcomes, and delaying the onset was detrimental to recovery. The contralesional motor areas could affect recovery through the powerful and complex interhemispheric interactions that we find between these areas.

**CAN MOTOR RECOVERY IN PATIENTS AFTER STROKE BE IMPROVED BY NON-INVASIVE
BRAIN STIMULATION?****John Rothwell***University College London, UK*

Transcranial magnetic stimulation and transcranial direct current stimulation (sometimes known collectively as “non-invasive brain stimulation”) can change the activity of neurones in the human brain. If they are applied for several minutes they can produce after-effects on the excitability of the stimulated regions that outlast the period of stimulation. These may result from plastic changes in the strength of neural connections. Many centres have attempted to employ these effects in a therapeutic setting to enhance recovery and learning of new skills after injury, but the results from different centres have been mixed: sometimes spectacular, sometimes null. I will explore some of the causes of this: some are controllable, some are individual to the brain of the person stimulated. Is this a clear case for personalised medicine?

DO THE ARMS PLAY A ROLE IN THE REHABILITATION OF WALKING AFTER SPINAL CORD INJURY?

Vivian K. Mushahwar

*Division of Physical Medicine & Rehabilitation, Department of Medicine and Centre for Neuroscience
Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alberta, Canada*

Locomotion relies on the integration of cortical input, sensory feedback, and activity in spinal networks. The spinal networks in the cervical and lumbar cord are actively coupled during locomotion, and the involvement of the arms shapes leg activity. Nonetheless, current rehabilitation interventions for walking focus only on the legs. After spinal cord injury (SCI), the arms may play an important role in reorganizing the spinal intersegmental networks and improve leg function. The overall goal of this project was to assess the importance of the arms in the rehabilitation of walking after incomplete SCI. We also investigated the nature of coupling and modulatory interactions between the arm and leg centres in the spinal cord during locomotion, and assessed the effect of arm movements on the corticospinal drive to the legs. The results suggest that a training paradigm involving the arms provides better improvements in walking capacity than a training paradigm focusing on the legs only. A strong interspinal coupling between the cervical and lumbar regions of the spinal cord exists during locomotion, and rhythmic activation of the arms enhances the corticospinal drive to the leg region. We conclude that the arms may indeed play an important role in the rehabilitation of walking after iSCI. This could also be the case for the rehabilitation of walking in other conditions including stroke, multiple sclerosis and cerebral palsy.

**CONTROLLING CYCLIC LIMB MOVEMENTS
IN REHABILITATION OF SPINAL CORD INJURED INDIVIDUALS**

Jozsef Laczko

University of Pecs, Hungary, Wigner Research Centre for Physics & Pazmany Peter Cath. Univ. Budapest, Hungary

In order to establish stimulation patterns for functional electrical stimulation (FES) of spinal cord injured (SCI) individuals we analyse cycling limb movements of able bodied people. Kinematic and EMG data recorded during upper- and lower limb cycling are analysed for this purpose. One aim is to define stimulation patterns for spinal cord injured individuals to make them able to drive the crank of an ergometer by their own (electrically stimulated) muscles with altering cycling cadence and against altering crank resistances. This allows them to produce larger power output, that helps them to maintain their cardiovascular, respiratory functions and enhance their general physiological well being.

Increased power output can be gained by increasing cycling cadence or by cycling against increased crank resistance. This might be achieved by reducing the co-activation of flexor-extensor muscles and/or by increasing individual muscle forces. Co-activation during lower limb cycling is quantified by the range of angular crank positions accompanied to simultaneous activities of hamstrings-quadriceps muscles. Analyzing the data of able bodied participants, we found that when cycling against increased crank resistance, muscle co-activation range decreased. This may reflect a control strategy adapting to altered external forces.

Another question is that how the activity levels (EMG amplitude) of knee extensor and flexor muscles change if cycling cadence or crank resistance is increased? Comparison of muscle activities shows that when cycling faster, hamstrings activity increases generally at a higher rate than that of quadriceps. The change of muscle activities with respect to cadence change is not resistance invariant. The average EMG amplitudes increase at a higher rate with respect to change of cadence when cycling against higher (but constant) resistance. Similarly, EMG amplitudes increase at a higher rate with respect to change of resistance if cycling cadence is higher.

Analysis of upper limb cycling will also be reported and compared to lower limb cycling. For these movements there was no significant difference between the range of co-activation of biceps and triceps muscles obtained in various resistance conditions, neither between co-activation ranges of Delta anterior and Delta posterior.

Our observations help to define stimulation patterns for FES driven cycling of SCI individuals. The persons who participate in this training program may reach increasing power output at consecutive trainings. Interestingly, generally not the power output but produced mechanical energy is increased in consecutive training sessions. The reason of this is that SCI participants prefer cycling longer against a given resistance instead of increasing the resistance level. Although an adequate stimulation pattern (timing of muscle activities) make them able to cycle against higher resistance.

The effect of stimulation frequency on power output will also be presented. An „optimal” stimulation frequency varies among individuals. However, for each participant increased power and energy output is an invaluable psychological benefit, since they see that during FES trainings they are able to drive the stationary bike by their own muscles, even if the motor command is not arriving from their brain to their muscles.

ABSTRACTS OF SHORT ORAL PRESENTATIONS

INSIGHTS INTO THE MECHANISMS MEDIATING CROSS-LIMB TRANSFER FOLLOWING UNILATERAL BALLISTIC MOTOR LEARNING

Tino Stöckel^{1,2}, Mark R. Hinder¹¹ Human Motor Control Laboratory, School of Medicine, University of Tasmania, Hobart, Australia² Sport & Exercise Psychology Unit, Department of Sport Science, University of Rostock, Germany

Introduction: Cross-limb transfer is the performance benefit conferred in the untrained limb after practice of a task with the contralateral limb. While the existence of cross-limb adaptations has been confirmed in many phenomenological and behavioural studies, the mediating mechanisms remain poorly understood. The aim of the present study is to understand the neural processes underlying cross-limb transfer of motor skill by means of non-invasive brain stimulation. Specifically, we investigated the effects of intermittent theta-burst stimulation (iTBS), a high frequency transcranial magnetic stimulation (TMS) protocol that has been shown to enhance corticospinal excitability (CSE), on prior and subsequent motor learning and accompanying cross-limb transfer effects.

Methods: Thirty-six healthy participants practiced a ballistic motor task with their dominant right index finger (150 trials), followed by iTBS applied to either the contralateral, trained (left) primary motor cortex (cM1 group), the ipsilateral, untrained (right) motor cortex (iM1 group), or the vertex (SHAM group), followed by a further 150 training trials. Performance (peak acceleration of the index finger) and CSE (MEP amplitudes of the FDI muscle evoked by single pulse TMS) were assessed before motor learning, pre- and post-iTBS, and following the second training session.

Results: For all groups, motor training significantly increased performance and CSE of the trained hand, and performance, but not CSE, of the untrained hand. Performance gains in the untrained hand were predicted by training-induced performance and CSE gains in the trained hand. Following iTBS, performance and CSE were significantly reduced in the cM1 group's trained hand by 37% and 27% respectively, while the untrained hand remained unaffected. In the iM1 group, participants' performance and CSE of the untrained hand increased by 41% and 39% respectively without affecting the trained hand. No significant effects of iTBS were observed in the SHAM group.

Discussion: First, these results suggest that movement information stored in the untrained hemisphere during motor learning, as opposed to information stored in the trained hemisphere, is subsequently retrieved to drive cross-limb adaptation. Second, motor learning and accompanying cross-limb transfer appear to represent distinct adaptation processes. That is, cM1 iTBS degraded motor learning gains in the trained hand a finding which is consistent with homeostatic plasticity whereby prior motor learning (a LTP process) reversed the expected LTP-like effects of iTBS in this hemisphere. In contrast, iM1 iTBS facilitated untrained hand performance (indicative of a LTP-like effect), despite the fact that this hand had also significantly benefited from unilateral motor training; this suggests that adaptations due to cross-limb transfer interact differently with iTBS than do actual use-dependent gains. The findings have implications for clinical and rehabilitation settings.

MOTOR IMAGERY OF TONIC AND BALLISTIC CONTRACTIONS ACTIVATES DIRECT AND INDIRECT CORTICOSPINAL PATHWAYS DIFFERENTLY BUT IN A SIMILAR WAY THAN REAL TONIC AND BALLISTIC CONTRACTIONS

Benedikt Lauber¹, Albert Gollhofer¹, Wolfgang Taube², Martin Keller²

¹ Department of Sport Science, University of Freiburg, Freiburg, Germany

² Department of Medicine, Movement and Sport Science, Fribourg, Switzerland

Introduction

It is well accepted that motor imagery (MI) and actual movements share overlapping activation of motor areas (Jeannerod 2001). One possibility to assess neural activation during MI is to apply transcranial magnetic stimulation (TMS) over the primary motor cortex. This technique showed that MI and actual movements modulate motor cortex excitability similarly (Stinear CM, Byblow WD 2003). It is, however, not known if MI also affects the activity of different corticospinal pathways in a contraction-specific way as was shown for actually executed movements (Taube et al. 2011). The aim of the present study was therefore to elucidate whether MI of tonic and ballistic contractions leads to differential activity of direct and indirect corticospinal pathways.

Methods

Ten healthy participants volunteered for the present study. Activity of the different corticospinal pathways was assessed at rest and during MI of ballistic (MI_{bal}) and tonic (MI_{ton}) contractions using the H-reflex conditioning technique. Therefore, the soleus H-reflex was conditioned with TMS using different interstimulus intervals. In order to avoid biased MEP / H-reflex amplitudes due to voluntary or involuntary contractions, trials with enhanced EMG levels prior to stimulation (time window: 5 to 55 ms before stimulation; criteria: >4 times standard deviation) were removed.

Results

The conditioned H-reflexes of the early facilitation, which indicate the contribution of direct corticospinal pathways, were not different between rest, MI_{bal} and MI_{ton} ($F_{2;18}=0.67$; $p=0.52$). The conditioned H-reflexes that reflect activity of indirect, slower corticospinal pathways were significantly different ($F_{2;18}=4.25$; $p<0.05$) between conditions, revealing highest facilitation in MI_{ton}, followed by rest and MI_{bal}.

Discussion

Previous studies have shown that slow corticospinal pathways are differently affected by ballistic and tonic contractions (Taube et al. 2011, Nielsen & Petersen 1995, Nielsen et al. 1993). The authors showed for physical task execution a late inhibition for ballistic contractions but a late facilitation during tonic contractions. Thus, the present study shows for the first time that MI of ballistic and tonic contractions activates corticospinal pathways in a contraction-specific way that resembles activation patterns during physical task execution.

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STIFFNESS ESTIMATION OF METACARPOPHALANGEAL JOINT OF INDEX FINGER AND ITS RELATIONSHIP TO EXTRINSIC AND INTRINSIC MUSCLES**M.Ali Akhras^{1,2}, Gabriel Baud-Bovy¹, Francesco Nori¹**¹ *Istituto Italiano di Tecnologia, Genoa, Italy*² *University of Genoa, Genoa, Italy*

Biomechanical properties of joints are widely used in compliance and impedance control of robots. These properties are mainly described by stiffness and damping. In humans, natural adaptive regulation of the joint impedance is a fundamental requirement for stable grasping and dexterous manipulation actions. Human subjects tend to adaptively adjust their joint stiffness with the level of muscle activations depending on the task. Stiffness property has active and passive components. Passive stiffness is known as a biomechanical property of muscle actuators due to muscle tendon unit elasticity. Active stiffness can be controlled voluntarily (e.g. central neuromuscular control of stiffness) or involuntarily (e.g. stretch reflex control of stiffness) by modulating muscle activations of antagonist muscles actuating finger joints. However, the main contribution of stiffness modulation in simplifying the control task in a presence of motor control redundancy is still under discussion in scientific community. In addition, the relationship between the joint stiffness and the neuromuscular control levels is unknown.

We developed a mechatronic perturbation system to estimate the metacarpophalangeal (MCP) joint stiffness of index finger as a function of joint torque and position and to record Electromyography (EMG) of four actuating muscles (e.g. two intrinsic muscles and two extrinsic muscles) involved in MCP actuation for flexion and extension movements of index finger. We aim to investigate the task effect on stiffness to understand how our central nervous system (CNS) adapts the biomechanical properties of the musculoskeletal system to the characteristics of the environment. Our objective from recording EMG activity during our pilot experiments is to understand the functional advantage of intrinsic and extrinsic muscles in the motor control of hand fingers. Our analyses focus on the pre-reflex epoch to exclude the contribution of the reflex or voluntary control in adjusting the stiffness through muscle activations after destabilizing the index finger.

Our preliminary results based on simulations and some pilot experiments suggest that the stiffness increases nonlinearly with the co-activation levels which lead to generation of the same joint torque. Stiffness of joints can be adjusted when antagonist muscle co-contract. However, there is no dependent evidence to confirm that if muscles are in antagonistic geometric configuration, the co-contraction will necessary lead to a variation in the joint stiffness. Therefore, we considered the problem of muscle geometric characteristics to understand the functional role of extrinsic and intrinsic muscles in relation to stiffness modulation. In addition, we found from our test data that stiffness is different among the tasks in which it is lower in isometric condition (e.g. co-contraction) than in isotonic condition (e.g. force generation or resistance) and obviously the lowest in relax condition. This provides a hint on dependence of natural modulation of the stiffness on tasks when one considers the stability requirements of the finger at equilibrium. Thus, the minimum amount of stiffness required to maintain the finger at equilibrium can be determined based on the motor control task. However, our next experiments will provide us definitive conclusions to answer our research questions mentioned above.

CONTROL ARCHITECTURE FOR HUMAN-LIKE MOTION WITH APPLICATIONS TO SOFT ROBOTICS

Cosimo Della Santina¹, Matteo Bianchi^{2,1}, Manolo Garabini¹, Antonio Bicchi^{1,2}¹ *Research Center "Enrico Piaggio"- University of Pisa, Pisa, Italy,*² *Department of Advanced Robotics - Istituto Italiano di Tecnologia (IIT), Genova, Italy*

Humans can achieve a high level of motor performance because of two main reasons: the physical properties of the muscle-skeletal system, and the effective control by the central and peripheral nervous system (CNS and PNS). While for many years, traditional type of robots were very far away from the physical characteristics of the human body, the recent introduction of soft robotics technology and variable impedance actuators represent an attempt to bridge the gap. However, under a control point of view, substantial advancements are still necessary to exploit the new possibilities and to achieve performance comparable with the human ones.

In this work, we propose a model-free control system, with the goal of overcoming the drawback of model identification (which is hard to obtain with the nonlinear soft robots dynamics) and ensuring natural movements in soft robots and specific functionalities of the central nervous system, such as learning by repetition, after-effect on known and unknown trajectories, anticipatory behavior and state covariation in task execution.

The control architecture proposed here consists of a low level part for dynamic inversion, which relies on iterative learning control techniques and a high level part for degree of freedom redundancy management or synergistic control. These parts are finally merged to achieve task specific dynamic inversion. Simulations and experiments were performed with variable stiffness actuators, showing the effectiveness of the here proposed control schemes.

INTERPRETATION OF MOTOR VARIABILITY DEPENDING ON FEEDBACK AVAILABILITY

Carla Caballero, David Barbado, Tomás Urbán, Francisco Javier Moreno

Miguel Hernández University of Elche, (Alicante), Spain

Introduction

The complexity shown in the biological signal has been related to the system's ability to adapt [1]. Previous studies in balance tasks have found that centre of pressure (COP) complexity is associated with better performance [2]. Nevertheless, Vaillancourt and Newell [3] have suggested that this relationship depends on the nature of both the intrinsic dynamics of the system and the task constraints. To address this issue, the difficulty and the presence of biofeedback during a balance task was manipulated in order to explore how these task constraints affect variability dynamics of COP and their relation to motor control strategies.

Methods

Fifty two volunteers took part in this study (Age: 25.5 ± 6.01 years; Height: 1.70 ± 0.25 m; Mass: 70.66 ± 10.33 kg). Participants were asked to stand still (70s) on a stable surface and on three unstable surface. The difficulty of the unstable conditions was manipulated by using three rigid hemispheres with different diameter (0.5, 0.4, and 0.3 m). Each condition was performed twice, with and without biofeedback (displaying a target and COP). Balance performance was assessed by bivariate variable error (BVE) of COP. Dynamics of COP displacement was measured through Fuzzy Entropy (FE) and Detrended Fluctuation Analysis (DFA).

Results

The BVE increased as the difficult level was increased ($F=374.305$; $p<.001$; $\eta_p^2=.880$). However, it didn't show significant differences between visual biofeedback conditions ($F=2.637$; $p<.111$; $\eta_p^2=.049$). Although, the participants showed a similar error in both visual biofeedback conditions, the FE and DFA showed different development according to the presence or the absence of the visual biofeedback (FE: $F=83.739$; $p<.001$; $\eta_p^2=.621$; DFA: $F=66.358$; $p<.001$; $\eta_p^2=.565$). When biofeedback was available, FE decreased and DFA increased as the level of difficulty increased. However, the opposite trend happened in the conditions without biofeedback.

Discussion

According to previous studies [3], the dynamics of COP variability in the balance task were different according to the visual biofeedback availability and difficulty. In easier balance tasks without biofeedback, there are a greater number COP locations where stability can be maintained [4]. Conversely, in presence of biofeedback, the target acts like a fixed point attractor, constraining COP behaviour. In the most difficult tasks the participants' behaviour was similar with and without biofeedback, meaning that high difficulty level limits the region of stability in a similar way than biofeedback does. [5]. Therefore, biofeedback could be redundant information in the highest levels of difficulty. Future studies should take into account intrinsic dynamics to provide a more comprehensive explanation of motor variability is relationship with performance and the ability to adapt.

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**PRACTICE-RELATED IMPROVEMENTS IN VISUOSPATIAL ATTENTION DRIVE MOTOR
LEARNING IN A MOTOR TASK REQUIRING CONTINUOUS AND SIMULTANEOUS PERCEPTUAL,
COGNITIVE AND MOTOR PROCESSING**

Tarkeshwar Singh, Kayla Goins, Christopher Perry, Troy Herter

University of South Carolina, Columbia, SC.

Many motor tasks impose real-time interactions between perception, cognition and action. For example, while driving a car, we continuously and simultaneously process visual information (e.g., identifying and localizing of automobiles, pedestrians and traffic signals), make decisions (e.g., when and where to accelerate, stop or turn) and perform motor skills (e.g., manipulating the gas pedal, brake and steering wheel). In the lab, perceptual, cognitive, and motor learning are normally studied separately, thus it remains unclear whether changes in information processing, decision-making and/or movement execution normally contribute to improvements in motor behavior. Changes in information processing can be probed by examining attention, a neural mechanism used to selectively allocate processing resources to information that is relevant to task performance (e.g., automobiles, traffic signals). Visual attention is commonly shifted to various environmental features through eye movements that move the fovea to different stimuli (overt attention). Visual attention can also be shifted by selectively allocating visual processing different regions of peripheral vision without moving the eyes (covert attention). The goal of this study was to investigate if changes in visuospatial attention and/or movement execution mediate practice-related improvements performing an upper-limb motor task.

Eighteen participants practiced an Object Hit and Avoid (OHA) task once a week for six weeks on a KINARM Endpoint robot with integrated gaze tracking. In the OHA task, 300 objects (8 geometric shapes) moved towards the subjects, who used virtual paddles to hit away two objects (Targets, $n=200$) and avoid hitting the other six objects (Distractors, $n=100$). Participants performed six repetitions of the OHA task during their weekly session. During each task repetition, the number and speed of objects increased over time making the task more difficult. Between repetitions, the shape, location and speed of objects were randomized to ensure that every repetition was unique. We hypothesized that practice would lead to improvements in task performance that are mediated by improvements in visual attention and movement execution.

Participants exhibited significant improvements in task performance during the six weeks of practice. The number of targets hit increased from $78.5 \pm 2.6\%$ on the first repetition in Week 1 to $94.6 \pm 0.76\%$ on final repetition in Week 6, whereas distractor hits decreased with practice. Importantly, improvements in task performance were closely mirrored by improvements on measures of visual attention. The number of objects (targets and distractors) that were overtly attended (foveated) increased significantly by 10% from the first repetition in Week 1 to the last repetition in Week 6. Subjects also hit a higher proportion of targets that were overtly attended, although the amount of time spent foveating targets decreased by about 7%. Additionally, with practice, subjects hit a higher proportion of targets that were not foveated, suggesting that improvements in task performance were also mediated by improvements in covert attention. Finally, improvements in movement execution contributed to increases in task performance. The average velocity and workspace area covered by the dominant hand increased by about $\sim 31\%$ and 28% , respectively. These results show that improvements in attention can drive improvements in motor behavior (i.e., motor learning).

QUANTIFYING THE EBBINGHAUS FIGURE EFFECT IN PERCEPTUAL AND PERCEPTUAL-MOTOR CONTEXTS

Hester Knol^{1,2,3}, Raoul Huys^{1,2,4}, Jean-Christophe Sarrazin³, Viktor Jirsa^{1,2,4}¹ Aix-Marseille Université, Institut de Neurosciences des Systèmes, Marseille, France;² INSERM, UMR_S 1106, 27 Bd Jean Moulin, 13385, Marseille Cedex 5, France;³ ONERA, Systems Control and Flight Dynamics Department, Salon de Provence, France;⁴ Centre National de la Recherche Scientifique, France

Over the last 20 years, visual illusions, like the Ebbinghaus figure, have become widespread to investigate functional segregation of the visual system. This segregation reveals itself, so it is claimed, in the insensitivity of movement to optical illusions. This claim, however, faces contradictory results (and interpretations) in the literature. While these contradictions may be explained along various lines, they may simply be due to a lack of illusion effects, which is frequently not verified. Indeed, despite the long history of psychophysics research with the Ebbinghaus figure, standardized configurations and rules to predict the illusion effect are missing. Here, we present a complete geometrical description of the Ebbinghaus figure with three stimulus sizes compatible with Fitts' task. Each trial consisted of a stimulus and an isolated probe. The probe was controlled by the participant's response through a staircase procedure. The participant was asked whether the probe or stimulus appeared bigger. The factors stimulus size, context size, target-context distance, and a control condition resulted in a $3 \times 3 \times 3 + 3$ factorial design. The results indicate that the illusion magnitude, the perceptual distinctiveness, and the response time depend on the context size, distance, and especially, stimulus size. In 33% of the cases there was no illusion effect. The illusion magnitude ranged from zero to (exceptionally) ten percent of the stimulus size. This range suggests that the (reported) absence of motor effects may be due to absent (or small) illusion effects. Alternatively, the absence or presence of motor effects may be task specific, and, in particular, dependent on the motor classes involved. To investigate this issue we are currently running an experiment in which the same group of participants performs an aiming precision (Fitts') task. The participants perform cyclic movements between Ebbinghaus stimuli (as targets) for an index of difficulty (ID) of 4, 5 and 6 bits. Pilot data suggest that the dynamics underlying the movements are locally adjusted in some conditions. The results of both the perceptual and motor experiment will be discussed at the conference.

Our perceptual results provide a basis for the application of the Ebbinghaus figure in psychophysical and motor control studies. The results from the presently conducted sensorimotor study will provide insight in the influence of optical illusions on motor control mechanisms. In combination, these experiments allow us to quantify the relation between perception and action as a function of the task layout.

IS UNDERWATER ENVIRONMENT A GOOD WAY TO SIMULATE MICROGRAVITY? SOME CUES FROM ARM REACHING AND POSTURAL CONTROL

Thomas Macaluso¹, Christophe Bourdin¹, Frank Buloup¹, Bernard Gardette², Marie-Laure Mille¹, Caroline Nicol¹, Fabrice Sarlegna¹, Patrick Sainton¹, Virginie Taillebot², Jean-Louis Vercher¹, Peter Weiss², Lionel Bringoux¹

¹ Aix-Marseille Université, CNRS, ISM UMR 7287, Marseille, France;

² COMEX S.A., Marseille, France

Astronauts' training is conventionally performed in a pool in order to reproduce a weightless environment and facilitate motor performance during extra-vehicular activities. To that purpose, astronauts are usually immersed in a pressurized spacesuit, facing tasks involving accurate goal-directed actions. However, this method has not yet been scientifically validated, requiring first to study the effects of underwater exposure on motor behavior. The aim of this study is to precisely characterize the motor organization underwater by comparing it with that produced on land. Eight experienced divers were asked to perform arm reaching movements toward visual targets of different sizes during standing (feet fixed to the ground). Targets were presented either near or far from the subjects (requiring an additional postural component to arm reaching in the latter case). The task was performed either outside the pool or underwater with the subjects equipped with a wetsuit or immersed in a submersible spacesuit. Preliminary results highlight the impact of underwater environment and the type of suit on the spatiotemporal characteristics of arm reaching and postural control. Specifically, arm movement duration underwater did not systematically vary with the execution constraints of the task. However, kinematics of goal-directed arm movements and posturo-kinetic strategies observed underwater in wetsuit tended to remain close to those encountered on land. On the other hand, these parameters markedly differed when divers were equipped with a submersible spacesuit. More precisely in this latter condition, the relative time-to-peak velocity, which illustrates the integration of gravitational constraints in arm motor planning, substantially decreased, and trunk flexion was largely reduced when reaching distant targets. This might reflect a new postural strategy in which divers no more compensate for the center of mass excursion classically encountered on land. Overall, the motor behavior observed in the submersible spacesuit condition seems to share common properties with that observed in real microgravity (e.g., longer deceleration phase of the reaching movement, trunk-leg alignment maintained during large center of mass excursion). These results suggest that motor exposure performed underwater with a submersible spacesuit could be a valid way to optimize astronauts' training, notably with respect to the use of classic pressurized spacesuits in which gravitational load still applies inside.

PERFORMING MAXIMAL NATURAL VERTICAL JUMPS: ROLE OF THE COUNTERMOVEMENT DEPTH

Radivoj Mandić¹, Sasa Jakovljević¹, Slobodan Jarić^{2,3}¹ *University of Belgrade, Faculty of Sport and Physical Education,
The Research Center, Blagoja Parovica 156, Belgrade, Serbia;*² *University of Delaware, Department of Kinesiology and Applied Physiology,
Rust Arena, Rm. 143, 541 South College Avenue, Newark 19716, DE, USA;*³ *University of Delaware, Biomechanics and Movement Science Graduate Program,
Rust Arena, Rm. 143, 541 South College Avenue, Newark 19716, DE, USA*

A number of studies have presumed that tested subjects are able to select the movement pattern that maximizes the height of the maximum vertical jump, and to reproduce it over a series of consecutive trials. As a consequence, a possible effect of the countermovement depth (H_{min}) on the various variables that have been obtained from the maximum countermovement vertical jumps remains largely neglected. Here we hypothesized that¹ the optimum H_{min} for maximizing jump height exists, while² an increase in H_{min} would be associated with a decrease in both muscle force and power output. The maximum jump height, peak muscle force, and peak power output from the concentric phase, and H_{min} were assessed. Two groups of subjects, high-level male basketball players and physically active male students performed maximum countermovement jumps with and without arm swing while varying $H_{min} \pm 25$ cm from its preferred value. Although regression models revealed a presence of optimum H_{min} for maximizing jump height, the height revealed only small changes within a wide range of H_{min} . The preferred H_{min} was also markedly below its optimum value. However, both muscle force and power output sharply decreased with H_{min} . Therefore, we conclude that although the optimum H_{min} should exist, the magnitude of its effect on maximum jump height should be only minimal within a typical H_{min} range. The preferred H_{min} could be selected for a 'multiple task' aimed not only to maximize jump height, but also to minimize the effort and reduce jumping time. Conversely, muscle force and power output of leg muscles assessed through maximum countermovement vertical jumps should be taken with caution since both of them could be markedly confounded by H_{min} .

WHAT, WHEN, WHETHER - THE ELECTROPHYSIOLOGICAL CORRELATES AND CLASSIFICATION OF VOLUNTARY ACTION IN VIRTUAL ENVIRONMENT**Konrad Stanek^{1,2}, Hartwig R. Siebner², Steffen Angstmann², Kristoffer H. Madsen², Ole Winther¹**¹ *Technical University of Denmark, DTU Compute, Cognitive Systems, Denmark*² *Danish Research Center for Magnetic Resonance, Hvidovre Hospital, Denmark*

The study of (Libet 1985) gave rise to active discussion among scientists over the nature of free-will and conscious voluntary action, suggesting that, at least in certain circumstances, an intention to perform voluntary action can be predicted from prior neural activity. (Brass and Haggart 2008) proposed to distinguish three different classes of voluntary decisions: "what" type of action to perform, "when" to act, and "whether" to act or not. Those distinct decisions might involve different neural pathways and distributed anatomical regions (Haggart 2008, Brass 2013, Mueller 2007, Krieghoff 2009), including medial pFC, ACC, preSMA and SMA, PMC, and parietal cortex.

In our study, we confront participants with the three classes of decisions in more natural, yet still strictly controlled experimental setup, involving navigating a car through a virtual environment. We investigate the behavioral and electrophysiological characteristics of different classes of decisions and identify the relevant neuroanatomical regions modulated in decision conditions. By adopting the virtual environment, rather than abstract pictogram-based stimuli, we intend to provide more natural platform for analysis of neural correlates of voluntary action, and avoid common problems such as random sequence generation behavior (Jahanshahi and Dirnberger 1999) and lack of external validity (Haggart 2008).

While navigating a simulated car through dedicated virtual environment, each of the 16 participants performed 840 voluntary decisions split into blocks corresponding to "what" (left/right turn), "when" (first/second crossroad), "whether" (turn or do not turn), and "control" (do not take any decisions). The decisions were time-locked to the intervals when car was passing through tunnels with stable visual field, constant luminance and visible fixation cross. Depending on prior decision, participants performed action of button press few seconds later upon approaching an appropriate crossroad. High-resolution EEG data was acquired with 128-channel Biosemi ActiveTwo system. Oculo-motor activity and gaze position were recorded with SMI eye-tracking system and synchronized with EEG signals. For each participant we acquired structural MR brain image (3T Philips scanner) and recorded exact electrode coordinates with Localite neuro-navigation system.

We demonstrate electrophysiological differences in activation of neural networks distributed over cortical midline related to the three aforementioned classes of decisions, in terms of timing, spatial distribution and power modulation of lower (theta/alpha) and higher (gamma) frequency bands, time-locked to the onset of the decision intervals. This event-related modulation of EEG signals, along with subject-specific T1 images, session-specific electrode coordinates, and set of spatial filters are then used to reconstruct decision-relevant neuroanatomical sources activated in prefrontal, motor and parietal cortical regions.

Furthermore, we apply spatial filtering to select the most discriminative features and apply probabilistic methods (Tipping 2001, Frolov 2011) to classify decision trials against control trials and to predict decision outcome on single-trial basis. We demonstrate above-chance prediction accuracy and discuss feasibility of using single-trial classification of voluntary decisions to build natural, intention-driven BCI systems.

USING NON-NEGATIVE MATRIX FACTORIZATION AS A FILTER TO IMPROVE USABILITY OF MYOCONTROL FOR CHILDREN WITH CEREBRAL PALSY

Cassie N. Borish¹, Matteo Bertuccio¹, Denise J. Berger³, Andrea d'Avella³, Terence D Sanger^{1,2}¹ *University of Southern California, Los Angeles, CA, USA*² *Children's Hospital Los Angeles, Los Angeles, CA, USA*³ *Santa Lucia Foundation, Rome, Italy*

For children with movement disorders due to cerebral palsy (CP), prosthetic devices can provide mobility, manipulation, and functional communication. However, the goals of prosthetic control in children with impairments need to be different from those in adults. Children need flexible interfaces whose motions are not described in advance, so they can develop their own movements and explore varying and unpredictable goals. We use multi-muscle electromyographic control ("myocontrol") to accomplish this. Surface EMG is a non-invasive way to capture EMG, but the high level of noise makes it difficult to use in real-world applications. Furthermore, it has proven difficult for even healthy adults to learn myocontrol with multiple degrees of freedom. Children with CP have muscle co-contraction and obligate abnormal muscle synergies, and therefore may have difficulty finding independently controllable dimensions in order to use myocontrol. Non-negative matrix factorization (NMF) will identify independent dimensions (synergies), but we must then separate controllable dimensions (voluntary signals) from uncontrollable dimensions (involuntary muscle activity). We hypothesized that extraction of controllable dimensions would improve myocontrol performance for children with CP but not for age-matched controls because controls already have independently controllable dimensions.

In this study, we tested whether NMF can identify independent controllable dimensions for children with CP by comparing 3 different myocontrol conditions:¹ All Muscle myocontrol,² Single Muscle myocontrol,³ Synergy myocontrol. Subjects first used myocontrol to move a cursor in a 1-D isometric reaching task using 8 Single Muscles, All Muscle myocontrol in the x- and y- directions, and each Synergy identified using NMF. From this task, Fitts' Law was used to assess the most controllable muscles and synergies based on Index of Performance (IP). Subjects then moved a cursor in 2-D in an isometric center-out reaching task using myocontrol. For All Muscle myocontrol, EMG from 8 muscles was mapped to the 2-dimensional plane using multiple regression with the torque direction. In Single Muscle myocontrol, only the top 4 controllable muscles were used. For synergy control, the top 4 controllable synergies were used.

Preliminary results showed that patients have varying degrees of control for individual muscles and synergies, allowing us to rank them for application in 2-D myocontrol. NMF found independently controllable dimensions for some patients, which improved their performance in Synergy myocontrol compared to All Muscle myocontrol. Healthy subjects did not improve with synergy control because they already have independently controllable dimensions in the All Muscle condition. For patients without improvement, NMF likely still includes dimensions of involuntary control. Results suggest that dimensionality reduction may act as an additional, personalized filter in noisy EMG. This work will also improve our understanding of the existence of synergies in CP and direct future research in rehabilitation.

COMPARISON OF CATHODIC AND ANODIC TRANS-SPINAL ELECTRICAL STIMULATION TO EVOKE POSTERIOR ROOT-MUSCLE REFLEXES

José Luis Vargas Luna^{1,2}, Matthias Krenn³, Simon M. Danner³, Ursula S. Hofstoetter³, Karen Minassian³, Winfried Mayr³, Thordur Helgason¹

¹ Health Technology Center, Reykjavik University - Landsþtali University Hospital, Reykjavik, Iceland;

² Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Monterrey, Mexico;

³ Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria;

⁴ Department of Neurobiology and Anatomy, Drexel University College of Medicine, Philadelphia, USA

Transcutaneous stimulation of the lumbosacral spinal cord is a promising new technique for human spinal reflex studies and neuromodulation of circuits' function. This technique can elicit twitches in the lower limb muscles bilaterally. The responses are caused by depolarization of mainly Ia afferent fibers in the posterior roots and subsequent monosynaptic excitation of motoneurons innervating the lower limb muscles. These twitches are called posterior root-muscle (PRM) reflexes because of their initiation and recording site [1]. Standard stimulation procedures to elicit PRM reflexes via epidurally implanted or transcutaneous electrodes have been previously described but, unlike other stimulation techniques, the effect of the polarity on the stimulation outcome has not been addressed in detail. This work presents a comparison between cathodic and anodic trans-spinal electrical stimulation to evoke PRM reflexes via surface electrodes.

Trans-spinal electrical stimulation was applied to five subjects (4 males) with intact nervous system as described elsewhere [1]. Two active stimulation electrodes of 5 cm diameter were placed on the back at the level of the T11-T12 spinous processes and the larger indifferent counter electrode on the lower abdomen [1]. Current controlled monophasic cathodic and anodic pulses (active paravertebral electrodes against reference) with 1ms pulse width were delivered at different amplitudes. The electromyographic activities of quadriceps, hamstrings, tibialis anterior, and triceps surae were monitored bilaterally and the peak-to-peak values of the PRM reflexes were analyzed.

PRM reflexes could be elicited with both stimulation polarities but the recruitment characteristics were different and, in all five subjects, showed the same trend. In the applied intensity range, the cathodic stimulation induced larger amplitudes of the PRM reflexes. In the left triceps surae, the cathodic pulses start to elicit PRM reflexes at 31.5 mA, whereas anodic pulses that start at 59.6 mA; while in left hamstrings they start at 33.3 mA and 60.2 mA for cathodic and anodic pulses respectively. Such behavior is similar in both sides of the body.

These findings show that the polarity of the applied stimuli is an important parameter to be considered in applications of neuromodulation therapies using trans-spinal electrical stimulation. We conclude that monophasic trans-spinal electrical stimulation is more efficient when cathodic pulses are applied to the paravertebral electrodes.

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THE EFFECTS OF THERAPEUTIC HORSE RIDING ON THE MAIN PARAMETERS OF GAIT

Henriette Steiner, Zsolt Kertesz*Budapest University of Technology and Economics Department of Control Engineering and Information Technology, Budapest, HUN (Tel:(+36 1) 463-2699; e-mail: henriette@iit.bme.hu)*

Our research was aimed at evaluating the effects of therapeutic horse riding on the development of visually impaired children. For our purposes, we examined gait; more specifically, the gait cycle, because this type of motion is unburdensome and at the same time suitable for describing motor coordination.

METHODS: In this research we examined the therapeutic effect based on data generated for three years. We followed the development of students at the Primary School for the Visually Impaired in Budapest in therapeutic horse riding. The children were divided into four groups based on the following parameters: hearing and visually impaired; visually impaired schoolchildren of normal intelligence; visually impaired kindergartners of normal intelligence; and children with multiple disabilities. Altogether, we made 738 measurements and we appraised gait each time before and after equine therapy. We examined gait with a computer-guided, video-based motion analyzing system called Ariel Performance Analysis System (APAS), which is grounded on optical principals. The system is composed of a high-performance computer and four digital camcorders. This allows for motion to be recorded on four planes (front, back, and two sides) and for 3D motion images to be created. We attached another high-performance computer to the system for statistical data analysis using the SPSS 19 statistical analysis software. The model consisted of 14 points and their attached sections, corrected in each case by anthropometric data from the subject. We examined basic statistical parameters (average, standard deviation, variance, minimum and maximum), after which we examined similarities and differences in data sets created by the given parameter, using t-test, paired t-test, Pearson's chi-squared test, cross-tabulation, and, since sample data are interrelated, ANOVA.

RESULTS: We defined the efficacy of therapeutic horse riding based on data on gait cycle parameters measured and calculated from the spatial position of the ankle (ratio of step length and phases of the gait cycle), as well as on data from deviations from the midline defined by horizontal deviations, the measurable distance of the two legs (step width), and the location of the center of mass. On account of the aspects We examined we can make the following statements: According to the location of the left and right ankles: The length of the gait cycle increases in all four groups. Asymmetry of the sides decrease in all groups except the hearing impaired. Stability increases in the sagittal direction. Mobility increases both vertically and horizontally.

CONCLUSIONS: These changes mean a more harmonic gait appearance, better balance, and better spatial orientation. Therefore, my research supports the hypothesis that therapeutic horse riding improves gait appearance in visually impaired children, their gait becomes more harmonious and their balance improves. Our results show that therapeutic horse riding as a supplementary therapy is clearly beneficial, and in cases in which the child's physical or mental condition leaves no other options, it can become a fundamentally important form of rehabilitation.

THE EFFECTS OF DIFFERENT AEROBIC ACTIVITIES ON I TYPE DIABETIC SUBJECTS IN HYPOXIA CONDITION ON POSTURAL CONTROL IN QUITE STANDING

Mariusz Paweł Furmanek¹, Kajetan Słomka¹, Barbara Głuchowska², Aleksandra Żebrowska², Grzegorz Juras¹

¹ The Jerzy Kukuczka Academy of Physical Education in Katowice, Department of Human Motor Behaviour, 72A Mikołowska St, 40-065 Katowice, Poland;

² The Jerzy Kukuczka Academy of Physical Education in Katowice, Department of Physiological and Medical Sciences, 72A Mikołowska St, 40-065 Katowice, Poland

Background: Regular physical activities could potentially compensate for diabetes metabolism and minimize the chronic risk of complications in cardio-vascular system, peripheral nervous system and other organs. The concept of altitude or hypoxic training is a common practice for improving aerobic capacity in healthy people. However, there are no reports on how a moderate altitude, between 2000 and 3000 m above sea level influences the balance control of diabetic people performing various physical activities. The purpose of this study was to examine static and dynamic balance of diabetic subjects after performing physical activities under normobaric hypoxia.

Material and methods: Eleven (age: 30 ± 9.7 years, height: 179.6 ± 9.4 m, body mass: 75.2 ± 13.2 kg) diabetic (type I) subjects took part voluntarily in this study. A force plate (AMTI, Accugait, USA) was used to evaluate the balance by acquiring COP data. These were processed with the use of standard stabilogram decomposition method known as a rambling/trembling. The limit of stability tests in forward direction (LOS_F) was also established. Sampling frequency was 50Hz. The initial QS (sea level) trials under the normoxia condition (rest condition - RC_N) were followed by four different randomized activities under a hypoxia condition (2500 m above sea level). The latter were performed on four separate days (one activity each day): a rest period of 40 min duration (rest condition - RC_H), a 40 min bicycle ride with mild intensity (constant condition - CC_H), a 40 min bicycle ride with constant progression (progress condition - PC_H), an intermittent exercise comprised of four periods a bicycle ride (intermittent condition - IC_H), each 5 min long, and four rest breaks, each 2 min long. Each activity on a given day was concluded with the QS trials that lasted 30 s, during which subjects were asked to remain still. During the LOS tests lasting 30 s subjects were asked to lean forward as far as possible, after initial 10 s. For each QS trial the following variables were analyzed; path length of COP, rambling, and trembling in two direction, anterior-posterior (AP), and medio-lateral (ML). Each test was followed by blood sugar level measurements. To see any significant differences a repeated measures analysis of variance and post-hoc analysis (Bonferroni tests) were used.

Results: In the AP plane the length of COP under PC_H significantly increased compare to RC_H ($p=0.038$) and IC_H ($p=0.017$). For the length of Rambling besides RC_H and IC_H, the CC_H were significantly lower than PC_H (all $p<0.05$). For the length of Trembling all others activities were significantly lower than PC_H (all $p<0.05$). In the ML plane only the length of Trembling was significantly different between, PC_H increased in compared to CC_H ($p=0.016$). As far as dynamic balance is concerned the trials showed that there are no statistically significant differences between the LOS tests for different activities under hipoxia.

MEASUREMENT OF UPPER-LIMB COORDINATION IN CHRONIC STROKE SUBJECTS

Marcos R. M. Rodrigues^{1,2}, Matthew Slimovitch^{2,4}, Andreanne K. Blanchette³, Mindy F. Levin^{1,2}¹ School of Physical and Occupational Therapy, McGill University, Montreal, Quebec, Canada² Feil and Oberfeld Research Center, Jewish Rehabilitation Hospital, Center for Interdisciplinary Research in Rehabilitation of the Greater Montreal (CRIR), Montreal, Quebec, Canada³ Department of Rehabilitation, Laval University, Quebec, Canada⁴ Faculty of Medicine, McGill University, Montreal, Quebec, Canada

INTRODUCTION AND AIM Movement coordination is important for upper limb (UL) function. Impairment in UL interjoint coordination (IJC) is widespread after stroke. We determined the ability of a clinical test, Finger-to-Nose test (FNT), to identify temporal and spatial coordination deficits in stroke compared to healthy subjects.

METHODS UL kinematics were recorded using 28 markers on arm, trunk, nose and target (Optotrak, 30s, 100Hz). Two trials of 10 movements each in which stroke subjects (n=20) alternatively touched their nose and a target (ReachIn; ReachOut) located at 90% arm-length, as fast as possible were recorded bilaterally. Healthy subjects (n=20) performed at self-paced and slow speeds. Data for each direction were analyzed for time to perform the task, arm and trunk kinematic differences between groups and relationships with clinical scores in stroke subjects.

RESULTS Compared to healthy subjects, stroke subjects made more curved endpoint trajectories (Index of curvature: stroke=1.23, control=1.04, $p < 0.05$, ReachIn) and used less shoulder horizontal abduction (stroke=11.8°, control=17.6°, $p < 0.001$, ReachIn). Stroke subjects moved their affected arm slower than their less-affected arm (ReachIn: 18%, ReachOut: 43%; for both directions $F=14.136$, $p < 0.001$) and had more curved trajectories (ReachIn: 18%, ReachOut: 27%; for both directions $F=6.003$, $p < 0.05$). Interjoint coordination was similar between the two arms. Stroke severity moderately correlated with endpoint speed ($r=-0.55$, $p=0.006$) and straightness ($r=-0.47$, $p=0.018$) but not precision. FNT time correlated with endpoint straightness ($r=0.77$, $p=0.001$), temporal ($r=0.63$) and spatial ($r=-0.61$) interjoint coordination. Shoulder horizontal abduction range ($\beta=0.127$), temporal ($\beta=0.855$) and spatial ($\beta=-0.191$) interjoint coordination explained 82% of the variance in the time to perform FNT.

CONCLUSION Shoulder movement and temporal and spatial interjoint coordination were predictive of the time to perform the FNT, indicating that this clinical test can be used to measure UL coordination after stroke.

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ABSTRACTS OF POSTER PRESENTATIONS

A-0024

TASK DEPENDENCY OF THE COMPLEXITY OF POSTURAL CENTER OF PRESSURE PATTERNS

Avelino Amado, Mike Busa, Richard van Emmerik*University of Massachusetts Amherst*

Many activities of daily living require adaptability and flexibility to switch between movement patterns. From a dynamical systems perspective, adaptability is assessed by measuring complexity of a system, generally through entropy techniques derived from information theory (Costa et al., 2002). Within the "Loss of Complexity" hypothesis movement patterns that show reductions in complexity have been interpreted as less adaptable, but this interpretation is born from studies that have quantified complexity by observing older adults as well as individuals with various pathologies under steady state conditions (Lipsitz, 1992; Vaillancourt & Newell, 2004). Within this construct the study of constraints is narrowly focused on age and disease but if we are to truly have a hypothesis that addresses the role of complexity in biological adaptability then our understanding of the constraints, such as those that arise during activities of daily living, need to be assessed. Because task dynamics interact with intrinsic dynamics of the system, Vaillancourt and Newell (2004) suggested that complexity changes are not uni-directional but bi-directional, and its directionality is based on task constraints. The purpose of the current research was to investigate the relationship between postural and manual tasks and their impact on systemic complexity. We specifically examined the impact of postural constraints by changing the size of the base of support, and task constraints by requiring participants to produce bimanual coordination patterns of varying difficulty. Working from the loss of complexity hypothesis, we predicted that increasing postural demand as well as manual task demand would reduce postural complexity. Twelve expert marching percussionists from the UMass Drumline performed three drumming conditions: 1:1 (anti-phase), 2:3, and 2:3-F (this condition was the 2:3 played faster) in two different postures: standing on two feet, and standing on one foot. Prior to performing the drumming conditions, the participants stood in quiet stance in each posture for 30 s. To assess changes in postural complexity multiscale entropy analysis was applied to center of pressure data. The results from the quiet stance baseline trials revealed that complexity of the single leg posture was significantly reduced compared to the two-legged posture in the medial-lateral direction ($p < .001$), thereby agreeing with the loss of complexity hypothesis. In the drumming conditions medio-lateral single legged complexity remained lower compared to the two-legged stance across all three conditions ($p < .001$), and displayed different changes in complexity as the rhythmic condition changed. Complexity did not change from the 1:1 to the 2:3 manual task ($p=.93$) in the single leg posture, but did so in the two-legged posture ($p=.002$). In the 2:3-F manual task complexity increased in the single leg posture ($p = .005$) but decreased significantly in the two-legged posture ($p=.001$). These results indicate that in two-legged stance postural complexity both increases (with more complex manual rhythms) and decreases (with increasing movement frequency), and these results do not support our hypothesis that increasing manual task demand would decrease complexity. In line with Vaillancourt and Newell (2004), our results demonstrate that changes in complexity are task dependent.

A-0069

ACQUISITION OF SERIAL ORDER IN SPEECH PRODUCTION: AN ULTRASOUND STUDY OF TYPICAL 4-YEAR-OLD CANADIAN FRENCH CHILDREN

Guillaume Barbier¹, Pascal Perrier¹, Lucie Ménard², Yohan Payan³, Mark K. Tiede⁴, Joseph S. Perkell^{5,6}

¹ GIPSA-lab, CNRS & Grenoble Universities, Grenoble, France

² Laboratoire de Phonétique, Université du Québec à Montréal, Montréal, Canada

³ TIMC-IMAG laboratory, CNRS & Grenoble Universities, Grenoble, France

⁴ Haskins Laboratories, New Haven, Connecticut, USA

⁵ Boston University, Boston, Massachusetts, USA

⁶ M.I.T., Cambridge, Massachusetts, USA

This study investigates the process by which young children learn to produce sequences of speech sounds in an adult-like manner. Learning to produce speech sounds requires precise motor control of several oro-facial muscles and the ability to link these motor activations both with articulatory movements in the vocal tract (via somatosensory feedback) and with acoustic realizations (via auditory feedback). During this first learning phase, a number of agonistic and antagonistic muscle synergisms are developed. The acquisition of serial order in speech production implies, in addition to these skills, the ability to plan and execute sequences of motor commands with fine temporal coordination.

In line with theories of optimal motor control, gesture planning is assumed to make use of neural representations (internal models) of the motor system in order to minimize some measure of cost in producing sequences of movements. In this framework, the efficiency of speech planning is considered to reflect the maturity of these neural representations.

It is well-established that normally developing children above a certain age are able to produce all the sounds of their native language distinctively. However, we hypothesize that these children are not able to organize gestures temporally and spatially in an adult-like manner when producing sequences of speech sounds, reflecting a lack of maturity of motor control.

To test this hypothesis, we conducted an experiment in which we recorded acoustic and ultrasound data (collected in the mid-sagittal plane) from twenty four-year-old children and from ten adults aged 19-30 for comparison. Participants had to recall, plan and pronounce utterances in an experiment designed as a puppet game in which puppet names were isolated vowels and vowel-consonant-vowel sequences. We obtained tongue-movement recordings with the Haskins Optically Corrected Ultrasound System (HOCUS), which uses optical tracking of infrared emitting diodes, positioned both on the ultrasound probe and on the head of the participant to provide a representation of the data corrected for probe movement and aligned with palatal hard structure.

In agreement with numerous studies of arm motor control and studies of speech production development, we found more token-to-token variability in young children than in adults for isolated sounds in both the articulatory and acoustic domains. For speech sequences, also in both domains, results indicate that children display less anticipatory coarticulation (i.e., less influence of an upcoming sound on the current one). Based on these findings, we infer that despite their ability to reach the production targets in a 3-sound sequence, four-year-old children are not able to take advantage of perceptually licensed variability of a given speech sound in anticipating forthcoming gestures. According to our theoretical framework, this finding reflects a lack of maturity of children's neural models of the speech production mechanism.

A-0081

IMPAIRED FINE MOTOR LEARNING IN WILLIAMS SYNDROME

Andrea Berencsi^{1,2}, Ilona Kovács¹¹ *Pázmány Péter Catholic University Laboratory for Psychological Research, Budapest, Hungary;*² *Eötvös Loránd University Bárczi Gusztáv Faculty of Special Education, Institute for Methodology of Special Education and Rehabilitation, Budapest, Hungary*

Williams syndrome (WS) is a rare neurodevelopmental disorder due to microdeletion on chromosome 7 in the q11.23 region. In WS, motor problems have an early onset and persist into adulthood. The present study aimed to investigate whether individuals with WS differ from their age-group in a sequential finger tapping (FT) task, and whether they are able to improve their performance during a five-day-learning session.

14 participants with WS (6 males and 8 females, age range: 11 to 26 years, 10 right-handed, 2 left-handed, 2 mixed-handed), and 80 typically developing (TD) controls (age-range: 7-30 years, divided into 8 age-groups) took part in the study.

Finger tapping (FT) is a motor learning paradigm where performance gain is shown to be sleep dependent during extended practice (Karni, 1995; Walker, 2003). In an improved version of the original paradigm, we developed a data glove that enabled the measurement of exact timing while participants can use their hands free during the task. A four-element-sequence was practiced for five consecutive days. Motor performance was monitored both in terms of accuracy and speed using a combined measure of 'Performance Rate' (PR). Transfer to the contralateral hand and to a novel sequence in both hands was also tested.

In WS, fine motor performance was characterized by decreased speed, accuracy and PR regarding the first day performance as compared to age-matched TD individuals. In order to investigate the effect of corticospinal tract conduction speed (that varies due to age, experience, and myelination level) on serial performance, we also measured maximum motor speed by index finger tapping. Although a subgroup of WS participants presented with maximum motor speed in the TD range, serial motor speed plateaued off regardless of maximum motor speed. This suggests that the serial, rather than a simply repetitive task puts a constraint on performance speed. In WS, both initial and learning performance showed great individual variability with close to negative correlation between initial performance and improvement. On a group level, learning performance lagged behind TD, although some task specific learning took place both in terms of speed and accuracy. Based on our data, we hypothesize a possible dysfunction in motor cortex-basal ganglia networks during motor performance and learning in WS. The individual results also show a lack of sleep-dependent learning in many cases, which suggests the potential involvement of sleep disorders.

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A-0094

GENDER DIFFERENCES IN THE PUBERTAL TRAJECTORY OF FINE MOTOR DEVELOPMENT

Andrea Berencsi^{1,2}, Patrícia Gerván¹, Orsolya Filep¹, Ilona Kovács¹¹ *Pázmány Péter Catholic University, Laboratory for Psychological Research, Budapest, Hungary*² *Eötvös Loránd University Bárczi Gusztáv Faculty of Special Education, Institute for Methodology of Special Education and Rehabilitation, Budapest, Hungary*

Puberty involves marked changes in the musculoskeletal and nervous systems and shows gender-based behavioural and morphological differences. The present study aimed to investigate developmental changes in fine motor function and map sex-related differences using a finger tapping (FT) paradigm. Age-dependent improvement of finger movements in terms of speed mainly depends on the maturation of the brain, corticospinal (CS) tract, spinal cord circuits, and periphery; while improvement in accuracy is mainly attributed to brain maturation. Speed and accuracy show a trade-off during performance.

118 typically developing participants (male n=56, female n=62) were assigned to six age groups (10, 12, 14, 16, 18, 20 years), ages counterbalanced. Repetitive (index FT with dominant and non-dominant hand) and serial (four-elements-sequence with non-dominant hand) tasks were performed.

Results showed that repetitive FT speed (index FT) increased with age at both the dominant and the non-dominant hand. With the dominant hand, significant female advantage was seen at the age of 10 that diminished later, and a significant male advantage appeared at 18 years. With the non-dominant hand, there was a significant difference between male and female groups at 18 and 20 years, a tendency similar to that of the dominant hand. There was a gender specific developmental pattern regardless of hand-dominance. Females increased speed markedly until the age of 14 years then the developmental curve slowed down. Developmental curve of male participants showed gradual increase with age, with no plateau at 14 years, resulting in a male advantage at later ages. Speed in a serial task with the non-dominant hand showed a similar developmental pattern to that of the repetitive task in male and female groups, respectively.

In order to minimize the effect of CS tract myelination and conduction speed on serial performance, we corrected the serial FT speed with the index FT speed. In the corrected speed, there was a significant difference between males and females at the age of 10 years, with the female developmental curve levelling off at the age of 14 and the male curve at 16 years. Error rate in serial performance decreased with age. After taking both corrected speed and errors into account, a significant difference at 10 years remained between the sexes.

Regarding laterality, the dominant hand was faster in index FT. While speed differed in absolute values in male and female groups through the age groups, the ratio between index finger tapping speed and non-dominant / dominant hand did not differ after 12 years of age between the two genders.

The possible role of gender-based differences in developmental changes of the nervous system, such as earlier maturation of white matter in females, and a male advantage in CS tract myelination/ axonal diameter will be discussed.

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A-0030

TUNING OF POSTURAL RESPONSES TO INSTABILITY AND COST FUNCTION

Matteo Bertuccio¹, Amber Dunning¹, Terence D. Sanger^{1,2}¹ *University of Southern California, Los Angeles USA*² *Children's Hospital of Los Angeles, Los Angeles, USA*

Awareness of risk guides all of our actions, and this is essential for our survival in an unpredictable and potentially hostile environment. We describe risk specifically as the product of two factors: the probability of failure and the cost of failure. The human standing position is an especially high component in the likelihood of failure due to the inherently unstable nature of bipedal posture. The aim of the study was to investigate how humans control the posture under unstable conditions and different costs of failure in a continuous task. We consider the hypothesis that humans actively and dynamically estimate both the probability of failure and the cost of failure, and that they make ongoing corrections based on these estimates by tuning the muscle activity to minimize the cost of behavior.

To test this hypothesis, we designed a driving simulation with iPad® experiment with a loss function using a 1-degree of freedom balance board. Healthy young adults were asked to maintain one-dimensional steering control of a vehicle in a driving simulation with both legs while standing on the balance board. The iPad® was embedded into the balance board such that the inclination of the board resulted with the steering control of the vehicle. Standing on the balance board provided increased uncertainty due to an augmented instability to control the posture. The goal of the game was to complete each trial as quickly as possible, where the speed of the vehicle was determined solely by position on a two-lane road. While on the road, driving within a lane yielded acceleration to the maximum velocity, driving on the dashed line between the two lanes caused the vehicle to decelerate. Points awarded were inversely proportional to the time taken to complete each trial. Different cost (loss) functions were provided with different penalties on the score when driving the vehicle outside of the road. By manipulating the sensitivity of the accelerometer in the iPad®, we were able to simulate different levels of instability while controlling the vehicle with the board. We calculated the probability distribution of the position of the car during the experiment. Moreover, we collected the EMG activity of the calf muscles and calculated the joint angles in both the legs.

Interestingly the results demonstrated the subjects' awareness to changes of task cost and provide evidence that they avoid risk. As expected, position data resemble bimodal Gaussian distributions as it was reported in a previous bimanual study. As instability and cost increased, the two peaks of the distribution tend toward each other, merging into a single normal distribution at high motor uncertainty. The effects of cost and probability of error on the muscles' responses and the lower limbs joints strategies will be also shown.

The findings support our hypothesis that humans tune their statistical postural responses based on cost, taking into account entire probability distributions of all possible outcomes in response to unstable control systems.

A-0129**STRUCTURAL LEARNING MANIFESTS IN VISUOMOTOR ROTATION TASK AIMING STRATEGIES****Krista Bond¹, Jordan Taylor^{1,2}**¹ *Princeton University Department of Psychology;*² *Princeton Neuroscience Institute*

Structural learning is a metalearning phenomenon in which prior experience with a particular task structure expedites learning in novel tasks that share the same structure. This increased learning rate is thought to be accomplished by implicitly extracting invariant features of the task, which reduces the dimensionality of the solution space. Indeed, there is evidence to suggest that experiencing randomly varying visuomotor perturbations of a fixed structure (i.e., rotations) facilitates learning novel perturbations with the same structure (Braun et al., 2009). Recent visuomotor rotation experiments have revealed that the implicit learning of an internal model appears relatively slow and inflexible while explicit aiming strategies appear able to compensate rapidly and flexibly. This suggests that explicit learning may be a more important component of visuomotor rotation task learning than previously thought (Bond and Taylor, 2015). In light of this, we sought to test the idea that structural learning manifests in explicit aiming strategies. In the structure training phase of our experiment, we imposed visuomotor rotations of pseudorandom magnitudes, then tested for structure-specific facilitation by imposing a novel rotation of a consistent magnitude. In addition, participants were asked to report their intended aiming direction on each trial, which allowed us to dissociate the contribution of explicit aiming strategies and the implicit learning of an internal model. We found that participants quickly countered the pseudorandom rotations imposed during structure training through the use of aiming strategies. Furthermore, strategic aiming was the primary source for facilitated learning in the test phase, while the contribution from an internal model was minimal. These results provide evidence that structural learning can operate on an explicit level, while also reinforcing the conclusion that strategic aiming is a fundamental component of learning in visuomotor rotation tasks.

A-0009**LATENCY OF ANTICIPATORY POSTURAL ADJUSTMENTS DEPENDS ON THE INTENDED, NOT ON THE ACTUAL MOVEMENT VELOCITY****Carlo Bruttini, Roberto Esposti, Francesco Bolzoni, Paolo Cavallari***Section Human Physiology of the DePT - Università degli Studi di Milano, Milan, Italy*

Literature reports that the Anticipatory Postural Adjustments (APAs) preceding voluntary movements are programmed according to several task parameters, including movement velocity (for a review: Bouisset & Do, *Neurophysiol Clin* 2008). However, the linkage between APAs and velocity has been highlighted within single subjects, who were asked to perform several movements at different velocities; therefore, till now, it has been impossible to discern whether the key factor determining the APA latency was the intended movement velocity or the actual one. Aim of this study was to distinguish between the above two factors.

We analyzed the APA chain that stabilizes the arm during a brisk flexion of the index finger (Caronni & Cavallari, *Exp Brain Res* 2009): such movement, driven by the prime mover Flexor Digitorum

Superficialis (FDS), is preceded by an APA chain in the upper limb, consisting of an excitatory burst in Triceps Brachii (TB) and in an almost contemporary inhibition in Biceps Brachii (BB) and Anterior Deltoid (AD). These APAs allow to counteract the elbow and shoulder flexion induced by the upward perturbation that the index finger movement causes on the metacarpophalangeal joint.

Experiments were carried out in two groups of subjects:¹ 29 who composed our database from previous experiments and were asked to flex the finger “as fast as possible” (go-fast), but actually performed the movement with different speeds (from 238 to 1180°/s), and² ten new subjects who performed the go-fast movement at more than 500°/s and were then asked to go-slow at about 50% of their initial velocity, thus moving at 300 to 800°/s. Subjects sat on a chair with both arms along the body, elbows flexed at 90°, dominant hand prone, in axis with the forearm, and index-finger extended. Subjects produced a sequence of 30 finger flexions for each required velocity. Recorded variables were the index-finger movement and the rectified EMG from FDS, TB, BB and AD. For each sequence, the 30 traces were aligned on the FDS onset (taken as time zero) and averaged; then the latency of APAs in arm postural muscles was measured.

No correlation between the APA latency and the actual movement speed was observed when all subjects had to go-fast (for all muscles: $r^2 < 0.015$, $p > 0.50$), while APAs delayed of about 20-25 ms were found in the ten new subjects when they had to go-slow ($p < 0.001$). Moreover, in the speed range between 300 and 800°/s, the APA latency depended only on movement instruction: subjects going fast showed APAs that were about 15-30 ms earlier than those of subjects going slow ($p < 0.001$).

These data suggest a stronger role of the intended movement velocity versus the actual one in setting the timing of postural muscles recruitment with respect to the prime mover. Such linkage between the APA programming and the intended velocity of voluntary movement also strengthens the idea that the postural and prime mover muscles are driven by a “shared” motor command, as proposed by Bruttini et al. (Exp Brain Res 2014).

A-0043

THE ROLE OF ADDITIONAL ARM SUPPORT WHEN USED IN AN ACTIVE BALANCING TASK

Jernej Čamernik^{1,2}, Luka Peternel¹, Jan Babič¹

¹ Department for Automation, Biocybernetics and Robotics, Jozef Stefan Institute,
Jamova cesta 39, 1000 Ljubljana, Slovenia;

² Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

In perturbed standing balance conditions, humans often use their arms in order to reach and hold on to stationary objects. These contacts can be very light, like touching with the tip of a finger, or firm as actively holding to the object. Reinforced with information regarding postural orientation an equilibrium from these contacts, the CNS can make more suitable and economical postural adjustments. These are reflected in an instant and as a reduced activation of the lower leg muscles and reduced body movement. However, little is known about the functions of the active hand support and its influence on the overall body movement. Such knowledge could be helpful in treatment of postural control disorders and development of new rehabilitation techniques.

Our aim was to identify the actual role of the arm muscles when used in an active balancing task. Therefore we developed a novel experimental paradigm where the subjects were standing and holding to a handle while their balance was continuously perturbed by a waist-pull perturbation

system. We investigated the adaptations in activation of postural and arm muscles and compared them with activations when the subject were not holding to a handle. We measured the forces that subjects exerted on the handle and the antero-posterior shifts of their centre of pressure (CoP). Apart from recording EMG activity of six postural muscles, we also tracked the whole body motion of the subjects.

We made a step beyond the current understanding of influence of additional hand contact on the postural equilibrium by focusing on the complex whole body kinematics and dynamics. We assessed the difference in adaptation reflected in muscle activation between conditions when the subjects were using the additional arm support and not. The results of the EMG analysis show that the activation of lower leg muscles was significantly reduced when the subjects were using the additional arm support, but not affected by repetitions of perturbations. The adaptation in activation of leg muscles occurred only in the condition with arm support. Interestingly the activation of the trunk flexor muscle was higher when the subjects used the additional hand support and the activation of the trunk extensors remained unchanged, regardless of the condition. The CoP displacement in antero-posterior direction significantly decreased through the sessions regardless of the additional hand support which indicates motor adaptation in both conditions. The adaptation to repeated perturbations was also shown for the arm extensor muscle but not for the flexor muscle.

However, these findings need to be further complemented with dynamical simulations of our measurements. Therefore we are in a progress of creating the musculoskeletal models of our subjects and of making the dynamic simulations of their movement. Modelling and simulations are being made with an open source software platform OpenSim. The preliminary work on creating model simulations indicates that the subjects were exerting very similar forces on the handle, and performed very similar motion. However, further simulations and analysis of the dynamics of their motion will reveal more details.

A-0055

FORCE CONTROL AND INTEGRATION OF PROPRIOCEPTIVE FEEDBACK IN CERVICAL DYSTONIA

**Loïc Carment¹, Jean Pierre Bleton^{2,3}, Sophie Sangla³, Serge Mesure⁴, Marc A Maier^{1,5},
Pavel G Lindberg^{1,6}**

¹ Université Paris Descartes, FR3636 CNRS, Sorbonne Paris Cité, 75006, Paris, France;

² INSERM U894, Université Paris Descartes, Service de Neurologie, Hôpital Sainte-Anne, Paris, France;

³ Fondation ophtalmologique Rothschild, Paris, France;

⁴ CNRS UMR 7287, Aix-Marseille Université, Marseille, France;

⁵ Université Paris Diderot, Sorbonne Paris Cité, 75012, Paris, France;

⁶ Centre de Psychiatrie et Neurosciences, Inserm U894, 75014 Paris, France

Background: Cervical Dystonia (CD) is a movement disorder characterized by sustained or intermittent muscle contraction causing abnormal neck movements and posture. Faulty sensorimotor integration is considered a key pathophysiological mechanism. Studies on force control and the capacity to adapt force control to sensory feedback are lacking in CD.

Objectives: We hypothesize that force control in neck extension will be affected in CD and predict that tasks with proprioceptive feedback will show greatest group differences.

Methods: We record the force control accuracy in a cervical spine extension task at different force levels (5 and 20% maximum voluntary contraction - MVC) in twenty patients with CD. Performance is compared to a group of healthy aged-matched controls. Subjects first perform isometric force

matching to an indicated target level (with a visual force feedback). Secondly subjects reproduce the same force level without feedback (recall), using proprioceptive cues. Recall conditions are pseudo-randomised and consist of performing force matching in conditions allowing access to proprioception: (i) without feedback on screen (no cursor displayed), (ii) without vision (eyes closed, eliminating visuo-spatial references); and in conditions with perturbed proprioception: (iii) without feedback and with vibration of extensor neck muscles, (iv) without vision and with vibration.

The first and second conditions highlight the role of afferents inputs while the two last conditions highlight the role of efferent copy in force control accuracy. In a fifth condition, the subjects are instructed to maintain the force level for six seconds (without displayed force feedback). Muscle activity is recorded in all conditions using electromyography (splenius, trapezius, sternocleidomastoid) and will inform on muscle activation patterns between groups.

Results: Preliminary behavioral testing shows task feasibility for a patient with CD with no pain reported during or after protocol. Fatigue is monitored using visual analog scale and so far no problems have been reported. The CD patient tested showed impaired force matching (error) without feedback and a greater difference in mean force applied in all recall conditions at 20% MVC. In the fifth condition at 5% MVC, the patient overestimates the applied force without feedback and shows greater variability than controls. Recruitment of patients will be completed by May 2015 and complete results from the various tasks will be presented.

Conclusions: Further analysis of the role of proprioceptive feedback during cervical spine extension should be useful for a better understanding of the pathophysiology of CD. The findings may have implications for the development of rehabilitation approaches using neck proprioception in CD.

A-0078

REACTION TIME BALLISTIC MOVEMENTS AND THEIR REGULATION ACCORDING TO MOTOR PLANNING

J.M.Castellote^{1,2}, J. Valls-Solé³

¹ *Physical Medicine and Rehabilitation Department, Complutense University of Madrid;*

² *National School of Occupational Medicine, Instituto de Salud Carlos III, Madrid, Spain;*

³ *Department of Neurology, Hospital Clínic, University of Barcelona, Barcelona, Spain*

INTRODUCTION: Movement execution requires preparation of the motor system at various levels. The neural bases of such preparation for reaction time tasks are different from those for internally generated movements. In some movements, we are required to integrate prepared reactions and self-initiated actions, as it happens with driving or in some sports in which the subject's voluntary drive is under constant interaction with environmental changes, often represented by the action of other persons. In these situations, subjects usually respond to external inputs (reaction) and are able to adjust smoothly their internally prepared movements (action). However, the unexpected presentation of a startling auditory stimulus causes an acceleration of reaction time (the StartReact effect) and may disturb the integration between reaction and action. We used here a model that, making use of the StartReact effect, combines actions and reactions to better understand the differences in motor preparation between these two conditions.

METHODS: Subjects seated in pairs facing each other were asked first to perform fast wrist movements to the presentation of an auditory stimulus, which intensity could be low (auditory cue) or high (startling stimulus). Then, one subject (first) was requested to prepare a self-generated wrist flexion movement (sham trials), to be performed at will, except in those trials in which the sound cue was

presented (low/high), for the subject to perform wrist extension instead. The other subject of the pair (second) was requested to react according to the movement performed by the first, i.e., wrist flexion always, except in trials presenting the cue sound for wrist extension. We recorded the EMG activity from wrist extensors and movement of the wrist joint, to measure task-related activity, and from the orbicularis oculi and sternocleidomastoid muscles to measure startle responses.

RESULTS: Movement onset and end were advanced, and peak velocity was larger, in trials containing the startling stimulus for all conditions. Subjects showed responses with more muscular activity and higher peak velocity when they acted as first subjects than in the other conditions. Subjects acting in second place were able to correctly respond in most trials with the required task. Even if they responded to the first subject's movement, second subjects reacted faster and with larger amount of muscular activity to the presentation of a startling stimulus than with a low sound.

DISCUSSION AND CONCLUSION: When subjects perform an externally driven task over-imposed to an internally prepared program the task is modulated by a startling imperative signal, even if the programme to be executed is modified unexpectedly.

A-0041

FATIGUE- AND TRAINING-RELATED MODULATION OF “ β ” EMG-EMG COHERENCE BETWEEN SYNERGIST AGONIST MUSCLES DURING ISOMETRIC CONTRACTIONS: NEW EVIDENCE OF THE SIGNIFICANCE OF INTERMUSCULAR COUPLING IN MOTOR CONTROL

Camille Charissou^{1,2,3}, Laurent Vigouroux¹, Eric Berton¹, David Amarantini^{2,3}

¹ Aix-Marseille University, CNRS, ISM UMR 7287, Marseille, France;

² Inserm, Imagerie cérébrale et handicaps neurologiques UMR 825, Toulouse, France;

³ Université de Toulouse, UPS, Imagerie cérébrale et handicaps neurologiques UMR 825, Toulouse, France

A key question still to be addressed in motor control is the central nervous mechanisms underlying modulation of the synergistic activation of the agonist muscles involved in voluntary contraction. Previous studies have provided evidence that a central common oscillatory drive may be responsible for synchronous activity patterns of the muscles. In the “ β ” frequency band, the modulation of coherence between electromyographic (EMG) signals is likely to infer the importance of the common synchronous drive from the corticospinal pathway to a pair of muscles in the control of voluntary contraction, and is thought to reflect the coupling between synergistic muscles. The present study investigated fatigue- and training-related changes in “ β ” EMG-EMG coherence during maximal voluntary contractions. Considering the changes caused by fatigue and the adaptations induced by training at the central level, our aim was to gain new insights into the nervous mechanisms underlying the control of synergistic muscle activation.

Control, strength-trained and endurance-trained participants were asked to perform maximal isometric knee extension contractions before and after a sustained submaximal contractions fatiguing protocol. EMG-EMG coherence between rectus femoris and vastus medialis was calculated in the time-frequency domain using wavelet analysis. The level of intermuscular coupling was quantified in the β -band (15-35 Hz) from EMG-EMG coherence values when the correlation between EMG signals was significant.

Results revealed that significant “ β ” EMG-EMG coherence was systematically detected in all participants before and after fatigue. This finding emphasized the importance of intermuscular coupling as a fundamental mechanism responsible for motor control of voluntary contraction. It also indicated the functional significance of the common synchronous drive from the corticospinal

pathway in regulating synergist agonist muscle activation during isometric contractions. Before fatigue, results showed that intermuscular coupling was lower in trained subjects than in the control group. Considering the training-induced central adaptations, this finding could be interpreted as optimization of the coupling among synergist agonist muscles. This could reflect improved motor control in trained participants, contributing to greater maximal net joint torque before and after fatigue, or greater holding time during submaximal fatiguing contractions. Moreover, results showed that the level of intermuscular coupling decreased only in control participants while, concomitantly, the net joint torque decreased in all groups after exhaustion but remained greater in trained than in control participants. This could indicate intermuscular coupling between synergistic agonist muscles as a key mechanism involved in human motor control for maintaining the performance of the neuromuscular system.

The present study brings new insights in the functional role of the coupling between synergist agonist muscles in motor control. The results highlighted the significance of the modulation of the common synchronous drive from the corticospinal pathway to agonist muscle pair for enhanced control of torque production during fatigued and non-fatigued contractions. From a methodological perspective, the present study proposes a general framework for accurate assessment and improved quantification of pairwise interactions between electrophysiological signals. These findings may find clinical application in rehabilitation, and may have potential for improving EMG-based control of artificial limbs and exoskeletons.

A-0033

VARIATIONS IN BRAIN ACTIVITY AS A FUNCTION OF HAND/TARGET VISUAL FEEDBACK AVAILABILITY

Darian Cheng, Krista Fjeld, Gordon Binsted

University of British Columbia, Kelowna, Canada

In this study, brain potentials associated with target encoding and movement execution under varying visual conditions were examined using electroencephalography. Specifically, we were interested in examining whether event related potentials (ERP) and frequency components would differ as a consequence of visual feedback during movement execution. The four visual conditions included vision of hand & target, hand only, target only, and no vision of hand & target. At the start of each trial, a target was previewed, followed by a delay period. Participants (n=18) executed a movement towards the target location upon hearing an imperative auditory tone. Epochs for ERP analyses were obtained by time locking EEG segments to: 1) target preview, in order to explore if participants encoded the target differently when the upcoming visual condition was known, and 2) movement start, to examine if ERPs varied depending on visual feedback availability of the hand and/or target. While the findings indicate no differences during the preview and encoding of the target; potentials associated with movement execution first occurred over motor areas, contralateral to the acting hand, and migrated to medio-frontal regions of the brain. In addition, activity in occipito-parietal regions occurred when vision of the hand (hand & target or hand only conditions) was made available to participants. Additionally, time frequency analyses were performed in order to decipher the frequency band at which brain activity was predominantly occurring. Data were consistent with processes related to error detection mechanisms in the fronto-parietal circuit.

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A-0050

WHOLE-BODY MOTOR STRATEGIES FOR BALANCING ON A BEAM WHEN CHANGING THE NUMBER OF AVAILABLE DEGREES OF FREEDOM

Enrico Chiovetto¹, Meghan Huber², Ludovic Righetti³, Stefan Schaal³, Dagmar Sternad⁴, Martin Giese¹

¹ *Section for Computational Sensomotorics, Department of Cognitive Neurology, Hertie Institute for Clinical Brain Research, Centre for Integrative Neuroscience, University Clinic Tübingen, Tübingen, Germany;*

² *Department of Bioengineering, Northeastern University, Boston, Massachusetts, United States of America;*

³ *Autonomous Motion Department, Max Planck Institute for Intelligent Systems, Tübingen, Germany;*

⁴ *Departments of Biology, Electrical and Computer Engineering, and Physics, Boston, Massachusetts, United States of America*

How the central nervous system controls the excessive number of degrees of freedom to accomplish complex, whole-body movements remains an open question. Many recent studies have shown that a possible solution to the problem might be provided by a modular architecture that is composed from invariant control modules (usually referred to as motor primitives or synergies), which are linearly combined to generate the desired motor output. Although many studies have focused on the identification of such primitives, less attention has been given to adaptive mechanisms that allow the system to deal flexibly with varying constraints or situations when specific degrees of freedom become unavailable. This question is particularly relevant in the presence of task constraints or physical impairments (e.g. after stroke) that make subsets of degrees of freedom unavailable for control. So far, it remains largely unknown how modular architectures for motor control might be able to cope flexibly in such situations.

In this study, we investigated how complex motor coordination patterns vary over time during a highly redundant whole-body task, in both constrained and unconstrained conditions. We examined 3D body kinematics of humans that walked on a narrow beam (3.4cm wide, 5m long). The limited support surface aimed to increase instability compared to overground walking. To investigate how the motor strategies for balancing change with the availability of different sets of degrees of freedom, we added different physical constraints: 1) stiffening of the elbow joints, 2) strapping the arms to the body, and 3) adding rigid sandals to the feet to prevent movements of the toes and metatarsus. We asked 16 healthy participants to walk on the beam in these different conditions. For all conditions participant performed as many trials as necessary to complete 20 successful trials. Participants were motion-captured and their full-body movements in 3D were analyzed using different statistical and biomechanical approaches: a) approximation of the trajectories by superposition of learned movement primitives; b) using a highly simplified biomechanical model with clustering of the strategies for the compensation of the angular momentum in the sagittal plane; and c) analyzing standard kinematic measures of gait, including indices of symmetry between individual segmental movements.

Counter to expectations, we did not observe a significant decrease in performance when different sets of degrees of freedom were immobilized. Initial analysis of the kinematics suggests that also the structure of movement primitives does not differ between the different conditions. Statistical analyses suggest a hierarchy of strategies in order to control the angular momentum in order to stabilize balance, which successively recruit different sets of degrees of freedom.

Authorships: Enrico Chiovetto and Meghan Huber share the first authorship of this work. Dagmar Sternad and Martin Giese share the last authorship.

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A-0128**SUBCORTICAL INFLUENCES ON PAIRED-PULSE TMS-INDUCED I-WAVES IN HUMANS****John Cirillo¹, Monica A. Perez^{1,2}**¹ *Department of Physical Medicine and Rehabilitation, Systems Neuroscience Institute, University of Pittsburgh, USA;*² *Department of Neurological Surgery, The Miami Project to Cure Paralysis Lois Pope Life Center, University of Miami, USA*

Paired-pulse transcranial magnetic stimulation (TMS) of the human motor cortex results in consecutive facilitatory motor evoked potential (MEP) peaks in surface electromyography, allowing the possibility to make non-invasive inferences about the physiology of indirect (I) waves. Using paired-pulse TMS over the hand motor cortex of intact humans and individuals with incomplete cervical spinal cord injury (SCI), we examined early (first) and late (second and third) MEP peaks in a resting finger muscle. In uninjured subjects, we demonstrate a reduced amplitude and duration of the third peak compared with the second, irrespective of test (S1) intensity. A higher conditioning (S2) intensity increased the amplitude of the third but not second peak. No difference in amplitude and duration was found between the first and second peaks. A threshold electrical S2 over the cervicomedullary junction facilitated the second and third but not the first peak similarly to TMS. In SCI subjects, we found a decreased amplitude for all MEP peaks compared with controls. The onset of the second and third peaks were delayed, with the third peak also showing an increased duration. The delay of the third peak was smaller than in controls at a lower stimulation intensity, suggesting lesser influence of decreased corticospinal inputs. A mathematical model showed that the third peak aberrantly contributed to spinal motoneurone recruitment after SCI, irrespective of motor unit threshold. Additionally, temporal and spatial aspects of late peaks in SCI subjects correlated with MEP size and hand motor output. Our results indicate that TMS-induced MEP peaks undergo distinct modulation after SCI, with the third peak likely reflecting a decreased ability to summate descending volleys at the spinal level. We argue that subcortical pathways contribute to late TMS-induced peaks in humans with and without SCI.

A-0025**TACTILE GATING OPTIMIZES SENSORY INFLOW****Francisco Colino¹, Gavin Buckingham², Gordon Binsted¹**¹ *School of Health & Exercise Science, University of British Columbia, Kelowna, BC, Canada*² *School of Psychology, Heriot-Watt University, Edinburgh, Scotland*

Sensory events continually bombard our sensory system and it is critical that the nervous system to sort incoming sensory data and extract relevant information important for task completion and remove irrelevant sensory cues – termed tactile gating. Previous experiments (Buckingham et al., 2010; Colino et al., 2014) found detection rates decrease just prior to and during finger abduction, and decrease according to the proximity of the moving effector. The present study examined how task goal affects tactile gating behavior. Ten healthy human participants were recruited and asked to perform reach-to-grasp movements in response to an imperative cue and, conversely, were asked to pantomime reach-to-grasp movements. Comparing veridical movement to pantomimed movement

on their effect on tactile gating distinguishes whether tactile gating acts to remove task-irrelevant sensory noise or optimize task relevant sensory information for further processing. Therefore, observing how tactile gating behaves in response to different task demands will elucidate what function gating serves in reaching and grasping. Present results replicate findings from previous experiments (Buckingham et al., 2010; Colino et al., 2014) with a statistically significant effect of task. When participants performed veridical grasping, there was reduced tactile sensitivity at the moving limb's right forearm with intact sensitivity at the index finger. Whereas, tactile sensitivity was reduced at the right index finger while pantomime grasping with reduced tactile sensitivity at the forearm. The present study offers evidence that sensorimotor networks influence tactile gating such that task goal influences magnitude of perceived tactile events.

A-0126

EFFICIENT CONTROL LEARNING IN BALLISTIC-LIKE MOTION TASKS

Desislava Despotova, Petko Kiriazov

Bulgarian Academy of Sciences, Sofia, Bulgaria

Motion performance optimisation is needed in various daily life and sport activities: standing-up, walking, running, reaching, throwing, etc. The usual performance requirements for such ballistic-like motion tasks are positioning accuracy, movement execution time, and energy expenditure. According to the optimal control theory such optimization criteria are complicated, even contradictory ones and some optimal trade-offs have to be found. The human musculo-skeletal system is an extremely complex dynamic system and the challenging question is how it is controlled by the central nervous system (CNS) and the human performance - optimized with respect to these complicated requirements. In such cases, control functions (neural signals to muscles) are to be re-learned and the problem is to find efficient control learning (CL) strategies. In our study, a novel conceptual framework for optimal CL of fast, goal-directed movements is proposed. It is based on underlying principles and novel concepts of neurophysiology, robot dynamics, optimal control theory, and machine learning. Goal-directed movements with healthy persons are usually performed optimally as regards motion speed, position accuracy, and energy expenditure. Optimal control functions for such motion tasks have a triphasic (burst-pause-burst) shape and can be described by their magnitudes and switching times. They are the intrinsic parameters human has to learn in point-to-point motion tasks. The CL scheme has the following main steps: 1) control structure definition and parameterisation; 2) select most appropriate pairs of control parameters and controlled outputs; 3) make corrections in the control parameters until reach the target, applying a natural, bisection algorithm. During learning, we keep the control magnitudes constant and adjust only the switching times. The convergence of the CL process is mathematically guaranteed and it is found that the CL algorithm is optimal with respect to the number of trials.

Using realistic mathematical models, our CL approach was applied to motion tasks like arm reaching, sit-to-stand-up, and performing steps. Correspondingly, we simulate them with two-, three-, and six-degrees-of-freedom dynamical models. In the computer simulation we verified that the learning of control parameters converges and the number of trials is very small indeed. In practice, experiments with rapid reaching movements of the arm confirm the feasibility and efficacy of the proposed CL approach as well. Special attention in our current research is devoted to the challenging problem of CL in the real, three-dimensional human locomotion. We can perform proper decomposition of this

complex motion task into several goal-directed movements and apply the proposed CL scheme for each of them. Our CL approach makes it possible to derive control rules for the different locomotion phases and perform steps with variable length, height, direction and gait velocity.

The neural structures that compute the required control forces are the so-called internal models presenting a fundamental part of the voluntary motor control. We believe that the proposed approach can be used to rebuild such models (cortical reorganization) by proper training procedures. The work outlined here can provide a fundamental understanding of optimal movement learning and may lead to the development of strategies for efficient neuro-muscular rehabilitation.

A-0083

TOWARDS FULL-BODY MOTION SENSOR NETWORK BASED COACHING SYSTEM: A STUDY ON GOLF PUTTING

Haisong Dong^{1,2}, Tomoyuki Yamamoto^{1,2}, Hiroshi Ishiguro²

¹*CiNet, National Institute of Communications Technology (NICT), Suita, Osaka, Japan;*

²*Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka, Japan*

Motor learning is one of the most important aspects of skill acquisition and attracts enormous attention in different fields of sports science. However, despite plenty of training systems and methods that have been proposed over the years, most of them were based on verbal or visual instructions, which heavily relied on very timing-consuming practice and repetition to attain progress, and thus is very inefficient in terms of skill acquisition.

In this research, we are developing a type of novel coaching system that may extract the motion patterns of experts and provide real-time evaluation and feedback for beginners to facilitate motor learning. Rather than focusing on trajectory-tracking control as many previous works did, we try to concentrate on teaching kinetic chain and exertion of different body parts, which may be more important for understanding and imitating the experts' movement.

To verify the efficacy of the proposed system, we conduct experiment on golf players of different levels (beginner, amateur and professional players) using our system to learn the skill of putting stroke.

For this purpose, a set of wearable full-body motion sensor network integrated gyroscopes, accelerometers and other sensors is developed so as to capture subtle and precise motion features. Due to the flexibility of sensor nodes and portability of data acquisition unit, it can also be used under various other scenarios. Obtained data can then be processed in a computer. With its help, we are able to analyze and compare the distinctions between subjects that traditional trajectory-based motion capture systems may fail to extract under some conditions.

Rigorous analysis is conducted to identify motion patterns that may either differentiate experts from beginners or necessary for making a great contribution to the final performance. In the experiment, significant motion pattern difference can be observed between professional players and beginners. As a result, movement evaluation criteria can be established from these data for real-time movement sensing and evaluation. We also realize online movement segmentation for phase-wise coaching (backswing, downswing, impact and follow-through) as the natural process of learning does.

An inclusive feedback mechanism is also under development in order to inform the subject of unsuccessful trial and undesired motion patterns upon movement execution. Except for conventional visual feedback, acoustic and haptic feedback and conditional physical constraints are

also incorporated so that if any problem is recognized by our system, we may generate immediate feedback signal targeting specific body parts involved (such as vibration on upper arm or hip). Such real-time response and precise targeted feedback may greatly reduce unnecessary trial and error in traditional training approach and skill acquisition within much less time can be expected.

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A-0064

THE TUNING OF REFLEXES TO ENVIRONMENTAL RISK

Amber Dunning, Matteo Bertucco, Terence Sanger

University of Southern California, Los Angeles, California, USA

Recently, a lot of attention has been given to exploring the type of control algorithm humans implement in movement. There are several proposed models that exhibit characteristics similar to human behavior, but these models do not integrate risk appropriately (Terry 2015). In this context, we are describing risk as the combination of cost of failure and probability of failure. In order to characterize and emphasize the influence of risk in the environment on human behavior, we have designed a series of experiments. In a previous study, we provided evidence that not only do humans consider risk when initially planning a movement, but also that they are constantly evaluating the environmental loss function in a continuous task. Many studies have demonstrated that humans have the ability to modulate the long latency stretch reflex based on the goal of a task, such as in a go-don't-go paradigm (Pruszynski 2008). It is our hypothesis that awareness to risk is so fundamental, that humans also maintain reflexes tuned specifically to the risk of the environment, even when the goal of the task remains constant.

In the experiment, healthy, adult subjects ($n=9$) were positioned in front of a monitor with their right index finger attached to the arm of a robot that controlled a cursor on the screen. Surface electromyography from the first dorsal interosseous (FDI) was recorded (sample rate 1000 Hz, bandpass filter 25-250 Hz). The monitor displayed three rectangles: two cost regions on either side of a center reward region, which moved horizontally (remaining equidistant) in a randomized sinusoidal motion. Subjects were instructed to maximize points by keeping the cursor within the center reward region while avoiding the cost regions that would result in a loss of points. Nine cost environments were evaluated, all combinations of no penalty, low penalty, and high penalty, in order to evaluate the effect of both symmetric and asymmetric risk. Thus the goal of the task was always to remain in the center target, but the cost of hitting the penalty regions was varied. The robot generated a constant 1 N force with randomized 4 N perturbations in both directions (randomized) at a mean rate of 3 seconds.

Only trials in the direction that provoked the FDI stretch reflex were analyzed. Reflex response was categorized into standard epochs for baseline, short latency, long latency, and voluntary response. The filtered EMG within each epoch was averaged to a single value for analysis. Short latency epoch was not significantly different between cost environments. A significant difference ($p<0.01$) was found in the long latency epoch between cost functions. There was not a significant difference ($p=.59$) between cost functions that pushed toward higher cost versus away from higher cost. Therefore, results suggest that humans do plan for error by tuning reflexes to the risk of the environment and that they do this independent of the goal of the task. However, subjects did not demonstrate the ability to set separate reflex responses for different directions when the direction of perturbation was unplanned.

A-0008

ANTICIPATORY POSTURAL ADJUSTMENTS ASSOCIATED TO REACHING MOVEMENTS ARE LIKELY PROGRAMMED ACCORDING TO THE EXPECTANCY OF VISUAL INFORMATION

Roberto Esposti, Carlo Bruttini, Francesco Bolzoni, Paolo Cavallari

Section Human Physiology of the DePT - Università degli Studi di Milano, Milan, Italy

During goal-directed movements, the head, eyes and limb are dynamically coordinated so as to look at and reach a given target. This study examined whether changes in eye-head-arm coordination affects Anticipatory Postural Adjustments (APAs) in lower limb muscles when performing an arm reaching movement, toward a target of known position.

Standing right-handed subjects ($n=10$) flexed their shoulder and reached, with the index-fingertip, a target placed in front of them, at shoulders height. Four conditions were studied: 1) steadily looking at the target while reaching (Visually-Guided Reaching); 2) starting with the head flexed watching the floor, then Look and Reach the target; 3) as in 2, but Without Reaching and 4) keeping the head flexed until having reached the target (Blind Reaching).

Subjects memorized the target position by performing several reaching movements, until they felt confident. Thereafter, they performed in random order 7 sequences of 15 trials (separated by 5 min of rest): one in Visually-Guided Reaching, one in Without Reaching, one in Blind Reaching, and four in Look and Reach. Recorded variables were: arm and head kinematics, vertical electro-oculogram, EMG from right Anterior Deltoid (prime mover), pectoralis major and biceps brachii, EMG from right and left tibialis anterior and hamstring, forces exerted to the ground.

For what concerns Look and Reach movements, two coordination strategies were found: trials in which both the eyes and head movements preceded the arm prime mover activity (Look-First, $35.0 \pm 6.5\%$ of total), and trials in which the opposite occurred (Arm-First, $35.5 \pm 6.6\%$). In the remaining trials, which were discarded, the prime mover recruitment followed the head extension but preceded the eye movements, or vice-versa.

Data analysis revealed that APAs in leg muscles and forces to the ground were more anticipated in Look-First than in Arm-First, as it was in Visually-Guided than in Blind Reaching ($p < 0.0005$), i.e. when a visual information was searched for or already present before starting the arm movements. The time-lag from Look- to Arm-First was not different from that measured between Visually-Guided and Blind Reaching ($46.4 \pm 9.9\text{ms}$ vs. $42.5 \pm 9.1\text{ms}$, $p > 0.6$). Moreover, in Without Reaching trials the APAs associated to head extension always lagged the APAs observed in both Look-First and Arm-First conditions. Thus, the head extension alone could not be responsible for these latter effects.

In conclusion, according to the chosen strategy, Look and Reach movements are programmed by taking into account the availability of online visual information about target position. In fact, when Looking First, the CNS takes into account that such information will be already available when approaching the target, like in Visually-Guided Reaching; instead, when moving the Arm First, the CNS seems not to rely on such information, like in Blind Reaching. Neither the ocular movements nor the head extension seem to be responsible for the change in APA programming, given the similarity of the Look-First to Arm-First and the Visually-Guided to Blind Reaching time-lags. Thus, considering also the time for cortical processing, it is likely that the expectancy of visual information influences the programming of arm movement.

A-0089

VISUALLY AIMING AT THE SCORING TARGET IN BASKETBALL: AN EXPLORATORY STUDY

Pedro T. Esteves^{1,2}, Matt Dicks³, Bruno Travassos^{2,4}, Pedro Silva⁵, Teresa Fonseca¹¹ Polytechnic Institute of Guarda, UDI: Research Unit for Inland Development, Guarda, Portugal;² Research Centre in Sports Sciences, Health Sciences and Human Development, CIDESD, Portugal;³ University of Portsmouth, Portsmouth, United Kingdom;⁴ Department of Sport Sciences, University of Beira Interior, Portugal;⁵ Universidade do Porto, Faculdade de Desporto, Centre for Research, Education, Innovation and Intervention in Sport, Portugal

The exploration of perceptual information has been consistently purported as a primordial mean of motor control (e.g., Gibson 1979). Surprisingly, there is a lack of understanding on the impact of others on gaze control during aiming tasks. This study aimed to analyze the effects of the type of opposition on the visual fixation patterns of basketball players attempting to shoot at the scoring target, within an immersive sport setting. Four (n=4) expert basketball players from Portuguese Professional League participated in this study either as attacker and defender. Basketball shooting task was performed from a predetermined position in front of the basket (at 5.6m to the basket). Four experimental conditions implied the presence of a defender at different values of distance to the attacker: (i) 0.5m, (ii) 1m, (iii) 1.5m and (iv) 2m. An additional control condition was prescribed with no defender. The attacker was instructed to shoot at the basket according to the prescribed condition, without dribbling, and the defender to intercept the shot by jumping and moving their arms along the frontal plane of movement. Each attacker performed each trial with a SMI eye-tracking glasses (v2.0) system coupled to their head. Visual patterns of fixation were analyzed using SMI BeGaze software that permitted to compute the duration of fixation (ms) per area of interest. We considered the following areas of interest from the visual scenario: i) ball, ii) rim, iii) backboard, iv) space between attacker and defender, v) body of defender, vi) others. Preliminary results showed larger duration of fixations on the space between attacker and defender ($M = 204.72$, $SD = 202.57$) when the defender was at 2m to the attacker, and smaller duration of fixations on the ball ($M = 101.28$, $SD = 66.93$) when there was no defender ($d=0.77$). Interestingly, when the defender was closer to the attacker longer duration of fixations was related to the backboard ($M = 187.86$, $SD = 191.08$) while shorter duration of fixations was related to the ball ($M = 107.23$, $SD = 69.95$) ($d=0.62$). Together, these preliminary results indicate an adaptive control of gaze by the attackers in view of the type of opposition. Relevant potential implications may be further drawn from this study, either at theoretical and practical levels. It would be valuable to extend actual data analysis by attending to the dynamics of coupling between gaze behaviours and motor actions, which may inform on the prospective nature of movement regulation.

Gibson, J. J. (1979). The ecological approach to visual perception. Boston: Houghton-Mifflin Company.

A-0006**EFFECT OF ADDITIONAL SENSORY INFORMATION ON GAIT SPEED OF FALLERS ELDERLY****Isabela Feitosa de Carvalho¹, Marcos Eduardo Scheicher^{1,2}**¹ *Biosciences Institute, Paulista State University, Rio Claro, Sao Paulo, Brazil;*² *Department of Physical Therapy and Occupational Therapy, Paulista State University, Marília, Sao Paulo, Brazil*

0.05. Results – The mean of gait speed was 1.07 ± 0.08 m/s without bandage and 1.2 ± 0.09 m/s with bandage ($P = 0.03$). Key conclusion – The data showed that the manipulation of sensory information can improve the gait speed of the elderly fallers, decreasing the risk of falls. Previous studies have shown that the aging process is associated with changes to gait patterns and balance, which may predispose them to increased risk of falling. Others studies have investigated the manipulation of sensory information in the control of postural strategy using the soft touch on a hard and stationary surface, and found a significant reduction in the body oscillation compared with the situation without touch. Our previous study showed the decrease of time of TUG test in fallers elderly with the additional sensory information. The objectives were to investigate the effect of additional sensory information in gait speed in elderly people with a history of falls. Methods – Six elderly patients with a history of falls in the last year were evaluated. The gait speed was evaluated using the Ten-metre Walking Test. The additional sensory information was made with an elastic infrapatellar bandage placed bilaterally. The comparison was made by Wilcoxon matched pairs test, with P

A-0104**REGULAR VOLUNTARY RUNNING IMPROVES COGNITIVE FUNCTIONS IN AN ANIMAL MODEL OF ATTENTION-DEFICIT/HYPERACTIVITY DISORDER****Klára Felszeghy¹, Anikó Posa², Csaba Varga², Csaba Nyakas¹**¹ *University of Physical Education, Institute of Sport Sciences, Budapest, Hungary;*² *University of Szeged, Department of Physiology, Morphology and Neurobiology, Szeged, Hungary***Introduction**

Attention deficit hyperactivity disorder (ADHD) is a behaviorally defined motor and brain behavioral abnormality. The dysregulation of dopaminergic transmission is the major course in the extrapyramidal motor system and other brain areas innervated by dopaminergic neurons. Although hyperactivity shows remission over ageing, cognitive impairment still persists at adulthood. The neonatal dopamine (DA) depletion in rats is one of the most frequently used animal models for studying the disorder. In recent study we aimed at examining the cognitive performance of dopamine depleted animals (Luthman et al, 1997) following regular voluntary training at adult age.

Methods

At neonatal age (postnatal day 4) animals were DA-depleted by intraventricular injection of 20 microgram 6-hydroxydopamine. This intervention resulted in 70-90% decrement of extracellular DA content in dopaminergic brain areas. Control animals were sham operated. The half of adult depleted and control rats were placed into special cages containing a running wheel at the age of 3 months. The other half of each groups remained in normal cages by four animals per cage. Following 3 months of voluntary running animals were tested for hyperactivity and impulsivity in an open

field. Attention and memory functions were assayed in novel object recognition paradigm (Wappler et al, 2009), spatial learning and memory were evaluated in a Morris water maze.

Results

Dopamine-depletion resulted in motor hyperactivity in open field. Depleted animals showed impaired attention and memory function both in novel object recognition and in spatial learning tasks. Regular voluntary running decreased hyperactivity of depleted rats. In the novel object recognition test trained animals showed significant improvement in attention as compared to controls. In spatial learning task voluntary running resulted in better working memory function, but did not influence significantly the impaired reference memory of the dopamine-depleted rats.

Discussion

Our results indicate that 3 months of regular voluntary training decreased hypermotility and impulsivity of ADHD rats. Moreover, the regular exercise improved attention and memory function of DA-depleted animals comparing to those of untrained DA-depleted rats. These results strongly suggest that long-term and regular voluntary exercise as preventive-rehabilitating intervention can induce remarkable improvement in the symptoms of ADHD providing complementary therapy to the pharmaceutical treatment of developing adult ADHD brain pathology.

References

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A-0039

EMG ANALYSIS OF HIP AND TRUNK MUSCLES AMONG PEOPLE WITH CHRONIC LOW BACK PAIN

Regina Finta, Peter Katona, Rudolf Mihalik

University of Physical Education, Budapest, Hungary

Low back pain (LBP) is one of the most frequent cause of seeking medical advice. If this pain becomes chronic the scheme of muscle activity can be altered. The muscle activity and the sequence of engagement can be examined by electromyographic (EMG) analysis. Former investigations found differences in the activity of back muscles during isometric tasks among people with LBP.

We assume as a result of LBP the rate of engagement (RE) of the measured trunk and hip muscles changes, as well their activity. Thus we measured the rate of engagement and the activity level (AL) of the measured trunk and hip muscles, and we tested these parameters between a test and a control group.

35 people (24 female) were divided into groups (LBP, control – C) after they completed the Chronic Pain Grade Scale (CPGS). 12 muscles were measured with surface EMG (Telemmyo Mini 16) during a specified task: the arms were raised horizontally forward while standing with one leg is on a platform (30 cm high) and the other is on the floor. After a verbal instruction the leg on the platform had to be lifted until a comfortable point and then put back to the platform. The task was performed with each leg on the platform.

In the case of RE significant ($p < 0.05$) increment was found in the LBP group. In the case of AL a non-significant increment was found if the left leg was raised in the LBP group and the differences between the muscles on the two body side were reduced.

We assume, that the physiologically activated muscles were insufficient to maintain stability for some reason, so activated muscles had to be activated at a higher level or other muscles had to be activated because of this insufficiency. More investigations should be performed in different body positions or without visual feedback, so the differences could be more robust. It is clear from our results, that the number of activated muscles is raised as a result of LBP. This para-coordination should be dismantled during the rehabilitation, so the existing *circulus vitiosus* could be abolished and the probability of subsequent damage could be reduced. Probably one of the reasons behind the LBP is the altered neural control of postural muscles.

A-0026**THE EFFECT OF BEHAVIORAL INTERFERENCE ON THE KINEMATICS OF A MOVEMENT SEQUENCE DURING MOTOR LEARNING****Jason Friedman¹, Maria Korman²**¹ *Tel Aviv University, Israel;*² *University of Haifa, Israel*

While there have been numerous studies looking at different aspects of learning of a motor sequence (e.g., the effect of sleep, interference, the way training is performed), there have been very few studies looking at how, on a kinematic level, this improvement in performance is achieved. In this study, subjects performed a finger opposition task (touching the thumb and another finger of the hand in a specified order), with the goal to perform the task as fast and accurately as possible. The trajectories of the fingertips were recorded during testing and training with a magnetic motion capture system. Two groups participated in the study, one learning a single sequence (no-interference group), while the other group learned an additional different sequence shortly after learning the first sequence (interference group). Both groups were retested the following day (after sleep) to assess memory consolidation as reflected in delayed, off-line, gains in sequence performance.

We decomposed the changes in performance into those due to changes in the movement properties, and those due to changes in timing. For the no-interference group, we observed robust consolidation gains in performance at 24h re-test. These gains were mostly due to a reduction in the gaps between movements. Relatively little improvement was seen in terms of the movement time - although subjects moved their fingers faster, they concurrently increased the amplitude of the individual finger movements, cancelling out much of the gain from increasing velocity. This strategy is likely a way to enhance tactile feedback. In contrast to the no-interference group, the interference group did not show delayed gains (after a night's sleep). This group did, however, show similar to the no-interference group patterns in terms of the immediate and overnight changes in the kinematics of the movements (i.e., greater velocity and greater amplitude), suggesting that movement-specific changes follow a different time-course to sequence-specific changes in motor learning. The results from this study demonstrate that behavioral interference, in the form of training on a different sequence within 2 h after training on the original sequence, hampers delayed improvements of timing between movements in the original sequence but does not affect changes in the kinematics of individual constituent finger movements.

A-0110**GAIT RECOGNITION WITH DEPTH CAMERA FROM A MOVING PLATFORM****Kevin Leyden¹, Krisztián Gergely², Miklós Koller², György Cserey²**¹ *University of Notre Dame, Notre Dame, IN, USA;*² *Pázmány Péter Catholic University, Budapest, Hungary*

The human walking cycle varies slightly from individual to individual. Extracting these minute variations let us develop an individually identifying biometric marker. These markers can then be applied to track and re-identify humans. The process is commonly known as gait recognition.

Among the family of biometrics, gait recognition has some unique advantages. In contrast with other techniques, such as DNA, fingerprint, iris, or retina recognition, gait information can be extracted from a distance, without the active participation or even knowledge of the identified individuals. This enables ambient scanning of large moving crowds. Applications involve security monitoring at airports, or statistical data mining of the behaviour of shopping mall patrons.

Based on the involved sensor modalities, we can distinguish pressure sensor or video feed based gait recognition methods. Our method falls squarely into this later category, since we are employing a structured-light based depth camera, the so called Kinect sensor. This sensor was originally developed by Microsoft to provide natural gesture interface for their game consoles. Incidentally this made the unit into a low-cost motion capture system, which was already used in several gait recognition projects.

During most gait recognition experiments the data acquisition happens from a fixed sensor position in an artificial laboratory environment. The individuals are either asked to walk on a treadmill, or to move along a pre-determined path on the ground. This technique can introduce several biases. It's unknown how much individuals unconsciously change their gait pattern under observation. Also during practical applications the walking path relative to the sensor, and thus the observing angles varies more widely than the laboratory models.

To alleviate these shortcomings we propose to acquire gait data from a moving robot platform. The robot can seek out pedestrians, move along with them for a short time while recording their walking patterns. The experiment can be conducted in any public space, such as a university lobby or a shopping mall. Passer-bys will obviously see the robot, but they need not be informed that it observes their walking specifically. The moving platform can also employ active strategies to keep the observed human in the sensor frame for the optimal recording duration, while minimizing occlusions.

Further goal of our study is to experiment with Recurrent Neural Networks for gait classification on the acquired data. RNNs has been reported to achieve favorable results on time series datasets. This motivates their usage for gait recognition. Their drawback is, that they require an order of magnitude more training data, than what was previously feasibly collectable. We hope that the mobile robot based sensing will lead to sufficient data quantities.

A-0112

IMPROVING BALANCING ABILITY TO MITIGATE SIMULATOR ADAPTATION SYNDROME

Germán Gálvez-García^{1,2,3}, Lucio Rehbein¹, Leonardo Lagos¹, Miriam León¹¹ Departamento de Psicología, Universidad de La Frontera, Temuco, Chile;² Departamento de Psicología Experimental. Granada. Spain; ³ Département de Psychologie Cognitive & Neuropsychologie, Institut de Psychologie, Université Lyon 2, Lyon, France

We investigated the correlation between the balancing ability and simulator adaptation syndrome (SAS) using two different techniques: Galvanic cutaneous stimulation (GCS) and auditory stimulation. Fifteen drivers (9 men; Mage $\pm$ 23.2 years) participated in a driving simulation experiment comparing three different stimulation conditions (GCS, auditory stimulation and no stimulation as a base line condition) in curves on a virtual urban circuit. Firstly, we found that GCS and auditory stimulation decreased SAS. We therefore recommend that both techniques be used in future driving simulation experiments. Secondly, the analysis of head movements showed that GCS and auditory stimulation have a positive impact on vestibular system, improving the sense of balance (Less head sway). Thirdly, we found that the head sway increased with the severity of sickness symptoms in all the experimental conditions. This means that the positive impact of these techniques on vestibular system reduces simulation symptoms. Fourthly, the driving performance variables showed no difference between the no stimulation condition, GCS condition and auditory stimulation condition. Although the interpretation of null effect could be controversial, it is important to note that at least GCS and auditory stimulation did not adversely affect any driving variable, which is fundamental for the recommendation of both sources of stimulation for future interventions reducing SAS. We encourage the use of stimuli which influence the balancing ability to the design of future simulator protocols and devices to mitigate SAS.

A-0116

ATTENTIONAL SHIFT BETWEEN MOTOR EFFECTORS; ERGONOMIC APPLICATIONS

Germán Gálvez-García^{1,2}, Lucio Rehbein¹, Miriam León¹, Leonardo Lagos¹¹ Departamento de Psicología, Universidad de La Frontera, Temuco. Chile;² Département de Psychologie Cognitive & Neuropsychologie, Institut de Psychologie, Université Lyon 2, Lyon, France

Use of different effectors in two consecutive actions could generate an attentional shift between the effectors with shorter latencies in the second action of reaching. 18 participants (10 men; Mage = 21.3 yr.) participated in an experiment with two main variables:¹ effector switching with two levels (Switching and No Switching), where the participants use or do not use a different motor effector for each action;² lifting muscles, i.e., the muscles involved in the first phase of the reaching, with two levels (finger-lifting muscle and palm-lifting muscle). Premotor time, Motor time, Reaction time, Movement time, and Total time were measured. For Premotor, Movement, and Total times, faster responses were observed when there was no switching of the effector. This delay could be due to an attentional shift between motor effectors and its relations with motor processes. Possible applications include the ergonomic design of device controls, considering that the use of the same effector is beneficial when fast reaction times are sought.

A-0127

ACQUISITION OF MOTOR ACTIONS IN CHILDREN WITH MOTOR DIFFICULTIES

**Roberto Gimenez^{1,4}, Dalton Lustosa de Oliveira^{2,4}, Raquel Simoni Pires²,
Edison de Jesus Manoel³**

¹ *Universidade Cidade de São Paulo - Master Program in Education, São Paulo, Brazil*

² *Universidade Cidade de São Paulo - Doctoral Program in Physical Therapy, São Paulo, Brazil*

³ *Universidade de São Paulo, São Paulo, Brazil*

⁴ *Universidade Nove de Julho, São Paulo, Brazil*

Children with motor difficulties have been target of concern on the part of researchers in several areas. In the literature are found different denominations such as "Clumsy"; "Awkward"; "Dyspraxia"; Minimum Brain Dysfunction; Developmental Coordination Disorder. These children can demonstrate problems of visual and kinesthetic perception, memory and difficulties to form action programs. In special, the difficulties for the formation of action programs can represent a great constraint to the process of motor skills acquisition these individuals. The present study had for objective to investigate the process of motor skills acquisition of children with motor difficulties. The premise of this study is that it depends of the formation of an action program organize in macro and micro-structure (internal representation with features invariants and variants). Subjects were pre-selected by generalist teachers and physical education teachers. It was asked teachers to divide the children in two groups: without and with motor difficulties. Then, they were submitted to the Performance Test "Movement Assessment Battery for Children" - MABC (Henderson & Sugden, 1992). This test corresponds to a new version of "Test of Motor Impairment" (TOMI) prepared by Stoot, Moyes & Henderson (1984). The test allows the assessment of four categories of behavior, namely: manual dexterity, ball skills, static and dynamic balance. In addition, the subjects underwent a test to evaluate their graphic skills (Writing Speed and Accuracy Measurement-WSAM). This test has been used in several studies that focus on the characterization of writing (Berninger, Mizokawa & Bragg, 1991; Christensen, 2004). The test takes into consideration parameters such as the legibility and writing speed. In this context, 30 children (M age= 9.4 years; SD= 1.1) took part in this study, they were assigned in two groups: 15 normal subjects who have obtained higher score in WSAM test, 15 subjects with motor difficulties that presented the worst scores. The task consisted of reproducing the letter "y" cursive. The reproduction of the graphic pattern was made on a tablet, using a cordless pen pressure sensitive. Participants completed 100 trials. Measures as the number of errors of legibility, spatial linear error, speed of execution and control of force in the writing were used. Measures had been used to indicate the invariants characteristics of the action program, such as, number of fragments that the individuals divided the graphical pattern, variability of the number of fragments, time and relative size of the first fragment of the figure. The data were analyzed by Movalyser Program 3.2 version. Generically, the results have showed that the children with motor difficulties have presented more errors of legibility and they had not presented a so regular performance in the analyzed measures when compared to control group. Beyond, the results have tended to present greater values to the measures as the fragmentation and the variability of the fragments number. These results suggest difficulties in the formation of action programs.

A-0018

ANTICIPATORY AND CARRY-OVER COARTICULATION IN EXPERIMENTS WITH TWO SEQUENTIAL SUB-MOVEMENTS

Eva Hansen¹, Britta Grimme¹, Hendrik Reimann^{1,2}, Gregor Schöner¹¹ *Institute for Neural Computation, Ruhr-Universität Bochum, Germany;*² *Department of Kinesiology, Temple University Philadelphia, USA*

One of the most typical properties of natural human movements is that one movement is not independent but involved in a sequence of other movements. A movement segment can affect its successor (carry-over coarticulation) or its predecessor (anticipatory coarticulation). In redundant motor systems coarticulation can be found at the level of end-effector trajectories and at the level of joint angles. As anticipatory and carry-over coarticulation influence movements at different points in time, a comparison between them can help us to better understand the generation of movement. In our experiment right-handed participants moved a cylindrical object on a monitor-table from one circle to the next. Each condition included a starting circle (first target), a central circle (second target) and a final circle (third target). The starting and final circles are in the distance of 9 cm to the circle in the center at 3, 6, 9, and 12 o'clock. 16 different conditions are shown in pseudo-random order. To ensure complete attention to the task, the targets of the current condition were shown on the monitor and had to be memorized. Before the movement started the targets were removed and all possible targets of all conditions were shown. Additionally an experiment with only one starting circle (6 o'clock) and four ending circles was performed to analyze the effects of anticipatory coarticulation more closely.

To uncover coarticulation at the level of joint angle configurations, we applied an analysis of motor equivalence based on the concept of the Uncontrolled Manifold. We decomposed the difference between joint configurations in different conditions into components that leave the position of the transported object invariant (UCM) and those that affect the position of the object (orthogonal to the UCM, ORT). Motor equivalence is determined when this difference lies more in the UCM than in the ORT (same spatial trajectory, but moving through different joint configurations).

Direction-dependent coarticulation was visible at the level of the end-effector and at the level of joint angles. However the preparation of a movement seems to be distinctly different from its post-processing. Carry-over coarticulation was more visible in joint angles than at the level of the end-effector. In contrast anticipatory coarticulation was likewise visible at the level of joint angles and at the level of the end-effector.

A-0052

A TRADE-OFF BETWEEN REACH AND BALANCE EFFICIENCY EXPLAINS THE INTER-INDIVIDUAL DISPARITY OF POSTURE/MOVEMENT COORDINATION

Pauline Hilt¹, Bastien Berret², Thierry Pozzo^{1,3}¹ INSERM U1093, Dijon, France;² CIAMS Laboratory, Paris-South, France;³ Italian Institute of Technology, Genoa, Italy

Hand reaching and bipedal equilibrium are two fundamental features of human motor control. However, how the brain coordinates these two objectives during the planning of goal-oriented actions is not yet clearly understood. For instance favoring the stability of balance by keeping the projection of the center of mass (CoM) at the center of the base of support (BoS), or by lowering it, may be detrimental to the efficiency of reaching. Conversely, efficient reaching may induce unstable postures moving the line of gravity close to the extremities of the BoS. The aim of this study was to identify the extent to which equilibrium concerns can shape whole-body reaching strategies.

To address this issue and emphasize the expression of these motor decision processes, we studied a whole-body reaching task where no specific reach endpoint was imposed [2]. We thus added a large extrinsic redundancy (target-related) to the existing intrinsic one (body-related) which is traditionally studied in motor control [1]. The lack of pre-determined endpoint decreased the focal constraints and allowed subjects to freely choose final hand position and posture. We thus asked 27 subjects to reach to a uniform surface placed in front of them from a standing posture while dealing with equilibrium maintenance. An intra-subject analysis revealed that, despite this freedom, subjects did not vary much their (self-chosen) motor strategy across trials. On the other hand, a significant inter-subject variability was observed leading to a continuum going from a knee flexion strategy to a trunk bending strategy, which induced a variety of final CoM and hand locations.

Using optimal control methods, we identified two costs accounting for these two “extreme” strategies: the trunk strategy was well replicated by a cost measuring the absolute work of muscle torques (min. energy), whereas the knee strategy was well described by a cost measuring the total amount of squared muscle torque (min. torque). The energy cost led to unstable equilibrium at the end of the reach but to minimal body/hand displacement. In contrast, the torque cost involved stable equilibrium but required greater hand displacement. The important between-subject disparity could then be explained by a trade-off in the minimization of these two costs.

To better understand this link, we computed the distance of each subject from each one of the costs, defined as the error between the simulated and recorded joint trajectories. Subjects who were close to a minimum energy solution tended to reach higher and keep the CoM higher. Furthermore, distances to the minimum torque solution positively correlated with the antero-posterior CoM endpoint meaning that the projection of the CoM remained close to the center of the BoS. Our results suggest that posture and movement coordination may be viewed as a motor decision process between at least two costs. The first one would account for the reach efficiency at the price of selecting possibly unstable postures. In contrast, the second value would represent balance-efficient strategies but may then require larger limb displacements.

[1] Bernstein NA (1967) [2] Berret et al. (2011)

A-0058

GENERATING NATURALISTIC PLACING MOVEMENTS FROM THE ELEMENTARY MOVEMENT COMPONENTS TRANSPORT AND LIFT: A COUPLED OSCILLATOR MODEL

Jean-Stephane Jokeit, Britta Grimme, Gregor Schöner*Institut für Neuroinformatik, Ruhr-Universität Bochum, Germany*

The regularity of human reaching movements has been key to much theoretical thinking about optimality principles and potential underlying neural processes. In earlier experimental work [Grimme 2012] we found additional structure in naturalistic hand movements that lifted an object and placed it in a new location on a surface, avoiding in some conditions an obstacle. The three-dimensional trajectory of the obstacle was found to be planar and isochronous when the configuration of initial, target, and obstacle position were varied. The dependence on that configuration was further simplified when the object trajectory was decomposed into a transport component that connected the starting to the target position and a lift component that captured the movement within the plane of motion away from the surface on which the object rested before and after the action. In particular, the height of the obstacle only affected the lift component, which remained invariant, when the location of the obstacle along the transport direction was varied. The transport component, in turn, modulated its time structure so that the point of maximal lift elevation occurred just as the obstacle was passed.

We propose that the two components may be considered elementary movements that are generated from one neural oscillator each. The two elementary movements are coordinated, so that the transport component terminates just as the lift component returns the object to the surface. This coordination is modeled by coupling the two neural oscillators creating in-phase movements. Movement initiation and termination are organized by a neural dynamics of activation variables, to turn on and off the neural oscillator. A contribution from the obstacle to the oscillator dynamics deforms the movement trajectory of the end-effector.

We demonstrate this idea using, in a first attempt, two coupled Hopf normal form oscillators, one for the lift, one for the transport. We investigate what kinds of deformations of the vector-field generate the behavioral signatures of obstacle avoidance. We organize the initiation and termination of the movement based on principles of behavioral organization developed earlier [Richter 2012; Oubbati 2014]. The model is demonstrated in simulation and validated against experimental data.

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A-0125

THE ASYMMETRY OF FAST AND SLOW COMPONENTS OF DECOMPOSED COP SIGNAL IN PD PATIENTS

**Grzegorz Juras¹, Kajetan Slomka¹, Bogdan Bacik¹, Janusz Blaszczyk¹, Joanna Siuda²,
Justyna Szeffler³, Monika Rudzinska²**

¹ Department of Motor Behavior, Academy of Physical Education, Katowice, Poland;

² School of Medicine, Medical University of Silesia, Katowice, Poland;

³ Department of Neurology, Central Clinic of Medical University of Silesia, Katowice, Poland

Impaired balance is reported to be characteristic of the later stages of Parkinson's disease (PD). That fact justifies using posturography as a basic method besides functional clinical tests. The center of pressure (COP) measures is most commonly used in postural studies (e.g., COP range, sway path length and mean COP velocity). A relatively new method based on the equilibrium point hypothesis that addresses more explicitly the dynamic nature of COP and represents more subtle aspects of postural control is the rambling (RM) and trembling (TR) decomposition of a stabilogram. With this method, the COP trajectory can be decomposed into deviations resulting from supraspinal (i.e., RM) and spinal processes (i.e., TR). The trajectory generated by shifting COP is referred to as RM and its difference from the original COP signal is referred to as TR. The objective of this study was to assess the asymmetry of decomposed COP signal in PD patients.

Thirty two PD patients (stage 2 and 3) and thirty matched healthy controls at the same age were studied. The patients were evaluated in best 'ON' state using posturography. Prior to the experiment, subjects signed an informed consent form. The experimental procedures used in this study were in accordance with the Declaration of Helsinki and were approved by the Institutional Review Board. We used a Hall Effect force platforms (AMTI, Accugait, USA), with a fixed 100 Hz third-order analog filter. The platform sampling frequency was set to 100 Hz. The offline raw data were low-pass filtered at 6 Hz using a dual-pass second-order Butterworth digital filter using MATLAB. Two force platforms were placed side-by-side. Subjects performed 2 trials with eyes opened and 2 trials with eyes closed of quiet standing with each foot placed on one of the platforms. Subjects were instructed to stand barefoot in a comfortable foot position with their arms along their sides and with their gaze pointed straight ahead. The duration of each trial was 60 seconds, during which subject was asked not to shift their body weight.

Basic posturography parameters were calculated. Additionally, we performed RM and TR stabilogram decomposition (Zatsiorsky, Duarte 1999). All calculations were made for both directions (anterior-posterior and medio-lateral).

Analysis of COP signal has shown that significant differences could be observed only in the range of sway between both legs. Analysis of RM components yielded similar results as that obtained during analysis of sway characteristics based on COP signal. Interestingly, more significant differences were observed in TR analysis: both range and velocity of displacement were significant. This information may be useful in modifying the standard procedures for detection of early balance impairment.

A-0077

STABILIZATION OF DIFFERENT MECHANICAL VARIABLES BY MULTI-MUSCLE SYNERGIES
DURING MARCHING IN-PLACE**Shoko Kaichida¹, Stanislaw Solnik², Mark L. Latash²**¹Kagoshima National College of Technology, Japan;²The Pennsylvania State University, USA

We quantified multi-muscle synergies stabilizing various mechanical variables characterizing the interaction between the foot and the supporting surface over the single-support phase during marching in-place. Healthy volunteers marched in-place for 60 s at their preferred rate and also 20% and 40% faster than the preferred rate. Surface EMG signals of 12 leg and trunk muscles were recorded and then rectified and normalized by the maximal values observed across all single-support phases. Further, we used the framework of the uncontrolled manifold (UCM) hypothesis to quantify synergies in the muscle activation space with respect to several mechanical variables including the center of pressure coordinates in the anterior-posterior and medio-lateral directions (COP_AP and COP_ML), moment of force about the two horizontal axes (M_X and M_Y) and vertical force (F_Z). Data processing involved three main steps. First, all the data across all the single-support phases were subjected to principal component analysis with rotation and factor extraction. Four factors (M-modes) were accepted accounting, on average, for about 60% of the total variance in the muscle activation space. The composition of M-modes differed across subjects; most common M-modes united muscles of the dorsal side of the body, muscles of the ventral side of the body, and sometimes co-contraction M-modes were seen with heads of the quadriceps and hamstrings represented in a single M-mode with loadings of the same sign. Further, multiple linear regressions were used to link small changes in the M-modes to changes in each of the mechanical variables ($p < 0.001$ for each of the regressions). This resulted in the Jacobian matrix for each performance variable. The null-space of this matrix was accepted as the UCM. Across-steps muscle activation variance in the M-mode space was partitioned into a component within the null-space of the corresponding Jacobian that had no effect on a performance variable (V_UCM) and a component orthogonal to the null-space affecting that variable (V_ORT); each quantified per degree-of-freedom in the corresponding sub-spaces. The synergic signature, $V_UCM > V_ORT$, was consistently observed for all five mechanical variables. Since the M-mode space was four-dimensional, not more than three independent variables could theoretically show the $V_UCM > V_ORT$ inequality. Taken together, these results suggest that there were strong couplings in the space of five mechanical variables. PCA with rotation and factor extraction in the space of mechanical variables revealed three PCs accounting for over 99% of variance in each subject. The loading factors suggested strong coupling between COP_ML and F_Z, and between COP_AP and M_Y; M_X did not correlate with any of the other mechanical variables. Note that these coupling patterns are not trivial consequences of the methods of the computation of COP_AP and COP_ML. The results show that analysis of synergies in muscle activation space during whole-body tasks, such as marching in-place, can reveal synergies stabilizing different mechanical variables. Results of this analysis also provide a window into coupling among mechanical variables. This method can potentially be applied for analysis of multi-muscle synergies in persons with impaired motor coordination.

A-0065

WHY DO PSP PATIENTS FALL: THE ROLE OF POSTURAL GAIN, BODY SEGMENT CONTROL AND ANTEROPOSTERIOR ASYMMETRY

Kammermeier S.¹, Maierbeck K.^{1,2}, Dieterich L.^{1,3}, Plate A. 1, Lorenzl S.^{1,4}, Singh A.^{1,5}, Bötzel K.¹, Maurer C.⁶

¹Klinikum der Universitaet Muenchen, Neurologische Klinik und Poliklinik, Muenchen, Germany;

²Klinikum der Universität München, Klinik für Anästhesiologie, München, Germany;

³Kliniken Ostallgäu-Kaufbeuren, Abteilung für Allgemeinchirurgie, Kaufbeuren, Germany;

⁴Krankenhaus Agatharied, Abteilung für Neurologie, Hausham, Germany;

⁵Emory University, Yerkes National Primate Research Center, Atlanta, GA, USA;

⁶Universitätsklinikum Freiburg, Klinik für Neurologie und Neuropsychologie, Freiburg, Germany

Progressive Supranuclear Palsy (PSP) and late-stage Parkinsons' Syndrome (IPS) are neurodegenerative movement disorders resulting in different postural instability and falling symptoms. IPS falls occur usually forward in late-stage, whereas PSP falls happen in early stages, mostly backward, unprovoked and with high morbidity. The study investigates PSP and IPS neural system pathology for falling by platform tilt and neural network modelling.

Broadband frequency (0.05-2.2Hz) small-amplitude (0,5-1° maximum amplitude) anteroposterior platform tilt with posturography and 3D Zebris motion analysis with eyes open or closed was performed in 19 PSP, 19 IPS with falling history and 18 controls. Disease stages were assessed with clinical scales and scores. A Matlab-based neural network model emulated experimental results.

PSP postural gain exceeded the gain increase found in severe IPS versus control subjects with particular gain increases in the lowest and highest tilt frequency components. Upper body segment gain in PSP was disproportionately increased versus the lower segment, unlike IPS and controls. The neural proportional-derivative-integral model emulated after experimental results showed that PSP were defined by characteristic proportional gain deficits and preferred to align their body vertical closely to the tilting platform axis (proprioceptive sensory weighting), whereas severe IPS preferred space vertical body alignment. Anteroposterior postural directional asymmetry specific to PSP was found to predispose for backward falling. Disease-specific pathologies were shown to correlate with clinical severity.

Results indicate PSP-specific central postural control deficits of postural gain and body segment control, which contribute to PSP-specific falling pathophysiology.

A-0082

PROPORTIONAL MYOELECTRIC CONTROL FROM MOTOR UNIT BEHAVIOUR

Tamas Kapelner, Ning Jiang, Dario Farina

Department Neurorehabilitation Engineering, University Medical Center Göttingen, Georg-August University, Göttingen, Germany

One of the challenges faced by control algorithms for myoelectric prostheses is to provide control that feels natural for the users. Most algorithms employ an unintuitive control scheme that is very different from natural motor control, increasing the required effort of patients to learn to use the prosthetic device, and to perform activities of daily living.

While there are some recent approaches to provide simultaneous proportional control, these rely on

time-frequency based signal processing of the EMG, disregarding the physiological processes that generate the signal. We recently demonstrated that for pattern recognition, motor unit spike trains decomposed from high density surface EMG provide better classification accuracy than EMG-based features.

In this study we used motor unit activity information for regression, to provide proportional control for three degrees of freedom. We recorded surface EMG of 6 healthy subjects using 8 by 8 high density electrode grids wrapped around the forearm. The recorded EMG was band-pass filtered with cut-off frequencies of 3-500 Hz, digitized with 12 bits per sample and decomposed using an offline decomposition algorithm (Holobar and Zazula 2007). We also recorded kinematic data using motion capture pods, one placed proximal to the elbow, one proximal to the wrist and one the hand, all on the dorsal side.

We compared the regression accuracy of a linear regressor for the following features: RMS and time domain features (F1) (Hudgins, Parker, and Scott 1993); number of spikes in region based cumulative spike trains (F2); and F2 complemented with the residual EMG after decomposition (F3). All features were calculated based on a 100 ms time window, with 10 ms overlap between windows. The result of the regression was the R squared value between the estimated and the recorded joint angles.

We analyzed the data using two-way ANOVA and found no statistically significant differences between features, with statistically significant interaction between subjects and features ($p < 1e-6$). Repeated subject by subject one-way ANOVAs and post-hoc analyses have found that for two subjects, F1 outperformed F3 and F2 ($p < 1e-6$), for another two F3 outperformed F1 and F2 ($p = 0.01$, $p < 1e-6$), and for the rest no significant differences were detected.

In conclusion, complementing the classical features with motor unit information improves the accuracy of linear regression for some subjects. The performance increase of F3 and F1 over F2 is due to unreliable decomposition at low force levels, since F1 and the residual EMG in F3 contains the information missing from F2. Thus, for this type of application a more efficient decomposition algorithm is needed, especially at low force levels and dynamic contractions. Since F2 in some cases performs just as well as other features, we suggest that with the described reliable decomposition and a more robust control algorithm, motor unit activity information would be capable to outperform time-frequency features and has the potential to provide a more natural control for myoelectric prosthetic devices.

A-0115

REGULATION OF MUSCLE ACTIVITIES FOR FAST, ACCURATE, AND SMOOTH MOVEMENTS: EVOLUTION OF VIRTUAL TRAJECTORY VIA COUPLING OF DIRECTIONAL MECHANICAL IMPEDANCES

Keitaro Koba, Kanna Uno, Takanori Oku, Mitsunori Uemura, Hiroaki Hirai, Fumio Miyazaki

Graduate School of Engineering Science, Osaka University, Osaka, Japan

Multiple muscles in the human neuromuscular system are responsible for coordinating and regulating movements while negotiating with the dynamic environment. The establishment of a systematic framework to explain motor synergies, mechanical impedances, and virtual trajectories is a challenge to comprehensive understanding of motor control and learning. A mathematical theory enables us to relate these concepts with each other. In our view, the muscle synergy is a coordination index defined as a nonlinear function of co-activations of agonist-antagonist (AA) muscles. It is a composite

unit associated with the mechanical impedances and is also a functional module representing the reference axis in the polar coordinate system for the displacement of an equilibrium point (EP) in the task space. The endpoint stiffness is another index of the mechanical impedances; the balance of the co-activations of AA muscles determines not only the muscle synergies but also the shape and orientation of the endpoint-stiffness ellipse. The virtual trajectory is a time sequence of EPs at the endpoint. The EP can be represented as a point in the configuration space of muscle synergies, and the virtual trajectory can be identified by tracking the point with time in the muscle-synergy space. To clarify the evolution of these interwinding motors with voluntary training, we tested six healthy subjects. The subjects performed spiral tracing as fast as possible with their non-dominant hand in a horizontal plane while monitoring a display showing the ideal trajectory. All subjects were asked to perform the task 50 times per day for eight days, and the kinematics and electromyography signals during the training were analyzed to estimate the muscle synergies, endpoint stiffness, and virtual trajectories.

The results revealed that¹ the muscle synergies (i.e., the balance of mechanical impedances) exhibited similar patterns regarding both intra- and inter-individual variations during the training, and kinematics-assessment scores (spiral test; an index of fast and accurate movements) greatly improved. This indicates the existence of common and invariant reference frames for motor representation that are independent of the level of motor learning. Additionally,² the shape and orientation of the endpoint-stiffness ellipse hardly changed during the training. The orientation of the major axis of the ellipse tended to tilt toward the direction connecting the shoulder and the endpoint (i.e., the radial direction). Moreover,³ the virtual trajectory was organized from a disordered pattern into a smooth spiral pattern that rotated in the "opposite" direction of the kinematic trajectory. In the radial direction, the high endpoint stiffness caused movement with a 0-degree phase shift. In the tangential direction, the far smaller endpoint stiffness caused movement with a 180-degree phase shift. The coupling of these directional mechanical impedances yielded a counter-intuitive observation. This finding indicates that the central nervous system requires an internal model to achieve dynamic compensation in the process of motor learning.

The results indicate that mechanical impedance plays central roles in motor representation and internal model formation, which are essential for motor control and learning.

A-0123

VARIATION OF THE STIMULATION SITE CHANGES THE EXCITATION OF THE LUMBOSACRAL SPINAL REFLEXES

Matthias Krenn¹, Simon M. Danner², Jose L. Vargas-Luna^{3,4}, Andrea Toth¹, Ursula S. Hofstoetter¹, Karen Minassian¹, Winfried Mayr¹

¹ Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria;

² Department of Neurobiology and Anatomy, Drexel University College of Medicine, Philadelphia, PA, USA;

³ Health Technology Center, Reykjavik University - Landsptiali University Hospital, Reykjavik, Iceland;

⁴ Escuela de Ingenieria y Ciencias, Tecnologico de Monterrey, Monterrey, Mexico

Posterior root-muscle (PRM) reflexes can be elicited by epidural as well as recently also transcutaneous electrical stimulation of the lumbar spinal cord. Epidural spinal cord stimulation can be used for neuromodulation of spinal spasticity and generation of rhythmicity. For these purposes it was evident that the stimulation site was causative for the effect. Thus, here we tested the selectivity of

transcutaneous stimulation of the lumbar spinal cord by eliciting PRM reflexes and recording the compound muscle action potentials.

Ten subjects (5 f.) with intact nervous system were studied in supine, standing and prone position. The stimulation set-up consisted of an electrode array centered at the spinal level of T12 and large electrodes over the abdomen. The array had 7 levels, spanning 12 cm in rostrocaudal direction and each consisting of 3x1 cm electrodes. Every level was separately used for stimulation. Stimulation was delivered up to 125 mA. Electromyographic activities were recorded in thigh and shank muscle groups bilaterally.

With the variation of the stimulation level a definite change in the recruitment of PRM reflexes and M waves was observed. PRM reflexes of the quadriceps muscle group had the lowest thresholds and highest peak-to-peak (PTP) amplitudes at the rostral and triceps surae muscle at the caudal electrode levels. PRM reflexes in quadriceps were markedly reduced and the probability of eliciting M waves increased at the caudal stimulation sites. Whereas, in triceps surae M waves were rarely recorded. Changes of the body position clearly influenced the stimulation effect. In the supine position fewest M waves and lowest reflex thresholds were recorded. The PTP amplitudes of the responses in standing position were in mean 80% of the corresponding responses in supine position. Whereas, in prone position M waves were the predominate finding.

Even though the distribution of the generated electrical field with transcutaneous electrodes is unfocused in relation to the target structures, a selective stimulation is possible. The anatomical structure and electrical properties of the spine, i.e. relatively high conductivities of the intervertebral discs, might cause a segmental shift of the field, by changing the stimulation level. Changes of the PRM reflex elicitation with body position changes were most probably related to changes of the volume conductor as well as due to additional physiological influences.

A-0119

EXTRACTING HEART-BEAT SIGNAL FROM FNIRS - A PRELIMINARY STUDY

Christine Langhanns, Hermann Müller

Justus-Liebig-University, Giessen, Germany

Functional near infrared spectroscopy (fNIRS) has increasingly gained importance over the last two decades in neuromotor research. The method allows to measure brain activation during full body movements and therewith provides a key advantage relative to functional magnet resonance imaging. Typical fNIRS-raw data can contain motion artifacts caused by head movement, swallowing, breathing, and heart beat. For research on hemoglobin dynamic changes these artifacts typically have to be removed. However, since fNIRS is often applied to detect brain activation during physical movement, extracting the heart beat from fNIRS data can provide an additional physiologic measure without the need for an additional measuring instrument (e.g. electrocardiography). Heart-beat monitoring can be advantageous to control exercise intensity in individuals and further, to investigate whether there is a correlation of behavioral outcome and underlying fNIRS signal with physical activity. There is one study yet, providing evidence for the feasibility of this method. Perdue et al. (2014) focused on heart-beat monitoring in still sitting infants (age: < 1 y.). The present preliminary study aims to test heart-beat data extraction in adult subjects.

To test the validity of the heart-beat signal from fNIRS, heart beat was recorded via bipolar electrodes from a wireless electromyographic system and synchronized with one-channel fNIRS (PortaLite,

Artinis, Elst, Netherlands). The fNIRS probe was positioned at the right frontopolar area (Fp2 according to international 10-20 EEG System) and data was sampled with 25 Hz. EMG electrodes were attached on the sternum after preparing the skin to decrease skin resistance. Here, data was recorded with 2000 Hz. One male subject (age: 21 y.) executed a sitting, a treadmill walking (3 km/h) and a bicycle ergometer (150 W) phase of 60 seconds duration each. The heart-beat signal was extracted by a custom-made Matlab 8.1.0. (MathWorks, Natick, MA, USA) program and inspected manually.

fNIRS and EMG detected heart beats show high correlation (sitting: $r = .9966$; walking: $r = .9924$; cycling: $r = .9977$). Root mean square error (RMSE) calculated between the heart-rate curves of fNIRS data and EMG data grows only slightly with increasing movement intensity (sitting: RMSE = 0.28 bt/min; walking: RMSE = 0.42 bt/min; cycling: RMSE = 1.01 bt/min).

Heart beat extraction from fNIRS data appears feasible. However, the results of this single case study need to be confirmed using a larger sample size. The completed results will be presented at the conference.

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A-0085

DOES INTERLIMB TRANSFER OF SENSORIMOTOR ADAPTATION RELY ON THE SAME PROCESSES AS CONSOLIDATION OF MOTOR MEMORIES?

Hannah Z. Lefumat¹, P. Mutha², R. Chris Miall³, Jean-Louis Vercher¹, Fabrice R. Sarlegna¹

¹ Aix-Marseille University, CNRS, ISM UMR 7287, 13009 Marseille, France;

² Indian Institute of Technology Gandhinagar, Ahmedabad 382424, Gujarat, India;

³ School of Psychology, University of Birmingham, Birmingham B155 2TT, UK

It is well established that adaptation of reaching movements to a novel condition (i.e., a novel forcefield or a visuomotor rotation) is more efficient when subjects are re-exposed to the same perturbation after an interval of hours or days (Brashers-Krug et al., 1996; Krakauer et al., 2005; Joiner & Smith, 2008; Alahyane and Pelisson, 2005). This phenomenon of savings is thought to reflect the consolidation of motor memory, and it appears to be linked to the level of a specific sub-component of adaptation known as the slow process (Joiner and Smith, 2008) rather than to the overall performance during adaptation. The slow process underlying sensorimotor adaptation is now well characterized: it responds slowly to movement errors but retains information well from one trial to another (Smith and al. 2006). Like savings, interlimb transfer (which underlies how adaptation with one arm can benefit to the opposite arm) has been linked to the slow process as it is associated with brain activation that typically characterizes late learning and storage (Seidler and Noll, 2008). We thus hypothesized that motor consolidation and intermanual transfer both rely on the slow process.

In our experiment, subjects had to reach for visual targets in a rotating platform producing a velocity-dependent force field. Subjects were right-handed young adults. They had no visual, only proprioceptive feedback of hand movements. There were 3 experimental phases on the first day of test: pre-rotation (right/left hand), per-rotation (right hand) and post-rotation (left/right hand). Here, interlimb transfer was assessed by comparing the baseline initial direction of the left hand with the first trial of the post-test (DiZio & Lackner 1995). On the second day (24 hours later), savings was

assessed by testing again the right hand in the force-field.

Preliminary results (N=5) indicate that there is a significant difference in initial direction between the pre- and post-rotation phase of the left hand, thus indicating interlimb transfer. More subjects need to be tested in order to be able to reliably examine motor consolidation and the underlying processes involved in the multi-rate model of adaptation (fast and slow processes).

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A-0113

MOTOR ADAPTATION IN CHRONIC STROKE: THE INFLUENCE OF SPASTICITY ZONES

Mindy F Levin^{1,2}, Sandeep K Subramanian^{3,2}, Rhona Guberek², Anatol G Feldman^{3,2}

¹ School of Physical and Occupational Therapy, McGill University, Montreal, QC, Canada;

² Feil and Oberfeld JRH/CRIR Research Centre, Jewish Rehabilitation Hospital site of the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal, Laval, QC, Canada;

³ Département de Neurosciences, Université de Montréal, Montreal, QC, Canada

The ability of individuals post-stroke to re-learn motor tasks involving the spastic hemiparetic upper limb is an essential component of motor recovery. Studies of upper limb motor learning however, are inconclusive because of the failure to take into account the presence of angular zones in which spasticity interferes with the production of movement. Our previous studies have identified deficits in the ability of patients with stroke to regulate motoneuronal thresholds throughout the whole biomechanical range of the elbow, resulting in angular zones in which muscles cannot be deactivated (spasticity zones). We hypothesize that the ability to learn upper limb movement may be influenced by the presence of spasticity zones. The influence of spasticity zones on motor learning was investigated by comparing the adaptation of elbow movement to a new load within and outside identified spasticity zones. Subjects with stroke (Fugl-Meyer scores: 32-61/66) and age-matched healthy controls made rapid 50° horizontal elbow extension movements from an initial 3° to a final 6° target. Sixteen blocks of 6-10 trials were practiced in one (healthy subjects) or 2 sessions (stroke subjects). In Session 1 (healthy and stroke), movements were made in mid joint range (spanning spasticity zones) and in Session 2 (stroke), movements were restricted to a joint range outside the spasticity zone. Spasticity zones in stroke subjects were identified by determining the threshold joint angles at which stretch reflex (SR) responses occurred in elbow flexors despite the instruction

to relax muscles and not to intervene. In each block, movements were alternatively not loaded or loaded by a position dependent load (30% MVC). Subjects were instructed to extend the elbow to the final target in a single fast and accurate movement and to correct movement errors as soon as possible. Visual feedback of elbow position and movement speed was provided. Angular positions before correction were used to identify error correction strategies. Changes in load condition from load to no-load and vice-versa resulted in overshoot and undershoot errors respectively in both groups. In Session 1, subjects with stroke corrected errors in 1-4 trials compared to controls who corrected errors in 1-2 trials. For the same stroke subjects, the number of trials needed to correct errors fell to 1-3 with the majority needing only 1-2 trials in Session 2. Preliminary results suggest that spastic resistance of the muscles may influence the ability to display behavioral improvement in subjects with stroke. Results of this study may help distinguish arm motor learning ability from errors due to underlying motor deficits in the spastic paretic arm. The presence of spasticity zones should be accounted for during interpretations of results of motor learning studies.

A-0005**WHAT IS THE MECHANISM OF THE EFFECT OF LIGHT DIGITAL TOUCH ON POSTURAL SWAY?****Wen-Lin Liao, Fu-Chen Chen***National Pingtung University of Science & Technology, Pingtung County, Taiwan*

The effect of light finger touch on reducing postural sway has been widely replicated; however, the mechanism of this effect has not been well understood. While sensory effect hypothesis states that sensory information available in light finger touch is used to automatically diminish postural sway, suprapostural effect hypothesis argues that postural sway is adjusted by the demand imposed by the precision requirements of light finger touch. The object of the current study was to test sensory effect and suprapostural effect hypotheses. Thirty-four healthy young adults kept quiet bi-pedal standing while lightly touching a stable plate using index finger with various touch force (2 levels: very light touch, and light touch), and precision demand (2 levels: low demand, and high demand). Consistent with sensory effect hypothesis, postural sway is significant lower in the light touch compared to very light touch condition, as higher touch force level results in greater amount of sensory information. Also, consistent with suprapostural effect hypothesis, postural sway is significant reduced in the high precision than that in the low precision demand condition. The current results indicated that both hypotheses are valid, suggesting that sensory and suprapostural effects can coexist for the adaptive control of human postural sway, and in various scenarios one is dominant over another.

A-0004**LIGHT FINGER TOUCH ENHANCES FUNCTIONAL INTEGRATION BETWEEN POSTURAL CONTROL AND VISUAL SEARCH****Guei-Jen Lin, Jui-Hung Tu***National Pingtung University, Pingtung City, Taiwan*

People usually perform multi-tasks concurrently in activities of daily living. However, the mechanisms for the interaction between simultaneous postural and non-postural tasks have been controversial for years. The present study investigated the effects of light digital touch on both postural sway and visual search accuracy for the purpose of assessing two hypotheses (functional integration and resources competition), which may explain the interaction between postural sway and the performance of non-postural task. Participants (n=42, 20 male, 22 female) were asked to inspect a blank sheet or visually search target alphabets in a text block while using fingertip lightly contact with a stable surface (light touch, LT), or hanging both arms along sides of body (no touch, NT). The results showed significant main effects of light touch on reducing the magnitude of postural sway as well as enhancing visual search accuracy in the LT compared to the NT condition. The findings support the hypothesis of function integration, demonstration that the modulation of postural sway can be modulated to improve the performance of visual search task.

A-0075**DOES OLDER AGE AFFECT ACTION SELECTION?****Elizabeth Mallia, Sven Bestmann, John Rothwell***Sobell Department of Motor Neuroscience and Movement Disorders, Institute of Neurology, University College London, London, UK*

Motor function declines in old age and this may affect the ability to select the “best-at-the-time” action from a set of possible actions within an environment. The sensory information required to select the action can improve motor output in proportion to the probability of an upcoming event. However, dopaminergic transmission, thought to be critical in encoding the precision of the sensory information (Galea et al., 2012, J Neurosci.), becomes impaired in old age. We investigated action selection in healthy elderly subjects, by comparing the effect that improbable events within a predictable context have on finger movement selection, with that of young subjects. Reaction time (RT) and response force (RF) were used as measures of performance. Methods: Subjects in the Young group (n = 17; age: 18-25 years) and the Elderly Group (n = 18; age: 65-82) performed an isometric finger press with their right and left index and middle fingers on a force-sensing keypad in response to visual stimuli on a screen. Through trial-and-error, subjects learnt which finger corresponded to which stimulus. After, they performed a probabilistic reaction time task, which allowed for the selection of an action based on the probability of a future event given past experience. Subjects performed 4 blocks of 100 trials: in the first and last block (Unpredictable blocks) the likelihood of each stimulus appearing was random, while in the second and third block (Predictable blocks), the likelihood of each stimulus appearing was such that subjects experienced an implicit sequence (Probable trials) which, at times, was violated (Improbable trials). During the probabilistic reaction time task stimuli appeared for 300ms, every 1000ms. Results: For all correct responses, subjects in both the Young

Group and Elderly Group were slower to react to improbable trials, and faster to probable trials, with respect to trials in Unpredictable blocks (Young: $p = 0.010$, Elderly: $p < 0.0005$). Elderly subjects were not slower than Young subjects during improbable trials ($p = 0.562$). However, in the Elderly Group Normalized Peak Force during improbable trials was higher than that for probable trials ($p = 0.011$) – a difference not seen in the Young Group ($p = 0.492$); Probability by Group interaction: $p = 0.008$). There was no difference in Normalized Peak Force for Probable and Improbable trial types between groups (Probable: $p = 0.444$; Improbable: $p = 0.169$). Time taken to produce Peak Force was not different between trial types and between groups ($p = 0.297$). We intend to analyze the effect of different trial types on the relationship between RT and RF, and the how this changes with age. Additionally the improbability of each trial will be computed as Surprise (Harrison et al., 2006, Neural Netw.), and the relationship between Surprise and RT / RF, and how this relationship changes with age will be investigated. Conclusion: Preliminary results suggest that in the elderly, motor function is affected differently during action selection.

A-0122

EFFECTS OF NORDIC WALKING AND FREE GAIT TRAINING ON CLINICAL, FUNCTIONAL AND BIOMECHANICAL PARAMETERS IN SUBJECTS WITH PARKINSON'S DISEASE: RANDOMIZED CONTROLLED TRIAL

Flávia Gomes Martinez, Elren Passos Monteiro, Leandro Tolfo Franzoni, Giane Liedke, Patrícia Dias Pantoja, Leonardo Alexandre Peyré-Tartaruga

Federal University of Rio Grande do Sul, Porto Alegre, Brazil

Introduction: Changes in clinical, functional and biomechanical parameters of gait are remarkable features in Parkinson's disease (PD). Although exercise is recommended as an effective model of therapeutic intervention, little is known about the effects of Nordic walking (NW) on symptoms in patients with PD. Purpose: The aim of this study was to evaluate and compare the effects of a NW and free walking (FW) training program on clinical, functional and biomechanical parameters of gait in people with PD. Experimental Design: Randomized controlled clinical trial. Methods: The sample comprised 33 participants, aged above 50 years, of both sexes, with clinical diagnosis of idiopathic PD (stage 1-4 in the Hoehn and Yahr scale), that received two types of intervention: NW (NW, $n = 16$) and FW training program (FW, $n = 17$), during six weeks. Subjects underwent the tests in the following period: pre-training + pre-familiarization (T1); post-familiarization + pre-training (T2); post-training (T3). Outcomes of Study: Motor symptoms: balance, walking functional mobility, self selected walking velocity, and rehabilitation index. Non-Motor symptoms: staging and severity of PD, cognitive function, depressive symptoms and QL; kinematic parameters (spatiotemporal and dynamic stability of walking) and neuromuscular parameters considering muscles: Vastus Lateralis (VL), Biceps Femoris (BF), Tibialis Anterior (TA), Gastrocnemius Medialis (GM). Statistical Analysis: Sample characteristics, at baseline, were compared by applying the One Way ANOVA. Outcomes were analyzed using the Generalized Estimates Equations, to compare groups (NW and FW) and moments (T1, T2 and T3). Bonferroni post-hoc was used. Data were analyzed using SPSS, v.20.0, with a significance level of $\alpha = 0.05$. Results: The intervention proposed provided a significant beneficial effect after the training period, for all ICF domains and a reduction in UPDRS III ($p < 0,001$). For motor symptoms outcomes, increase in walking functional mobility ($p < 0,001$). For non-motor symptoms, there was an increase in cognitive function ($p < 0,046$), reduction of the depressive

symptoms ($p < 0,001$), and increase in the overall QL domain ($p < 0,001$), as well as in the physical ($p < 0,037$), psychological ($p < 0,019$), social participation ($p < 0,007$) and intimacy ($p < 0,033$) domains, independent of the training group. The NW group showed significant improvement in the autonomy domain when compared to the FW group ($p < 0,001$). For kinematic outcomes, there was a reduction in contact time, swing time, stride length and stride frequency, for NW when compared to FW ($p < 0.05$), while neuromuscular parameters showed reduction of the final activation threshold of the VL and GM ($p < 0.05$), in the activation of the VL and BF ($p < 0.05$) and in the co-contraction index of the TA and GM ($p < 0.05$) in NW group. Conclusion: The NW and FW training programs provided improvement, without difference between groups, in functionality domains after the intervention. However, NW compared to the FW showed advantages in functional mobility and neuromuscular specific parameters, improving, as well, clinical and functional aspects in individuals with PD.

A-0061

NEURAL CORRELATES OF ERROR PROCESSING IN A COMPLEX MOTOR TASK – AN EXPLORATIVE EEG-STUDY

Lisa Katharina Maurer, Heiko Maurer Hermann Müller

Neuromotor Behavior Lab, Justus-Liebig-University, Giessen, Germany

Error processing in the brain can be measured by event - related potentials in the EEG. Among these potentials, the ERN is a negative deflection in fronto - central regions that emerges with or shortly after an erroneous motor response, even prior to sensory feedback about the movement outcome such as knowledge of results (KR; Falkenstein et al., 1991; Gehring et al., 1993). The functional significance of the ERN is discussed in light of different aspects of error detection and error processing, all of which include prediction about the movement outcome. With a focus on the temporal relation of the ERN to the motor response, the ERN can be a useful tool to analyze error prediction in motor tasks. The current study strives to quantify the ERN in a relatively complex motor task where KR is delayed with respect to movement termination allowing to discriminate between error prediction and mere error observation.

24 participants (5 males; $M_{age} = 23.2$ years, $SD_{age} = 6.3$ years) performed a semi-virtual goal-oriented throwing task for 400 trials. They manipulated a real lever to throw a virtual ball displayed on a computer monitor with the aim to hit a virtual target as often as possible. During the task, EEG was recorded from F3, Fz, F4, FCz, C3, Cz, C4, P3, Pz, P4 (reference: averaged mastoids). For each subject, the continuous EEG signals were filtered (0.1 Hz high pass, 30 Hz low pass), corrected for ocular artifacts, and then segmented into epochs from 600 ms before and 1600 ms after ball release of on average 39.6 successful trials hitting the target and 33.8 error trials missing the target. The grand average of the FCz electrode of all subjects showed two rather separate negative deflections in error trials relative to hit trials, a relatively sharp one occurring 200-350 ms after release and another broader deflection from 400-900 ms after release. One-sample t-tests of mean amplitudes of the difference waves between error and hit trials revealed significant deviations from zero for both deflections (200-350: $t = -2.2$, $df = 23$, $p = .04$; 400-900: $t = -7.4$, $df = 23$, $p < .001$)

The second broader negative deflection ended with KR, i.e. when participants saw whether the ball hit the target or not. Since participants saw the complete ball flight from release to target hit or passing on the monitor, we assume that this deflection arose from an increasing certainty about failure of error trials inferred from ball trajectory. In contrast, the first deflection might represent

an ERN signal rather independent from visual feedback and thereby assumingly related to error prediction. In order to confirm these interpretations, further experiments are planned.

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A-0130

THE ROLE OF REWARD, PUNISHMENT, AND MOVEMENT DIRECTIONS ON IMPLICIT SENSORIMOTOR LEARNING

Samuel McDougle^{1,2}, Krista Bond¹, Jordan Taylor^{1,2}

¹ Princeton University Department of Psychology;

² Princeton Neuroscience Institute, USA

An influential model of human sensorimotor learning suggests that a fast process and a slow process operate in parallel to produce the canonical learning curve (Smith et al., 2006). Recent evidence supports the subdivision of sensorimotor learning into explicit and implicit processes that simultaneously subserve task performance (Taylor et al., 2014). Here, we set out to test if these two accounts of learning processes are homologous. Using a recently developed method to directly assay explicit and implicit learning in a sensorimotor task, along with a computational modeling analysis, we show that the fast process closely resembles explicit learning and the slow process approximates implicit learning in both force field learning task and a visuomotor rotation task. In addition, we find evidence that implicit learning can be further divided into two additional subcomponents. One of these subcomponents appears sensitive to movement direction, suggesting that it might be the result of “use-dependent plasticity” or a form of operant condition. Indeed, recent work suggests that implicit learning is differentially affected by reward versus punishment (Galea et 2015); therefore, in a follow-up series of experiments, we investigated how the time course of implicit learning is affected by the number of reach directions and the presence of reward and/or punishment. We suggest that implicit motor learning is often a conflated measurement, consisting of both trial-by-trial calibration and operant directional biases, both of which likely respond to different sources of feedback.

A-0016

LONG-RANGE CORRELATIONS IN THE FLUCTUATIONS OF STANCE, SWING AND DOUBLE-SUPPORT-TIMES IN NORMAL WALKING

Christoph Mickel¹, Gerrit Kollegger², Dietmar Schmidtbleicher¹¹ Institute for Sports Science, Goethe-University Frankfurt, Germany² Institute for Sport Science, TU Darmstadt, Germany

Introduction:

Plenty of research documents long-range correlations in stride interval fluctuations under different conditions for healthy subjects, while it has been shown that this structure breaks down with aging and several pathologies [1-8]. But are there also long-range correlations in the fluctuations of stance, swing and double-support-times?

Methods:

48 students of the Institute for Sports Sciences (height $178\text{cm} \pm 11,3$, weight $72,1\text{kg} \pm 12$, age $23,5\text{ years} \pm 3,92$) that had no acute or chronic lesions or diseases of the lower extremities carried four 3D accelerometers (Analog Devices ADXL 326), which were mounted to the distal end of Os metatarsale III and below the Malleolus lateralis of each foot. Sampling frequency was set to 2000 Hz. Subjects were instructed to walk at PWS for consecutive 20 to 25 minutes. Two double-photoelectric barriers measured locomotion velocity several times during the trial. Average locomotion velocity for the group was $1,57\text{ m/s} \pm 0,16$ with an average SD for the single subject of $0,02\text{ m/s}$.

Results:

After separating the accelerometer time-series into stride intervals, stance, swing and double-support time (=DST) their duration was selected resulting in a total of 13.552 step cycles that could be included in the analysis. Detrended fluctuation analysis (=DFA) was performed and compared to a surrogate-data test (thousandfold randomization). DFA resulted in $\alpha = 0,86$ for stride interval, $\alpha = 0,78$ for stance, $\alpha = 0,66$ for swing and $\alpha = 0,62$ for DST. All of them showed significant differences to the surrogates we can, therefore, deduce that those are long-range correlations.

Discussion:

The α of the single phases show long-range correlations that are below the ones for stride interval. One suspects to find a synergy between stance and swing that sum up to stronger long-range correlations for stride interval. Testing this with a technique similar to the uncontrolled manifold hypotheses did not provide clear results. It has still not been explained what the underlying mechanisms of the long-range correlations are.

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A-0117

NEURAL SUBSTRATE OF THE EFFECT OF STIMULUS SALIENCY ON MOVEMENT PLANNING AND EXECUTION

Raphaël Mizzi¹, Germán Gálvez-García^{1,2}, George A. Michael¹¹ *Département de Psychologie Cognitive & Neuropsychologie, Institut de Psychologie, Université Lyon 2, Lyon, France;*² *Departamento de Psicología, Universidad de La Frontera, Temuco, Chile*

In this study, we aimed at investigating the relationship between the salience-based progression of visual attention and the associated motor action. On the one hand, attention has been shown to progress from the most to the least salient item in a given scene. On the other hand, very recent studies have shown that the attentional effect of saliency can be assessed through hand movement. Hence, in order to investigate more deeply the salience based progression of attention, we adapted the Multiple-Saliency-Level-Visual-Search-Task to a reaching paradigm. Participants were asked either to reach toward lateral bulls-eye pads (Reaching condition), or only to lift a response-button (Lifting condition) as a function of the orientation of a target. A central search display presented the target among several distractors with items of different sizes to manipulate saliency. Results showed that size of target had an effect on performance, participants were faster when the target was the largest item, relative to the medium or the small target. Progression slopes computed on the total movement time showed that the performance was more affected by size in the reaching condition relative to the lifting condition. Results allow to argue in favor of the influence of the salience-based progression of exogenous visual attention on the elaboration of movement and its neural substrate. Moreover, this effect seemed to impact both planning and execution of movement.

A-0076

STABILIZATION OF ARM CONFIGURATION AND MUSCLE ACTIVITY PATTERNS DURING CYCLING ARM MOVEMENTS AGAINST EXTERNAL RESISTANCES

Mariann Mravcsik¹, Lilla Botzheim⁴, Norbert Zentai¹, Jozsef Laczko^{1,2,3,4}¹ *Institute of Biology, University of Pécs, Hungary*² *Department of Information Technology and Biorobotics, University of Pécs, Hungary*³ *MTA Wigner Research Centre for Physics, Budapest, Hungary*⁴ *Faculty of Information Technology and Bionics, Pázmány Péter Catholic University, Budapest, Hungary*

Limb movement patterns and their variances likely depend on environmental forces. We investigated a task when the variance of the endpoint trajectory (hand path) is assumed to be very small. The question is, how arm configuration and muscle activity variances are influenced by external resistances. Seventeen right-handed, able-bodied participants (Age: 23.76, ± 2.33 years) performed arm cycling movements under three resistance conditions: low, moderate, high crank resistance (RC) on a MEYRA (Kalletal, Germany) ergometer. EMGs were recorded from biceps (BI), triceps (TR), delta anterior (DA), delta posterior (DP). Positions of markers placed on the participant's arm and on the ergometer's crank were recorded by a ZEBRIS (Isny Germany) movement analyzer. The intersegmental angle between the upper- and lower arm was computed from marker positions. Time courses of joint angles and muscle activities (EMG amplitude) were segmented based on the number of cycles the subjects completed. The frames in which the elbow reached the most flexed positions were used to define the starts of separate cycles. The time required to complete one cycle varied among

cycles. Time-normalization was applied to allow comparison of cycles. The cycle time within each cycle was divided into 100 time bins and joint angles were approximated with interpolation at the beginning of the bins. Similarly, EMG amplitudes of each individual muscles were interpolated. Then joint angle and muscle activity variances were computed across cycles at each percentage of cycle time. The variances obtained in low, medium and high resistances were compared applying repeated measures ANOVA. Our results support significant effect of resistance on the variances of muscle activities. When cycling with two arms, it was found that for the left arm there is a significant difference in the muscle activity variances obtained in low and high resistance conditions. For the right arm, significant differences were found between low and high and also between low and medium resistance conditions. Higher resistance induced higher variances of muscle activity profiles. When cycling only with the left arm, there were significant difference between low and medium and also between low and high RCs and the difference was marginally significant between data obtained in medium and high RCs. In contrast, when cycling only with the right arm, resistance condition did not affect muscle activity variances. Variances of joint angles didn't differ significantly for the three resistance conditions, neither in bimanual nor in unimanual cycling. Our conclusion is that the movement is stabilized at kinematic level (joint angles). To keep this stability when cycling against higher resistance the muscles use more variable muscle activity patterns. The movement is controlled through stabilizing arm configurations and less by stabilizing muscle activity patterns. The exception is when cycling is performed only by the right arm, the reason of this may be that the central control of the dominant arm is so robust that even muscle activity patterns are stabilized and their variance isn't effected by external resistances. Although the left arm's less stable performance is transferred to the right arm's movement when cycling bimanually against higher resistances.

A-0118

POWER OUTPUT OF SPINAL CORD INJURED INDIVIDUALS DURING FUNCTIONAL ELECTRICAL STIMULATION DRIVEN BICYCLING LOWER LIMB MOVEMENT

Mariann Mravcsik¹, Andras Klauber², Jozsef Laczko^{1,3,4,5}

¹ *Institute of Biology, University of Pecs, Hungary*

² *National Institute for Medical Rehabilitation, Budapest, Hungary*

³ *Department of Information Technology and Biorobotics, University of Pecs, Hungary*

⁴ *MTA Wigner Research Centre for Physics, Budapest, Hungary*

⁵ *Faculty of Information Technology and Bionics, Pazmany Peter Catholic University, Budapest, Hungary*

Functional electrical stimulation (FES) is used in rehabilitation of spinal cord injured individuals. We studied bicycling movements performed on an ergometer (Motomed VIVA 2, Germany). The aim of our study was to determine the effect of FES driven trainings on the mechanical power output of the participating persons.

In our study three spinal cord injured patients were involved, whose cycling performance was evaluated. They had FES biking trainings twice a week (the number of the evaluated trainings were 27, 12 and 10 for the three participants). Bicycling movements were generated with the stimulation of the quadriceps and hamstring muscles. An 8 channel stimulator provided the stimulation current (PE 11, developed at the Pazmany Peter Catholic University, Hungary). Bipolar surface electrodes PG473W TENS ELEC 45x80mm were applied. The stimulation frequency was 30 Hz with pulse width of 300 µs. The current amplitude was 25 -70 mA, 25-60mA, 20-40 mA, the cadence was 43-50 rpm, 30-48 rpm, 30-48 rpm, cycling time was 20-35 min, 4-30 min, 8-28 min for the three participants. Their level of injury were at Th 9, Th 4 and C 3-4 respectively. We investigated their performance under two

crank resistance conditions (RC): low level (1.4 Nm) and high level (2.1 Nm) crank resistance. The power output was computed for each RC separately as the product of crank angular velocity and torque (resistance). In addition we computed the energy as the multiplication of average power output and movement time.

We defined two hypotheses: 1. There is difference between the mechanical power outputs obtained in consecutive trainings. 2. There is a difference of energy between the sequential trainings.

The average power output of the participating persons was 6.83 W. Individual average power outputs were 7.61 W, 6.08 W and 6.8 W for 3 individuals. Our data didn't show effect of training numbers on power output obtained under a given RC except for one participant in the case of cycling with high resistance. The average energy over trainings was 12kJ, 8.4kJ and 6.4kJ for the 3 participants respectively. Over time there was an increasing tendency in the energy levels meaning that there was an increase in average energy with trainings in each participants (with slopes of regression lines 2.55, 0.55 and 18.53 J/serial number of trainings).

Based on our results one would assume that the lack of increased mechanical performance of participants over trainings was due to the insufficient number of trainings or the low level of crank resistance. Nevertheless the energy output during the trainings increased that may due to the fact that participants preferred a longer training time over cycling against higher resistance. It is advised to motivate participants to increase the duration of cycling time in high RC controlling these time intervals individually.

A-0034

EVALUATION OF VIDEO-BASED METHOD FOR THE MEASUREMENT OF REACTION TIME IN SPECIFIC SPORT SITUATION

Milos Mudric¹, Ivan Cuk¹, Aleksandar Nedeljkovic¹, Srecko Jovanovic¹, Slobodan Jaric²

¹ Faculty of Sports and Physical Education, University of Belgrade, Belgrade, Serbia;

² Department of Kinesiology and Applied Physiology, & Biomechanics and Movement Science Graduate Program University of Delaware, Newark, USA

The success in sports, such as soccer, basketball, tennis, or martial arts, is dominantly depended upon the skill of an athlete to react as fast as possible to opponent actions. The reaction time (RT) is determined by the visual information that are picked up and selected from an ongoing action. Several methods have been used in the literature to measure RT in sport. However, the external validity of these methods could be questioned since the RT is not based on the visual information collected from the realistic sport situation. Therefore, we designed the study aimed to evaluate a novel video-based method for the measurement of RT in specific sport situation. We recruited 20 adult male participants divided into two groups: 10 elite karate kumite and 10 karate beginners. The evaluated video-based method measured the reaction time in a quasi-real karate situation. Previously video recorded offensive actions, such as the kick with the front leg and reverse punch, performed by elite karate kumite athletes were projected to the participants who were instructed to react as quickly as possible by the upper and lower block, respectively. In addition, the kinematic parameters were recorded together with both video recording and video projections. The temporal coupling of the kinematic parameters of both offensive and defensive actions was ensured by an external trigger. The reaction time was calculated from the recorded kinematic parameters as a difference between the onsets of offensive and defensive actions. We measured RT under two different experimental conditions:¹ when the participants knew in advance what the offensive action will be projected, as

well as what the defensive action to use (Simple RT); and² when the participants were instructed to adequately react on the one of two possible offensive actions that were randomly projected (Choice RT). RT observed from 3 consecutive trials obtained across the different offensive actions, groups and conditions revealed high ICC (all above 0.82) and relatively low CV (below 6%) and SEM (below 0.02 seconds). In addition, the applied one-way ANOVAs showed no significant differences across 3 trials ($p > 0.05$). Two-way between-within ANOVAs were applied to assess the main effects of groups and conditions. For both offensive actions, Karate kumite reacted faster than the beginners under both Simple RT and Choice RT conditions ($p < 0.01$) suggesting higher level of sport skills. The longer Choice RT than Simple RT was in line with the Hick's law ($p < 0.01$). The obtained findings generally suggest that the evaluated video-based method could be developed into a reliable, valid, and sensitive method of skill not only in combat sports, but also in various sport games.

A-0070

REFERENT ORIENTATION OF THE BODY WITH RESPECT TO GRAVITY: A GLOBAL FACTOR IN THE CONTROL OF POSTURE AND MOVEMENT

**Aditi A. Mullick^{1,3}, Szu-Chen Hsu^{2,3}, Sandeep K. Subramanian^{3,4}, Nicolas Turpin⁴,
Anatol G. Feldman^{3,4}, Mindy F. Levin^{1,2,3}**

¹ School of Physical and Occupational Therapy, McGill University;

² Neuroscience Program, McGill University;

³ Jewish Rehabilitation Hospital (JRH) Research Site of the Center for Interdisciplinary Research in Rehabilitation (CRIR);

⁴ Department of Neuroscience, University of Montreal, Montreal, Canada

It has been suggested that multiple muscles of the body are controlled as a coherent unit based on the difference between the referent body configuration specified by the brain and the actual, emerging body configuration. The referent configuration is the configuration at which muscles begin to be activated. We suggest that there are referent body configurations that are used to orient actual body postures (straight or leaned) during standing and most body movements in humans and animals relative to gravity. In other words, we suggest that neural control levels can specify a referent body orientation (R) at which multiple muscles of the body reach their activity minimum. Under the influence of gravity, the body is deflected from the referent direction to a direction Q, at which the emerging muscle activity results in forces that balance gravitational forces and body stability is maintained. This hypothesis predicts that during back-and-forth movements, R and Q may momentarily coincide, bringing the activity of multiple muscles of the body to a minimum. We tested this prediction by analyzing the activity of multiple body muscles during rhythmical changes in the body orientation during standing. To manipulate R and create situations in which minima occur, participants were required to stand on 3 surface orientations, ascending, horizontal, and descending, and perform whole body sways and mini squats. EMG minima were identified from EMG signals recorded in 11 muscles across the body and the body postures at which EMG minima occurred were determined. Global minima were identified in all conditions, both in swaying and squatting movements. The EMG minima occurred in 20%-82% of cycles of movements in 4 participants analyzed. The postures at which global EMG minima occurred were different in different conditions. Preliminary results thus confirm the hypothesis. This study contributes to the understanding of how posture and movement are controlled in the gravitational field. It also extends the previous suggestion that multiple muscles of the body are controlled as a coherent unit depending on the difference between the actual and referent configurations of the body.

A-0019

LOCATION OF SOMATOSENSORY ELECTRICAL STIMULATION DOES NOT AFFECT INTERLIMB MOTOR SKILL TRANSFER

János Négyesi¹, Menno Peter Veldman², Tibor Hortobágyi^{2,3}¹ Semmelweis University, Budapest, Hungary;² University of Groningen, University Medical Center of Groningen, Groningen, The Netherlands;³ Newcastle University, Newcastle upon Tyne, United Kingdom

Introduction

Clinical studies show positive effects of somatosensory electrical stimulation (SES) on motor performance when delivered alone or before motor training (for a review see Veldman et al. 2014). We examined the hypothesis that the location of the SES, i.e., practice or the transfer-receiving arm, would affect the magnitude of interlimb motor skill transfer.

Methods

Twenty-seven subjects (age 22 ± 2.31 y, 13 men) performed 25 min of visuomotor practice (VMP) with the right-dominant wrist, using an error-based model of learning in the form of a template-matching motor task. Subjects were randomly assigned to one of three groups: right VMP, right VMP + right SES, and right VMP + left SES. SES intensity was 2x perceptual threshold targeting the median and radial nerves. All subjects received single pulse transcranial magnetic brain stimulation to both M1s before and after VMP and also radial nerve electrical stimulation to evoke motor potentials (Mmax). The key analyses was a Group (VMP, VMP + right SES, VMP + left SES) by Time (pre, post) repeated measures ANOVA on Time followed by, as necessary, a Tukey's post-hoc contrast at $p < 0.05$.

Results

The group by time interaction was not significant for the magnitude of reductions in error ($F = 1.6$, $p = 0.232$) but the time main effect was significant ($F = 53.4$, $p = 0.001$) in the practiced, right hand, revealing a 34.4% overall learning. In the non-practice left hand, there also was no group by time interaction ($F = 0.5$, $p = 0.618$) but there was a time main effect ($F = 13.6$, $p = 0.001$), suggesting a 13.5% skill transfer from the practice to the non-practice hand. Skill learning in the right and the left hands correlated $R^2 = 0.49$ ($p < 0.01$). Location of SES did not affect learning, transfer, or corticospinal excitability.

Discussion

VMP causes motor learning. However, when combined with SES to the left or to the right median and radial nerves, SES does not further increase learning in healthy young adults. Location of SES did not affect the interlimb transfer of a visuomotor skill and had no effect on corticospinal excitability. In conclusion, SES with the current parameters represents an insufficient stimulus and failed to further increase learning maximized by motor practice in healthy young adults. The idea is that SES is not specific to motor units activated during the learning task and/or SES is effective in selected patients' motor rehabilitation because it enhances compromised sensory function, absent in healthy adults.

Reference

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A-0036

A SIMPLE NEURAL CONTROL MODEL THAT STABILIZES THE UNCONTROLLED MANIFOLD

Jun Nishii, Toru Hamamura*Yamaguchi University, Yamaguchi, Japan*

When humans and animals perform a skilled motor task, they adaptively choose a solution depending on the circumstances by utilizing abundant degrees of freedom (DOFs) of their body. For instance, Latash et al. reported that a spinal frog can wipe irritating stimuli off by its foot even if a leg joint is fixed. In this example, multiple leg joints cooperatively work so as to control the foot position in a compensatory manner by utilizing available joints. Such a compensatory control among multiple joints is called joint synergy.

We developed a simple neural network model that realizes synergetic control that exploits abundant degrees of freedom. The model takes an architecture of a sand-glass type neural network (SNN). The SNN is a neural network model with five layers and capable of nonlinear principal component analysis when fewer number of cells are prepared in the middle layer than those in the input layer and the SNN learned the identity transformation. In our model, the SNN receives sensory signals from the controlled object and sends control signals to actuators, and learns the relation between the output signals and the resultant sensory input signals. We prepared fewer number of the cells in the middle layer than that of the input layer, hence, it is expected that the middle layer extracts low-dimensional essential variables required to generate the control signals from the sensory signals. Furthermore, we added a learning for a cell in the middle layer so as that the firing pattern of the cell expresses an essential variable to perform a task, so called the performance variable, e.g., the foot height. When the neural activity of the cell in the middle layer is modified by a feedback control so as to bring the performance variable to the desired value, the change in the activity of the middle layer results in the production of the control signal to accomplish the target task.

We applied this neural network model to the control of a 3-link arm model with six muscle-like actuators by a computer simulation. The results have shown that the model can perform a synergetic control that exploits abundant DOFs of the body and reproduced the characteristics of the scratch reflex of a spinal frog, i.e., the model brought the hand to a given target by using three joints if all joints are available, but even if one joint is fixed, the model found a solution to perform the given task by utilizing available joints. The important feature of this model is that each joint trajectory (elemental variable) is not controlled, instead only the performance variables, such as the foot position, are controlled, and each joint trajectory is autonomously generated so as to realize the desired value of the performance variables. The desired set of the elemental variables forms a manifold in the state space that is called the uncontrolled manifold (UCM). Our model would be a most primitive neural control model of the synergetic control that stabilizes the UCM.

A-0121

NEURAL REPRESENTATION OF INTERMANUAL MOTOR SKILL TRANSFER

Ori Ossmy^{1,2}, Roy Mukamel^{1,2}¹ *School of Psychological Sciences, Tel-Aviv University, Tel-Aviv 69978, Israel*² *Sagol School of Neuroscience, Tel-Aviv University, Tel-Aviv 69978, Israel*

Physical practice with one hand results not only in performance gains in the practiced hand but also performance gains in the non-practiced (passive) hand. This behavioral phenomenon has been termed motor skill transfer or cross-education. In the current study we examined the role of visual input and passive movement on transfer of performance gains to the non-practiced hand. We developed a unique experimental setup employing virtual reality and advanced neuroimaging methodologies to examine the behavioral and neural correlates of different short-term training conditions on motor skill transfer across hands. Throughout the study, healthy subjects wore motion sensitive gloves on both hands and learned to perform a sequence of finger movements. Subjects could not see their real hands but instead received visual input of virtual hands presented on a screen in front of them. Finger movement of the virtual hands was manipulated in the various training conditions by dedicated software developed in-house. In experiment 1 (N = 18) the following short-term training conditions were used:¹ Physical training with the right hand coupled with online congruent visual feedback of right virtual-hand finger movement;² Physical training with the right hand without visual feedback (static virtual hands presented on the screen);³ Physical training with the right hand coupled with online visual feedback of left virtual-hand finger movement (incongruent training); and⁴ Passive observation of the left virtual hand performing the finger movement sequence. We found that right hand physical training coupled with online visual feedback of left virtual hand movement (condition 3) resulted in highest levels of transfer (i.e. highest performance gains in left hand). In experiment 2 (N = 18) we introduced a custom-made device that yoked active right hand finger flexion/extension with passive movement of the corresponding left hand finger. We find that combining such passive training with incongruent visual feedback as in experiment 1 yielded even higher levels of intermanual transfer. Finally, in experiment 3 (N = 18) we repeated experiment 1 in an MRI scanner. We find that activity in right superior parietal lobule (rSPL) during incongruent training (condition 3) correlated with subsequent performance gains in the left (untrained) hand. Our results demonstrate that the combined use of manipulated visual feedback and passive finger movement improve intermanual transfer following short-term training, and suggest that the rSPL plays an important role in this process. These results have important implications for developing rehabilitation procedures in patients with hemiparesis (e.g. following stroke) by exploiting the beneficial outcome of healthy hand training and its transfer to the paretic hand.

A-0079**VISUAL CONTRIBUTION TO WALKING: HOW IS IT IN CHILDREN WITH A RISK OF MOTOR COORDINATION DISORDER?****Miriam Palomo, Rudolf Psotta, Reza Abdollahipour, Adrian Agricola, Ludvik Valtr***Palacky University, Olomouc, Czech Republic*

Research has shown that children with developmental coordination disorder rely more heavily on vision to perform movements skills than their typically developing (TD) peers. Yet, it is unclear that to some extent performance of motor skills depends on vision. The purpose of the current study was to investigate the contribution of visual information during walking between TD children and children with the risk of having developmental coordination disorder (DCDR). According to the psychological screen and total test score of the movement assessment battery for children-second version, thirty-two children (21 boys and 11 girls, mean age: 8.9, SD: 0.9 years) were divided equally into two motor competence groups. They were asked to walk along a 10-metre walkway where an Optojump-Next instrument was installed. They walked at a self-selected speed under four visual conditions: full vision, receiving vision for 150-ms and 100-ms within each 2 sec, and non-vision. The results showed that TD children walked faster and with longer steps and strides than DCDR children, regardless of the visual condition. Besides, the speed of walking and the step and stride length decreased significantly while the occlusion time increased, regardless of the level of motor competence. Also, time variables including stance phase (s), single support (s), load response (s) and pre-swing (s) were significantly different between TD and DCDR children regardless of the visual condition. The present findings suggest that withdrawing and limiting the vision affect the distance, speed and time parameters of the gait cycle in DCDR children more than TD children.

A-0020**A BAYESIAN FRAMEWORK FOR SPEECH MOTOR CONTROL****Jean-François Patri¹, Julien Diard², Jean-Luc Schwartz³, Pascal Perrier⁴**¹ *GIPSA-lab, UMR 5216 CNRS Univ. Grenoble Alpes, Grenoble, France;*² *Univ. Grenoble Alpes, LPNC, Grenoble, France;*³ *CNRS, LPNC, Grenoble, France*

A number of various experimental studies has demonstrated that speech is a skilled serial-order motor task that is adapted to achieve time series of goals within a timing that does not allow any online cortical processing of feedback signals. In addition, the speech motor system is highly redundant with many available degrees of freedom, which makes the inference of motor commands from the physical signals an "ill-posed" inverse problem. These degrees of freedom are used in different ways to deal with sequence planning and variations in the conditions of articulation. For instance, clear anticipatory behaviors have been observed in articulatory and acoustic patterns associated with speech sequences.

To deal with this complexity, speech motor control models classically consider a feedforward control scheme coupled with a feedback controller enabling a correction of motor commands in case of a wrong inference or in presence of an external perturbation. In this context, speech planning, which aims at solving the "ill-posed" inverse problem by setting the motor command patterns adapted to

the production of a speech sequence, has been classically modeled within an optimal motor control framework. This approach has proven to generate results in close agreement with experimental data, in particular in terms of adaptation to perturbations or in terms of anticipatory behavior.

However, criticisms of this approach include key issues, such as the nature of the neuro-physiological mechanisms likely to be associated with cost computation and cost minimization, or the inability to account for the well-known token-to-token speech variability. This last drawback is inherent to the feedforward optimal control scheme, since it basically cancels possible variations along the degrees of freedom directions, by specifying a unique optimal solution to the control problem.

In the present work, we propose an alternative approach by formulating feedforward optimal control in a Bayesian modeling framework. The methodology is based on the Bayesian Programming framework, which proposes a structure for the construction of Bayesian models. We consider this approach to be appropriate for solving the ill-posed problem while accounting for the observed token-to-token variability in a principled way, and preserving the basic principles underlying the search for optimality without being explicitly driven by the minimization of a cost. The approach is illustrated by reformulating GEPPETO, an existing optimal control model for speech production planning developed in the lab, into the Bayesian modeling framework. We demonstrate that models are nested, with optimal control as a special case of the Bayesian model: indeed, the Bayesian model reduces to the optimal control model, when the inferred control commands are strictly limited to those having the maximum posterior probability. Variability is formally generated by assuming that control is performed by sampling motor commands randomly according to the distribution solving the inference problem in the Bayesian model. An additional interest of the proposed formalism is its coherence for treating perception and action in a unified framework, as well as for dealing with additional constraints.

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A-0088

NORMATIVE NEUROFLEXOR DATA FOR EARLY DETECTION OF SPASTICITY AFTER STROKE

Gaia Valentina Pennati¹, Jeanette Plantin^{1,2}, Jörgen Borg^{1,2}, Pålvel Lindberg^{2,3}

¹ Department of Rehabilitation Medicine, Danderyd University Hospital, Stockholm, Sweden;

² Department of Clinical Sciences, Karolinska Institutet, Stockholm, Sweden; ³ Université Paris Descartes, FR3636 CNRS, Sorbonne Paris Cité, 75006, Paris, France

Introduction: The NeuroFlexor is a novel instrument allowing quantification of neural (NC), viscous (VC) and elastic components (EC) of the passive movement resistance. Previous studies in stroke have provided evidence of validity, reliability and sensitivity to change of this method. The lack of reference data makes it difficult to distinguish between normal and pathological values. The first aim of this study was to provide reference data from healthy population in relation to age and gender. The second aim was to calculate cut-off values and to use these to detect early signs of spasticity in a group of recovering stroke patients.

Materials and Methods: A total of 107 health adult subjects without neurological or rheumatological disorders (55 females and 52 males; age 20-68 years, with mean 44.5) volunteered to be tested with NeuroFlexor. Measurements followed the same procedure as in previous studies. Other measures

of upper limb function were maximal grip strength and passive range of movement. A sample of 39 post-stroke patients (13 females and 26 males; age 33-69 years, with mean 55.4) was assessed, in mean 4 weeks after event, with NeuroFlexor and using Modified Ashworth Scale to measure the presence of spasticity in upper limb.

Results: The mean and standard deviation of NC, EC and VC values were found to be 0.8 N and 0.866, 2.66 N and 1.113, 0.284 N and 0.266, respectively. The reference limit for the NC, obtained by adding 3SD to mean, was 3.398 N; for the EC was 5.998 N; for the VC was 1.082 N and for the resting tension (P0) was 8.971 N. Prediction reference limits (99%CI) were also developed from a linear regression, related to age and gender. Parametric methods were applied since the distributions of variables were not severely skewed (Skewness value for NC 0.449, EC 0.068 and VC 0.812). There were inverse moderate correlations by Pearson between Age and EC ($r = -0.302$; $p = 0.01$) and between NC and EC ($r = -0.451$; $p = 0.01$); grip strength moderate correlated with EC ($r = 0.327$; $p = 0.01$). Healthy subjects were divided into five age groups and then into gender groups and differences were studied using One-Way ANOVA. Significant differences among groups of different age were showed in EC ($F = 4.372$; $p = 0.03$), VC ($F = 3.247$; $p = 0.047$) and P0 ($F = 2.054$; $p = 0.047$). EC and P0 variables were higher in males compared to females ($F = 12.042$; $p = 0.001$ and $F = 12.759$; $p = 0.001$).

A total of 16 post-stroke patients had a value of NC higher than reference limit; two patients regarding EC and 23 for VC presented pathological values compared to the more conservative cut-off approach (calculated as mean+3SD). A positive MAS score occurred in 11 out of 39 patients, of whom only 6 also presented a pathological value of NC; six patients with negative MAS score had instead high NC values.

Conclusion: This study provides applicable reference values for measurements with the NeuroFlexor method and also demonstrates its usefulness in detection of spasticity in the early phase of recovery after stroke.

A-0071

RAMBLING-TREMBLING POSTURAL CONTROL PARADIGM: THE CONTRIBUTION OF COMPLIANT TENDONS

Davide Piovesan

Gannon University, Erie PA, USA

Bipedal postural stability is often modelled using an inverted pendulum which captures the first mode of vibration of the whole body center of mass about the ankle. Such mechanical representation is often paired with a control model. Amongst all control models two main theories stands out. The first theory is based on the alpha-model, where a time varying spring stiffness can modulate the position of the whole body center of gravity with respect to a constant resting angle. This angle is formed between the direction of the body radius of gyration and the direction of the terrestrial gravity field.

The most common alternative theory allows one more parameter to be changed. The spring set length can be modulated thus making the theory compliant with the equilibrium point hypothesis (lambda-model). Spring stiffness and its varying resting point can be inferred via the two main components of the center of pressure (CoP) trajectory. The first component called Rambling (RM) is a slow varying movement which is hypothesized to reflect the super-spinal control of the spring resting point. The second component called Trembling (TM), represent the difference between the position of the CoP

and RM. TM is characterized by higher frequency content than RM and is believed to reflect the action of spinal reflexes and the mechanical properties of the muscles

Both these models assume the tendon to be order of magnitude stiffer than the muscle. Yet, in a physiologically accurate model, compliant tendons act as stabilizing impedance buffers between the force-generating element (muscle) and the environment. Based on such observation, this work hypothesizes that RM and TM could be explained biomechanically if the muscle-tendon system is modelled as a third order Poyntin-Thomson (PT) mechanical system where the tendon is compliant.

Using an analytical approach, this work investigates the physiological parameters that influence the region of critical damping of a third-order muscle-tendon model. Such control model is associated with an inverted pendulum subject to the destabilizing effect of gravity. We present a set of boundary conditions for the achievement of critical damping during the recovery from fall. A biomechanical analysis of muscle and tendon stiffness demonstrates that critical damping can be achieved only with extremely high muscle stiffness, well above the stiffness for critical stability. As a result, the response of an underdamped PT model encompasses a high frequency oscillation given by two complex conjugate poles (which could represent TM) and a slow varying movement given by the remaining real poles (which could be the cause of RM).

We validated our model via a hold and release experimental paradigm intended to perturb quiet standing. Based on a time-domain system identification technique we inferred that during the recovery of fall muscle stiffness is higher than tendon stiffness confirming that the system cannot be approximated as second-order.

A-0080

POSTURAL ASYMMETRY, MUSCULAR DEMANDS AND ENERGETIC COST IN YOUNG AND ELDERLY INDIVIDUALS DURING UPRIGHT STANDING

Janina M. Prado-Rico¹, Rafael R. Garcia¹, Marcos Duarte²

¹ *Curso de Fisioterapia, Universidade Presbiteriana Mackenzie, São Paulo, SP, Brasil;*

² *Engenharia Biomédica, Universidade Federal do ABC, Santo André, SP, Brasil*

To remain standing for a certain period of time we periodically produce postural changes, which may favour the adoption of more asymmetric postures. In face of the postural control system deterioration, it is possible that older people find it difficult to adopt more asymmetrical postures during daily life activities. In addition, changes in muscle activation pattern may increase energy cost to stand in asymmetric posture, which would lead to muscle fatigue and as consequence increase the risk of falls in this population. The present study investigated body weight asymmetries, muscular demands of lower limb and energy cost in healthy young and elderly adults during standing tasks with different constraints. Twelve young and sixteen elderly subjects remained at different positions while we recorded the body weight asymmetry over time (WDA_m - difference between the body weight of the right and left legs normalized by the total body weight, by the vertical force of each force plate). All the participants undergone to electromyographic analysis of the thigh and leg muscles (lateral vastus, biceps femoris, medial gastrocnemius, anterior tibial) to quantify the muscular demand of each limb and total muscular demand. In addition, seven subjects of each group were submitted to metabolic analysis in order to quantify the energy cost, oxygen consumption, respiratory quotient

and heart rate. During quiet standing task, both age groups showed small WDA (young WDA_m = 10±5%; elderly WDA_m = 16±9%), young and elderly subjects stood in a small range of WDA (between 0 and 10%). In tasks which required greater WDA, the elderly subjects had difficulty in maintaining more asymmetric postures in comparison to the young individuals. In the unconstrained standing task, most of the time the subjects remained in small asymmetry ranges (between 0 and 10% of WDA), followed by a shorter period in more asymmetric postures (above 50% of WDA). When the subjects were instructed to transfer the body weight completely to either side of the body, the elderly participants exhibited again less asymmetric postures. In general, muscle activation level was higher in the elderly, but they were able to recruit the muscle groups in a similar way to young subjects. In addition, gastrocnemius activity increased proportionally to body weight support for both age groups – it was greater in the supportive limb. Although in this study the energy cost was not significantly affected by the asymmetry in body weight distribution for young and old individuals, the increased energy cost in the elderly was associated with an increase in muscle activity. This last result might explain the adoption of less asymmetric postures by these individuals (young: $r=0.05$, $p=0.78$; elderly: $r=0.59$, $p=0.006$). The results of this study raise the question of the possibility of higher energy expenditure in more asymmetric postures, especially in the elderly, and opens new possibilities for future studies to understand the metabolic demands during upright standing, particularly in tasks closer to the daily life activities.

A-0109

ACCELEROMETRY BASED HUMAN-MACHINE INTERFACE FOR ROBOTIC APPLICATIONS

Attila Répai, György Cserey

Pázmány Péter Catholic University, Budapest, Hungary

In this decade, wearable electronic devices were subject to several researches as they provide a convenient and more natural way to machine-human interaction. We propose a wearable, accelerometry-based motion analyzer system that can provide input to robotic devices such as limb prostheses and bio-inspired walking robots, or even to machine tools that require both hands of the user to be free.

Since in the case of wearable devices it is essential to affect the wearer's everyday activity the least possible, this system has to recognize user-defined patterns even when they are modulated with usual motions like walking. We also had to take into account the fact that humans cannot reproduce patterns precisely, time and amplitude distortions will certainly occur. Therefore we chose the Dynamic Time Warping (DTW) algorithm of Sakoe and Chiba, which originated from speech processing and since then proven its efficiency in a wide range of problems that involve time distortion. Recent studies [Petitjean et al.; 2011, 2014] provided enhancements for this classification technique, notably DTW Barycenter Averaging (DBA), which reduces of the cardinality of the training set, thus allowing the usage of Nearest Centroid classifier instead of Nearest Neighbour. This way the time requirements of the classification can be reduced, in addition, classification becomes more accurate due to the fact that the mean of samples can be more representative than individual ones. An acceptance threshold was also introduced, that is, if the DTW-distance of the nearest sequence is greater than a given amount, it is classified as „normal”, not triggering any response from the output device. Each accepted class ID or a pre-defined sequence thereof then can be mapped to specific hardware functionalities such as turning a servo by a given angle.

Our concept was tested on a Raspberry Pi computer because of its optimal computational performance - size ratio. Experiments included recognition of sudden turns, side movements and other „unusual” step patterns during walking and running using a sensor mounted on the hip, hand gesture recognition with a sensor on the wrist and the classification of the movements of a robot.

A-0063**POSTURAL SWAY IS REDUCED BY FINGERTIP TOUCH WHEN STANDING
ON UNSTABLE SURFACES**

Cristiano Rocha da Silva^{1,3}, Fernando Henrique Magalhães^{1,2}, André Fabio Kohn^{1,3}

¹Biomedical Engineering Laboratory, University of São Paulo, São Paulo, Brazil;

²School of Arts, Sciences and Humanities, University of São Paulo, São Paulo, Brazil;

³Neuroscience Program, University of São Paulo, São Paulo, Brazil

Light touch (LT) of a fingertip on an external stable surface greatly improves the postural stability of standing subjects. The hypothesis of the present work was that LT could improve postural stability in unstable surface conditions. Center of pressure displacement in the anterior-posterior axis (COPap) was calculated in 5 health subjects during upright stance on an unstable support surface (Airex balance pad - placed on the force plate) without vision, while touching a mini force platform with the tip of the index finger (< 1 N). The subjects had no previous knowledge about the experimental hypotheses, and they were not given feedback about their postural performance. The two experimental conditions (unstable surface with no contact (NT) and with touch contact (LT)) were presented in a randomized order. The subject performed 4 trials, each lasting 90 s, for each of the two experimental conditions. A resting period of ~120 s between trials was allowed to avoid fatigue (subject sat in a comfortable armchair placed next to the force plate). The power spectral density (PSD) of the COPap data was estimated in each experimental condition. The areas under the PSD were evaluated at three different frequency bands: “low frequencies” (LF, 0.05-0.25 Hz); “medium frequencies” (MF, 0.3-0.7 Hz) and “high frequencies” (HF, 0.75-2.0 Hz). The RMS values were also computed for COPap. A two-tailed paired t test was used to compare the conditions (NT vs LT) for RMS and frequency bands values. Effect size [ES, also known as “strength of association”] was calculated using Cohen’s effect size index. ES was considered large if > 0.14. The results are presented in mean (M) and standard deviations (SD) values. The preliminary results showed that LT caused a significant decrease in the RMS values (NT: M = 10.01, SD = 2.95; LT: M = 3.134, SD = 0.95) ($t(17.053)$, $p < 0.001$, ES = 5.282) and in PSD values at LF (NT: M = 578.613, SD = 417.322; LT: M = 78.463, SD = 41.34) ($t(4.645)$, $p < 0.001$, ES = 0.505), at MF (NT: M = 313.641, SD = 198.8; LT: M = 44.752, SD = 29.052) ($t(5.817)$, $p < 0.001$, ES = 0.772) and at HF (NT: M = 103.653, SD = 85.169; LT: M = 14.198, SD = 9.274) ($t(4.459)$, $p < 0.001$, ES = 0.468) of COPap. Thus, the present work showed that LT while standing on unstable surfaces attenuates postural sway and to higher extent than standing on a rigid surface. Further analyses of other variables such as muscle EMGs and body angles are under way to provide a more global understanding of the possible mechanisms behind LT on postural control of humans standing on unstable surfaces.

A-0124

Physiological and pathological factors influencing the scapulothoraci mobility

**Alexandra Roren^{1,2}, Marie-Martine Lefevre-Colau^{1,2}, Sessi Acapo¹, Serge Poiraudreau^{1,2},
Agnes Roby-Brami^{1,2,3}**

¹ *Department of Physical Medicine and Rehabilitation, Cochin Hospital (AP-HP),
Paris Descartes University, Paris, France;*

² *Institut fédératif de Recherche sur le Handicap, INSERM, Paris, France;*

³ *ISIR (Institute of Intelligent Systems and Robotics), CNRS UMR 7222, AGATHE INSERM U 1150, Sorbonne
Université, UPMC University Paris 06, Paris, France*

Scapular motion relative to the thorax has a theoretical maximum of 6 degrees of freedom (DoF), resulting from rotations at both clavicular joints (3 rotational DoF each). In recent studies we considered the rotation of the scapula and the 3D translations of its barycentre (providing a complete description of the movement at the proximal shoulder complex) during large arm movements (Roren et al 2015) and during pointing in the proximal work space (Roby-Brami et al submitted),. Measurements were recorded using a 6 DoF electromagnetic device and the acromial method of analysis was used. In both cases, principal component analysis (PCA) yielded three factors, explaining respectively 97.6% and 76.5% of the variance. The first two factors (protraction and shrug, according to clinical descriptions) combined rotations and translations, consistent with the hypothesis that the scapula rolls over the curved thoracic surface. The third factor related to lateral-medial rotation, thus representing rotation in the plane tangential to the thorax. The coupling evidenced by PCA could either be the result of anatomical factors constraining scapular motion around the thoracic wall and/or the synergic organization of movement by the central nervous system, two hypotheses which are not incompatible. In order to investigate this aspect, similar studies were performed in groups of patients with different pathologies. The results showed that the coupling between scapula rotation and the displacement of its barycentre persisted in case of clavicle pathologies or total shoulder prosthesis but was altered in patients with scapula winging due to muscle paralysis. However, the coupling was also observed during passive arm displacement in healthy subjects. Taken as a whole, these observations suggest that the coupling is due to the elastic properties of the muscles maintaining the scapula over the thoracic wall. Further experimental and biomechanical studies are needed to confirm this hypothesis.

A-0022

VARIATIONS IN BIMANUAL CONTROL DURING A FUNCTIONAL BIMANUAL BOX OPENING TASK IN CHILDREN WITH UNILATERAL CEREBRAL PALSY

Julian Rudisch¹, Ingar Zielinski², Pauline Aarts^{2,3}, Jenny Butler¹, Deirdre Birtles⁴, Bert Steenbergen^{2,5}, Dido Green¹

¹ Oxford Brookes University, Oxford, UK;

² Radboud University, Nijmegen, Netherlands;

³ Sint Maartenskliniek, Nijmegen, Netherlands;

⁴ University of East London, London, UK;

⁵ Australian Catholic University, School of Psychology, Melbourne, Australia

Background: Adequate temporal and spatial integration of both hands at the same time is crucial for successfully mastering numerous bimanual tasks in daily life. Bimanual coordination (BC) skills are often reduced in children with unilateral cerebral Palsy (uCP). This study was set up to identify relevant kinematic parameters of hand movement during a bidirectional bimanual movement task and explore the relationship of these parameters to the use of the affected hand in bimanual daily life tasks.

Methods: 37 children with uCP (aged 10.9 +/- 2.6 years, 20 male) participated in this study. 3D kinematic motion analysis of the hands was performed during a bidirectional bimanual movement task, in which a box was opened with one hand and a trigger inside pressed with the other. The task was completed in the conditions, affected hand (AH) and less affected hand (LAH) to open the box. Three variables were extracted: i) Total task duration (TTD), ii) temporal difference between box opening and start of second hand (BO-SSH) reflecting the ability of temporal coupling (negative values mean start of second hand is earlier than box opening), and iii) Total Movement Path of the second hand (TP) reflecting spatial accuracy. Use of the affected hand during bimanual tasks in daily life was obtained from a ratio score of the Children's Hand-Use Experience Questionnaire (rCHEQ), reflecting the number of activities where the affected hand is recruited divided by the number of all activities that can be performed independently.

Results: Median [lower-upper quartile] of TTD was 2.28 seconds (s) [1.79-2.77]. Children completed the task significantly faster in LAH than in AH (Difference(D)=0.19s [-0.05-0.68], $p < .01$). Box opening and start of second hand occur at about the same time (BO-SSH=-0.03s [-0.31-0.22]), with a more negative direction in condition AH (D=-0.14s [-0.65-0.1], $p < .05$). TP was 0.548 meters(m) [0.495-0.605] with no significant difference between conditions (D=-0.02m [-0.078-0.02], $p = 0.19$). For condition AH, significant correlations were found between rCHEQ and BO-SSH ($\tau = 0.34$, $p < .01$) as well as TP ($\tau = -0.31$, $p < .01$). Correlations between rCHEQ and TTD didn't reach significance ($\tau = -0.32$, $p = 0.06$). No significant correlations were detected between rCHEQ and outcome variables in condition LAH. A closer look at BO-SSH in condition AH revealed a bimodal distribution for the start of the second hand (SSH) if normalized to total time. Modes are located very early (time of start of first hand) and rather late (after time of box opening) relative to the total movement time.

Discussion: Use of the affected hand during bimanual daily tasks is only correlated with outcome variables for the condition AH. It seems that difficulties in bimanual control occur, when the affected hand is in focus of the task. An interesting, yet unexpected result was the bimodal distribution of the time point start of second hand in condition AH. A possible explanation for this phenomenon might be the occurrence of bimanual interference caused by neural crosstalk. Further research needs to be done to explore a possible effect of bimanual interference on BC in children with uCP.

A-0054**CAN INDIVIDUAL KINEMATICS AND BRAIN LATERALIZATION PREDICT INTERMANUAL TRANSFER OF SENSORIMOTOR ADAPTATION?****Fabrice R. Sarlegna, Alix Renault, Hannah Z. Lefumat, Lionel Bringoux, Christophe Bourdin, Jean-Louis Vercher***Institute of Movement Sciences, CNRS & Aix-Marseille University (UMR 7287), Marseille, France*

We can adapt our motor behavior to various environmental conditions, yet it remains unclear which factors enable us to transfer what we have learned with one limb to the other. Previous work has shown the importance of factors such as the trained limb (Sainburg and Wang 2002; Criscimagna-Hemminger et al. 2003) or the nature of the perturbation (Malfait & Ostry 2004; Berniker & Kording 2008). Recently, we examined the intermanual transfer of Coriolis force adaptation: as in DiZio & Lackner (1995), subjects were asked to perform forward reaching movements with the upper limb toward flashed visual targets in pre-adaptation, adaptation and post-adaptation tests. Only the dominant arm was used during force-field adaptation and interlimb transfer was assessed by comparing performance of the non-dominant arm before and after exposure to the novel force field. On average, significant but limited transfer was observed, and we also uncovered a substantial heterogeneity of interlimb transfer across subjects. Critically, we showed that interlimb transfer can be qualitatively and quantitatively predicted for each healthy young individual based on his/her task performance, most notably motor variability and peak velocity during learning, and laterality quotient, a classic measure of brain lateralization (Oldfield 1971). As sensory feedback and conscious credit-assignment strategies did not influence interlimb transfer of force-field adaptation, our study highlighted how individual characteristics shape the way the nervous system can generalize adaptation to a novel force field. We then addressed the differences between adaptation to a novel force field and adaptation to a visuo-motor transformation, which are well documented (Krakauer et al. 1999; Pipereit et al. 2006; Rabe et al. 2009). More recently, we thus hypothesized that intermanual transfer of prism adaptation (Harris 1963; Martin et al. 1996) is also determined by individual characteristics. We used the same paradigm as described previously except subjects had to adapt to prisms rather than to a novel force field. Preliminary results indicate, on average, a limited transfer to the untrained, opposite limb. More subjects are being tested to determine with correlations the influence of laterality quotient and motor variability during learning.

A-0086

KINEMATIC AND ELECTROMYOGRAPHIC FEATURES OF UPPER-LIMB MOVEMENT
PERFORMED BY HEALTHY AND POST-STROKE PATIENTS

**Rosa Mariana Silva^{1,4}, Pedro Fonseca^{5,6}, Ana Rita Pinheiro³, Carolina Vila-Chã^{7,8}, Cláudia Silva³,
Miguel Velhote Correia^{1,9}, Sandra Mouta^{1,2}**

¹ INESC TEC, Portugal;

² Centro de Computação Gráfica, Portugal;

³ Escola Superior de Tecnologia da Saúde do Porto – Instituto Politécnico do Porto / Centro de Estudos do
Movimento e Atividade Humana – ESTSP – IPP / CEMAH;

⁴ Departamento de Psicologia Básica, Escola de Psicologia, Universidade do Minho, Portugal;

⁵ Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial (INEGI), Portugal;

⁶ Laboratório de Biomecânica do Porto (LABIOMEPE), Portugal;

⁷ Instituto Politécnico da Guarda, Portugal;

⁸ CIDESD - Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano;

⁹ Faculdade de Engenharia da Universidade do Porto, Portugal;

It is extremely difficult to simplify the relation between several body parts, which perform human motion, into one set of features. Mainly, the upper-limb is capable of a wider range of actions, going from fine manipulation to prehension and grasping. Aiming to describe its complexity, several studies have been conducted in order to better understand the upper-limb specificities. However, most of studies restrain the task to pointing (Soechting, Lacquaniti, 1981), reaching (Wu, Trombly, Lin, Tickle-Degnen, 2000) or grasping (Yang, Zhang, Huang, Jin, 2002), which seems not enough to explain the wide range of tasks possible to be performed in a daily scenario. Moreover, the upper-limb is more dependent on processes related to decision making (Silva, 2013) and involves greater multijoint coordination movements (Aprile, 2014), than the lower-limbs. Due to these reasons, the parameterization of the upper-limb motor action is still scarce and not consistent. Furthermore, along with motor action execution, there is an activation of the neuro-musculoskeletal system. Some studies reported that, depending on the task to be performed, this system could be activated sooner than the moment of movement initiation (Zattara, Bouisset, 1988) and more sustained in time (Haggard, Clark, 2003). Additionally, the amplitude of the muscle activity could be informative of the properties of the target to be manipulated (Fligge, Urbanek, van der Smagt, 2013). Recently some researchers have been using simultaneous recording of motion capture and EMG data in order to classify human motor actions (Pradhan, 2007), although in a non-clinical population. There is a difficulty in establishing a solid protocol for certain goal-oriented tasks, mainly in the tools to collect data and in the joints or anatomical portions of the limb that are more informative for the specific task. Therefore, we propose a methodology to assess the upper-limb motor action in a set of daily functional tasks. In this study, we assess the role of target location in the workspace, the instruction given and the type of object. A workspace was defined for the execution of the motor tasks, with several marked positions according to the participant (0°, 22.5° and 45°) and at two distances (100% and 120% of functional distance). Motion capture and electromyographic data was simultaneously recorded in order to understand whether the type of object and instruction have an effect in the time of muscular activation and in performance. Participants were instructed to reach and drink from a bottle or to lift either a bottle or a solid paper tube. With this study we aim to characterize the upper-limbs motor action regarding functional tasks as well as to identify the tasks and environmental features causative of changes for a control and post-stroke patients' sample. We expect to find an effect of EMG activation on the intentionality of the task and type of object for both groups. We also expect the movement segmentation to be informative of the quality of the movement (e.g. smoothness) and performance.

A-0098**EFFECT OF DOG BEHAVIORAL TRAININGS ON THE ANXIETY LEVEL OF YOUNG ATHLETES****Agnes Simon***University of Physical Education, Budapest, Hungary***Introduction**

Previous studies have shown that being together with dogs has positive impact on humans (Nancy R. Gee, Elise N. Crist, Daniel N. Carr: Preschool Children Require Fewer Instructional Prompts to Perform a Memory Task in the Presence of a Dog, *Anthrozoos*, 2. 23., 173-184., 2010). Among others, the most important documented effects of dogs humans are the increased power of mental concentration, reduction in anxiety and aggressivity, improved sociemotional state (openness and friendliness) and even endocrinological changes, such as increased level of oxytocin (Meg Daley Olmert: Dog Good, *Psychology Today*, <http://www.psychologytoday.com/blog/made-each-other/201005/dog-good>, 2010 {2014. november 24.}). Interestingly, less is known whether or not, these effects are achievable in young teenagers, known to have mental and somatic difficulties.

Hypothesis and Aim

Thus I hypothesized that behavioral training of dogs by young athletes will reduced their level of anxiety.

Methods

Six ~14 years old volunteer athletes from a sport high school in Budapest were included in the study (3 girls and 3 boys). Together with the dog they participated in a behavioral training program twice a week between 45-60 minutes. An emphasis was given on the close contact with the dog and in addition, the student had to solve different tasks with the dog. The detailed scheme was put together by me, in harmony with the structure and characteristics of groups.

Results

The results were collected in the form of questioners: the ACSI-28 (Athletic Coping Skills Inventory-28) and CSAI-2 (Competitive State Anxiety Inventory-2) designed for athletes. The questioners were completed before the behavioral training program, a month after and finally three months after the start of program. After analyzing the questioners the results showed a tendency for a decrease in somatic anxiety, but not in cognitive anxiety. In addition, the controllability of athletes by their trainer also improved substantially.

Conclusions

In this preliminary study due to some limitations (the availability of dog and the number of athletes) no significant changes could be obtained. Nevertheless, I suggest that future studies will provide evidence for a reduced anxiety and increased coachability in athletes undergoing behavioral training with dogs.

A-0131

HUNGARIAN-DEVELOPED SENSORIMOTOR-BASED POSTUROGRAPHY PLUS HEART FUNCTION EVALUATING SYSTEM (PHF) FOR CLINICAL DIAGNOSTICS, REHABILITATION AND HEAVY-DUTY EXPERIMENTAL STUDIES (A PRELIMINARY)

L. Simon¹, B. E. Toth², V. Sarkisian³, S. Garab¹, M. Endrenyi¹, L. Gevai¹, P. Nagy¹, J. Tollar⁴, F. Nagy⁴

¹Lab.of Sensorimotor Adaptation, Semmelweis University, Budapest, Hungary

²Dept.of Pharmaceutical Surveillance and Economy, University of Debrecen, Hungary

³Lab.of Sensorimotor Integration, Orbeli Inst. of Physiology, NASRA, Yerevan, Armenia

⁴Dept.of Neurology, M. Kaposi Teaching Hospital, Kaposvar, Hungary

Posture is a seemingly transparent control mechanism, but it should be considered as a complex learned skill, running on the sensorimotor extrapyramidal-cerebellar machinery. The input information involves the reference of the visual field and a set of afferent channels of proprioceptivity and the vestibular input, while the output is resulted in the maintained position of head-neck-trunk-legs cascade. Nevertheless, the vestibular organ preserves the spatiotemporal orientation.

A novel Posture Evaluation Platform (PEP) has been developed in our laboratory in cooperation with Med-Eval Ltd. The main aim was to introduce a high-definition, nonexpensive facility with adequate capabilities both for clinical diagnostics and experimental applications. The PEP device is a monolithic tripod platform, representing the statically optimal design.

For clinical diagnostic tests, a consistent set of sensorimotor paradigms has been implemented. Instead of the sole application of the widely accepted Romberg position, we do propose to introduce the early adapted natural pose (spontaneous small standing straddle with open eyes) as the physiological standard for posture tests. As a reasonable compromise, a fourfold comparative evaluation test has been elaborated to achieve a complex sensorimotor analysis of posture control. The test battery of the Fourfold Comparative Posturography (FCP) for clinical diagnostics consists of four 20-sec sections given by the combination of straddle or closed legs and open or closed eyes. Both the impact of shutting the stable visual-field-reference on postural control, and of the reduced proprioceptive input (due to the closed legs) can be assessed by the comparison of the body sways at the four test positions. The hub of the clew-like X-Y draft of each 20 sec test session will represent the origo for the forthcoming analyses.

In clinical diagnostics, posturography is well accepted as the relevant representation of postural performance.

The FCP facility can be used both in neurological diagnostics of syndroms with vertigo-dizziness and motor control failures.

Nowadays the upmost critical problem of public health-care is the risk of falling at old population at home. In the rehabilitation of motor failures, posturography can evaluate and validate the different trainings' efficacy. The PEP instrument, completed with a real-time feedback facility - can become a powerful training tool as well. Samples of effective sensorimotor rehabilitation of Parkinsonian patients will be presented.

Experimental studies: The daily rhythm, effects of fatigue and sleep deprivation has been studied in young volunteers in a 24-hours experiment.

The PHF system has been invited for the Cardiopost Project of European Space Agency, where the postural, orthostatic and cardiac functions of three over-winter crews were observed by two of our PEP-instruments, one for sitting and standing position, respectively. Samples of preliminary results will be presented.

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A-0100**DECLINES OF PERFORMANCE IN TRAIL MAKING TESTS ACROSS ADULthood AND FOLLOWING STROKE REFLECT MULTIFACETED DEFICITS IN VISUAL SEARCH, WORKING MEMORY AND MOVEMENT SPEED****Tarkeshwar Singh, Angela Ross, Christopher Perry, Troy Herter***Department of Exercise Science, University of South Carolina, Columbia, SC*

Several anatomically distinct brain regions are involved in facilitating a seamless interaction of working memory, attention, and decision making in the execution of goal directed movements. In fact, eye movements are inseparably linked to the cognitive goals of the task (or observer) and this phenomena was first described in the pioneering study of Yarbus (Yarbus, 1967). One framework to study the complex interactions between these cognitive constructs in natural visually guided reaching tasks is the schema framework. This framework provides an elegant hierarchical structure that jointly binds the visual and motor systems within a supervisory controller, known as the "schema" system. One powerful experimental paradigm to study visually guided reaching using the schema system is the popular clinical neuropsychological test called the Trail-Making Test. The Trail Making Test (TMT) is a neuropsychological test, similar to "connect-the-dots", in which patients draw lines to connect numbers (TMT-A: 1, 2, 3...), or numbers and letters (TMT-B: 1, A, 2, B, 3, C...). TMT is sensitive to impairments of visual search, visuospatial attention, working memory and decision making. Here we use a robotic device (KINARM End-Point Lab) with integrated gaze tracking to investigate the contributions of visual search, visuospatial attention, working memory and executive function to TMT performance. We examined TMT performance in healthy adults (dominant hand) and individuals with stroke (less-affected hand), who were divided into three groups: Young (21-41, median = 30), Older (52-77, median = 63), and Stroke (48-85, median = 63). Dwell Time (average time the hand remained at each target) was much greater in TMT-B than TMT-A, whereas Movement Time (average time for the hand to move between targets) was only slightly longer in TMT-B. This indicates that most, but not all, cognitive processing occurs while the hand is stationary. Dwell Time was similar between Young and Older, whereas Movement Time was longer in Older than Young. In contrast, Dwell Time was much longer in Stroke than Older, whereas Movement Time was only slightly longer in Stroke than Older, suggesting that differences between Stroke and Older may reflect multiple factors. Eye tracking showed that Number of Fixations (number of times the eyes remained stationary at a location) was significantly greater in TMT-B than TMT-A, whereas Fixation Time (average length the eyes remained stationary) was similar in both tasks. Furthermore, our results show substantial aging and stroke induced deficits in working memory, spatial search, decision making and movement speed. We created a stochastic model of visual search and decision making to quantify aging induced deficits in stroke survivors. Finally, we offer an explanation of the results using a hierarchical framework of visual search.

A-0111**THE INFLUENCE OF STRENGTH EXERCISE ON FORCE PERCEPTION IN VERTICAL JUMPING****Kajetan Slomka, Tomasz Skowronek, Mariusz Furmanek, Grzegorz Juras***Academy of Physical Education, Katowice, Poland*

Finding the interdependence between the strength, physical effort and movement coordination is very interesting and is likely to be crucial in moving extreme limits of the human possibilities in sports. The main objective of the study was to determine the effect of strength conditioning on force sensation in vertical jumping. We examined this proprioceptive ability in the context of a whole body action. The study was conducted on 78 students of Physical Education course (49 men and 29 women). Research was carried out in two stages. The subjects participating in the experiment were divided into 2 groups. The first experiment consisted of the 4 series of vertical jumps exercise 80% of the maximum capabilities of the subjects, which were interspersed with a force perception test. Before the first series of vertical jumps control measurement was performed in order to determine the initial level of the ability. The second experiment consisted of the 4 series of 1 minute whole body vibration (WBV) training on a platform in a specific position. As in the first experiment, measurements were taken before the exercises and between sets of WBV. The results showed that the selected forms of strength exercises do not have a significant impact on the level of force perception. This could be explained by the precise control of selected skills and adaptation to that new action situation exercise, based on the feedback about the current state of the organism. Apart from the obvious sex differences in jump height, no significant differences in terms of the force sensation were observed. Further research is needed using a similar analysis to confirm this hypothesis in a wider population.

A-0053**CROSSED RESPONSES TO STRETCH IN DISTAL MUSCLES IN THE UPPER LIMB****Demetris Soteropoulos***Institute of Neuroscience, Newcastle University, UK*

In response to a mechanical perturbation, stretched muscles produce a burst of muscle activity, typically composed of multiple components (mediated by multiple pathways). If a perturbation is given during a bimanual movement, a response can be seen in the opposite, and unperturbed limb. Such crossed reflexes have been most studied for multi-joint proximal movements involving the elbow and shoulder but rarely for more distal movements involving finger muscles. We sought to address this by looking at crossed reflexes in an intrinsic hand muscle, the first dorsal interosseous (1DI). The aim was to assess if finger muscles show crossed responses to unilateral stretch, and if yes, how these responses depend on the perturbation parameters of the opposite hand.

Subjects performed a bimanual finger abduction task using custom made manipulanda. The left finger performed an isometric contraction and the right finger an isotonic contraction against a constant load. Force and position signals were collected from the left and right manipulanda respectively, and these were used to control the position of a cursor on a visual display. The task required subjects to move the cursor from a starting position to a target position following an audio-visual cue, and hold in target for ~1.5s. Feedback was given at the end of the trial on their performance. The cursor could only be moved in the horizontal direction, and its position was determined by an average of the left

and right finger signals. On some trials a perturbation was given to the right finger ~500ms once in target, in a clockwise or anticlockwise direction (randomly chosen). Muscle activity was recorded from 1DI bilaterally during the task. Analysis was carried out on the rectified muscle activity (EMG) aligned to perturbation onset.

Subjects were able to carry out the task successfully, scoring >95% on trials with no perturbations. Contraction levels were similar between the two muscles (Left: 24%, Right: 18% of maximal voluntary level). Most subjects (9/11) showed a response in the left (unperturbed) 1DI with an onset latency <100ms. The crossed response had two components – an early inhibitory one (mean onset latency 56ms) and a later excitatory component (mean onset latency 83ms). The peak amplitude of these responses relative to the baseline EMG levels varied from subject to subject and ranged from -40% to -15% (mean -25%) for the early suppression, and 5% to 43% (mean 25%) for the later facilitation. The structure of the crossed response depended on the direction of the perturbation – a clockwise perturbation of the R1DI produced much weaker early suppression in the L1DI compared to the anticlockwise perturbation (-25% vs -13%, anticlockwise vs clockwise). The inverse was seen for the later facilitatory component (12% vs 25%, anticlockwise vs clockwise).

Our results show that intrinsic finger muscles can show long latency responses to a stretch in the opposite finger, and that the nature of the responses depend on the parameters of the perturbation.

A-0049

SPIKING NEURAL CONTROL OF MUSCULOSKELETAL MOVEMENTS ABOUT THE HUMAN ANKLE

Manish Sreenivasa¹, Massimo Sartori²

¹ *Optimization in Robotics & Biomechanics, Interdisciplinary Center for Scientific Computing, Universität Heidelberg, Heidelberg, Germany;*

² *Department of Neurorehabilitation Engineering, Bernstein Focus Neurotechnology Göttingen, Bernstein Center for Computational Neuroscience, Universitätsmedizin Göttingen, Georg-August-Universität, Göttingen, Germany*

In movement biomechanics, the neural drive to muscles is often approximated by second-order system dynamics bounded by activation/deactivation time constants. This results in dimensionless continuous envelopes ranging from 0 to 1, characterizing the whole-muscle recruitment. While this provides a mathematically tractable formulation that enables the study of whole-limb biomechanics, it prevents a deeper investigation of the cellular mechanisms underlying human movement. That is, the interacting dynamics between spinal neural pools and the resulting musculoskeletal forces and function. In recent work, a Neuromusculoskeletal (NMS) model of the elbow joint was proposed, spanned by the biceps and triceps muscles, and modulated by the spinal neural dynamics.

Here, we extend this idea to the major muscles in the human ankle complex and the related spinal neural pools responsible for muscle reflexes. This framework enables characterizing at a deeper level the interacting dynamics between the neuromuscular and the musculoskeletal systems. In this, the reflex behavior of the ankle joint is simulated, subject to nominal inputs, and a forward integration over time of the combined closed-loop dynamics is performed. Spinal motoneurons and interneurons are simulated as leaky Integrate-And-Fire (IAF) models, with the neurophysiological variation in the IAF parameters derived from literature evidence. Efferent output from the motoneuron pools directly

drive muscle fiber bundles simulated as collections of Hill-type muscle models. Varying distributions of S, FF and FR fiber bundles across muscles and their contraction dynamics are constructed based on physiological motor unit counts and parameter estimation from experimental data. Fiber bundles are connected with series elastic tendons forming musculotendon units (MTUs). Each MTU is scaled and calibrated to match an individual's anthropometry and physiology. First, a linear scaling procedure adjusts MTU geometry to the subject's body proportions. Then, optimization identifies MTU morphological parameters that vary non-linearly with the subject anthropometry including: tendon-slack length, optimal fibre length, and maximal isometric force. Non-linear least squares optimization is solved to determine MTU-specific parameters to best match isometric ankle plantar-dorsi flexion moments across calibration trials covering a range of muscle contractile conditions. After calibration, the subject-specific NMS model allows synthesizing ankle function. Afferent feedback from muscle spindle and golgi tendon organs (Ia, Ib, and II) are modeled based on the simulated musculoskeletal kinematics and dynamics. Simplified control inputs to this model, simulating the cumulative outputs of the corticospinal tracts, are applied directly to the motoneuron pools as well as the interneuron pools responsible for reflex modulation. This simulation framework is developed using the software packages OpenSim, NEST and MUSIC, to enable open-source dissemination to the research community. Proving the robustness and reliability of such a complex framework is the focus of ongoing work. The assertion behind this methodology is that human movements occur as a cohesive interaction between mechanics and neurophysiology, and such models are the first step towards studying them as such. Eventually, these models may prove useful at predicting clinical interventions not only at the musculotendon level (e.g. tenotomy, muscle transfer), but also interventions and pathology related to the neural substrates (e.g. nerve resections, clonus).

A-0101

MOTOR EQUIVALENCE IN SPEECH MOTOR CONTROL: THE UNCONTROLLED MANIFOLD APPROACH

Andrew Szabados, Pascal Perrier

GIPSA lab University of Grenoble, France

For a given sound the positions of vocal tract articulators can be very different, depending on, for example, the neighboring phonemes [1], prosodic structure [2], or speaking rate or clarity [3]. This is due to a combination of factors, two of which are quite specific to speech. First, the goals of speech production are not in a physical space, but in a cognitive one of linguistic information. Ultimately, goals are categorical and allow variability within each category. Second, the relation between articulatory positions and perceptually relevant acoustic features is strongly many-to-one [4]. These extra degrees of freedom allow for an extraordinary capacity to compensate for many kinds of perturbations such as speaking with a pen between the teeth, while eating, while running, etc. This adaptability requires motor equivalence strategies. The present work is part of a larger project that aims at studying how motor equivalence strategies are elaborated, and how they are used to deal with variations in speaking conditions.

Our methodology is based on the concept of uncontrolled manifold (UCM) [5]. The basic idea is that motor control variables can be divided into two major subsets: a subset in which variations directly alter task variables, and a subset, the UCM, in which variation has no (or very little) impact on the task variables. The UCM is defined mathematically as the null-space of the Jacobian of the relation

between motor control and task variables.

A biomechanical model of the tongue [6] was used, in which motor control variables are muscle length threshold as proposed by the Equilibrium-Point Hypothesis [7]. Ten French vowels have been studied. For each vowel the motor goal is specified as an ellipsoid in the space of the first three spectral maxima of the acoustic signal. For each vowel 20 sets of motor commands have been randomly selected and the variability of the UCM within each vowel category is assessed. Similarly the variability of the UCM across vowel categories is measured. These results are interpreted in terms of possible categorical representations of motor equivalence strategies across vowels, in particular in the light of classical phonetic features such as "front-back", "open-closed" or "rounded-unrounded" vowels.

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A-0107

STRETCH-SHORTENING MUSCLE CONTRACTION CYCLE AND ITS RELATION TO RUNNING ECONOMY

Edina Szabo^{1,4}, Bernadette Misovics¹, Bettina Botka¹, Mark Vaczi^{1,3,4}, Tamas Atlasz^{1,2,3}

¹ *Institute of Sport Sciences and Physical Education;*

² *Department of Anatomy MTA-PTE PACAP „Lendulet” Research Team;*

³ *Janos Szentagothai Research Center;*

⁴ *Doctoral School of Biology and Sportbiology, Universtiy of Pecs, Pecs, Hungary*

Running is economical (RE) when energy expenditure is small compared to the distance covered or with a given velocity. Individuals with good RE use less oxygen than people with poor RE at the same speed (Saunders et al. 2004). RE is also important in the untrained population, because it can affect the quality of every day life. Various factors influence running economy, such as air resistance, body temperature, body weight, maximal aerobic power, and muscle fiber distribution (Kyrolainen et al. 2001).

The purpose of this study was to investigate the effect of an 8-week combined strength-plyometric training program on RE. Twenty untrained young females (age: 21.5 ± 2.2 years, weight: 63.1 ± 9.2 kg, height: 166.3 ± 5.1 cm) performed training sessions three times a week, for 8 weeks. They were split into two groups (ST, ST-Plyo group), both groups performed the same strength training sessions and one had additional plyometric training sessions (S-Plyo). Participants were measured before and after (pre and post) the training program, they performed maximal isometric (MVC) and concentric contractions (CC), as well as a stretch-shortening cycle (SSC), and a running test with gas analysis.

The results show some improvements of the maximal isometric strength and the above mentioned contractions. Oxygen consumption of the running task decreased but not statistically significantly. Work ratio during the SSC and CC (WSSC/WCC) highly correlated with oxygen consumption ($r=0.679$, $p<0.001$).

Improvements of the participants performance was found in the parameters of the RE. We did not

find statistically significant differences among the parameters. The adaptation process might be different in physically active and inactive people, because some research showed improvements in RE in a 6-week training period of athletes (Turner et al. 2003). Further studies are needed to examine the influential parameters in untrained participants. The results suggest that a combined plyometric-strength training program might improve RE in physically inactive young females, however, the effect on RE was unequivocal.

A-0021

GLOBAL STABILITY INDEX – NEW PROPOSITION OF STABILITY EVALUATION MEASURE

Sobota Grzegorz, Szymańska Dominika, Juras Grzegorz, Bacik Bogdan

The Jerzy Kukuczka Academy of Physical Education in Katowice, Department of Human Motor Behavior, Katowice, Poland

Objective: The aim of the study was attempt to use a new Global Stability Index (GSI) to evaluate static and dynamic postural behavior during standing after stepping on a force platform performed in different conditions.

Design: Pilot study

Participants: Nine healthy volunteers, 6 women and 3 men (age $19,4 \pm 0,7$ years; body height $171,1 \pm 6,47$ cm; body weight $67,4 \pm 3,5$ kg).

Methods: Each subject performed eight gait termination tests. The force data were collected with force platform (sampling frequency 100Hz). Signal processing allowed to divide vertical and fore-aft component of ground reaction force (GRF) into time windows and calculate of force impulse time series. Two factors – static (fS) and dynamic (fD) were set based on value of deceleration impulse, time to stability and time in stability, their quotient was defined as Global Stability Index (GSI).

Results: Mean GSIs varied between 0,31 and 1,66 depending on the condition. The lowest values of GSIs were registered when subjects stepped on the platform with the left foot and finished with the both feet on the platform with the eyes open ($GSI = 0,31 \pm 0,17$) and closed ($GSI = 0,51 \pm 0,13$). The highest value of GSIs were registered when subjects stepped on the force plate and finished with left ($GSI = 1,66 \pm 0,72$) and right ($GSI = 1,39 \pm 1,05$) leg elevated and eyes closed.

Conclusion: We assume that low value of GSI is an evidence of proper dynamic behaviors (high deceleration in shorter time) and static behaviors (faster stabilization of posture with small amount of corrections).

Presented procedure seems to be promising, but it's necessary to continue research. Examination on a larger population in different age, health conditions and level of motor skills would be essential.

A-0046**IN REWARD-BASED MOTOR SKILL LEARNING, EXPLORATORY MOVEMENTS OBEY TO A SPATIO-TEMPORAL SYMMETRY PRINCIPLE****Irene Tamagnone, Maura Casadio, Vittorio Sanguineti***Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genoa, Genoa, Italy*

In reward-based learning the only information provided to the learner is a score, or reward. If the task is redundant, many different strategies are equivalent in terms of the score provided. As the learning process is trial-and-error, the final solution achieved depends on the history of exploration. Understanding the way humans explore the space of solutions during reward-based learning may help to unveil how they represent the learned actions. We addressed this issue in the context of motor skill learning, by specifically investigating one aspect of the learning process, i.e. the spatio-temporal structure of the exploratory movements.

Subjects performed movements with a fixed starting and final position. A score was calculated according to the distance of the resulting trajectory from a 'hidden' via-point (Hidden group). In another group of subjects the via-point was continuously displayed on the screen ('Visible' group). Both tasks are highly redundant, as infinite trajectories are compatible with the maximum score. An optimal feedback control model was used to simulate the movements of the subjects in the Visible group.

The subjects in the Visible group rapidly converged to movements whose spatio-temporal features depended on via-point position. These features were accurately reproduced by the optimal feedback control model.

All subjects in the Hidden group managed to consistently achieve high scores, but the learned movements were widely different between subjects. Nevertheless, these movements exhibited an invariant spatio-temporal symmetry relation: half movement path was covered in half the total movement time. This relation did not depend on the performance – it was also present during the early exploration phase – as well as on via-point location and does not seem to be a consequence of effort minimization.

Our findings suggest that in reward-based learning the exploration of the action space is not random. In absence of explicit cues, subjects tend to prefer trajectories that satisfy a spatio-temporal symmetry principle that is largely independent on the particular task requirements.

A-0090**OPEN-LOOP CONTROL BASED ON THE MINIMUM ENERGY COST MODEL SUPPRESSES THE POSITIONAL VARIANCE AROUND THE END OF REACHING MOVEMENT****Yoshiaki Tani¹, Tomohide Naniwa¹, Jun Nishii²**¹ *University of Fukui, Fukui, Japan;*² *Yamaguchi University, Yamaguchi, Japan*

It has been reported that the variance of a hand position in an upper-arm reaching movement increases until the middle of the movement and then begins to decrease. It has also been reported that feed-forward control can not explain the reduction of the positional variance in the latter half of the movement. On the other hand, some studies have suggested that the viscoelastic control

based on the feed-forward control can reduce positional variability. The purpose of this study is to examine whether the optimal trajectory based on the feed-forward control can represent the profile of positional variability in a single-joint reaching movement. We obtained the control signal based on the minimum energy cost model for a one-link two-muscle arm model of the musculoskeletal system, and then computed the arm trajectory determined by the open-loop control by the optimal control signal and the time-profile of the positional variance due to noise effect. As the constraints of the optimal computation we required that the expected hand position is at the center of a circular target and the hand should be within a desired success rate at arbitrary moment during post-movement duration. Kelvin-Voigt model, a muscle model with adjustable viscoelasticity, was used as the musculoskeletal model. We considered noise that depends on the muscle activation level by which we reflect the linear relationship between muscle force and its variability reported by physiological experiments into the muscle model. The optimal solution based on the minimum energy cost model was solved by the sequential quadratic programming. The optimal trajectory based on the minimum energy cost model well expressed the profile of positional variability and the other characteristics of the reaching movement of human subjects: three-phasic EMG activities of antagonistic muscles, N-shaped equilibrium trajectory, two-phasic curve of joint stiffness and three-phasic torque variability. The optimal trajectory based on the minimum muscle-force change model was also computed. It well expressed the bell-shaped speed profile and the N-shaped equilibrium trajectory but not the profile of the positional variability. These results indicate that the reduction of the positional variance does not necessarily require feed-back control and might be realized by open-loop control in our nervous system, and the control signal might be designed based on the minimum energy cost model.

A-0092**SECONDARY HYDROCEPHALUS ASSOCIATED WITH SEVERE BRAIN INJURY, CEREBRAL SHUNT IMPLANTATION AND OUTCOME OF REHABILITATION: THE ESSENTIAL ROLE OF MOTOR CONTROL****Szilvia Tarjanyi, Helga Nagy, Galina Belinszkaja, Zoltan Denes***National Institute for Medical Rehabilitation, Budapest, Hungary*

Aims: The assessment of the occurrence, diagnosis, and rehabilitation efficacy of secondary hydrocephalus associated with severe brain injury with a special reference to motor control.

Methods and participants: We performed a retrospective, descriptive study by the review of medical files of patients admitted to the Rehabilitation Department of Brain Injuries at the National Institute of Medical Rehabilitation, Hungary, between January 1, 2008 and December 31, 2013.

Results: During the six-year study period, we treated 42 patients with cerebral shunts. In the case of 20 patients, the underlying etiology was trauma, whereas in the remaining 22 cases, other conditions resulted in hydrocephalus. The most frequent cause of non-traumatic brain injury was subarachnoid bleeding (16/22). The average age of trauma-exposed patients was 37.5 years and of the non-trauma exposed cases 41.0 years. The average duration of inpatient rehabilitation was 196 days in the trauma-exposed group, whereas it was 130 days in patients with non-traumatic brain injury. In the trauma-exposed group, cerebral shunt surgery was performed on average of 75th day, whereas in the non-trauma group, this procedure was conducted on average of the 49th day. In 13 patients, putative hydrocephalus was diagnosed during the rehabilitation treatment, and these patients were

transferred to neurosurgery units. Declining (n = 14) or non-improving (n = 22) clinical states were the most frequent scenarios raising the possibility of secondary hydrocephalus. After the implantation of cerebral shunts, we observed clinical improvements, including a significant remediation of motor control and gait disorder, with the exception of 7 patients. The mean changes between admission and discharge patients' Functional Independence Measure (FIM) subscales scores: self-care 12.4, sphincter control 4.2, transfers 6.8, locomotion 4.3, communication and social cognition 8.3. Side effects included infection (n = 2), meningitis (n = 5), subphrenic abscess (n = 1), and blockade of the shunt (n = 4).

Conclusions: The main symptoms of hydrocephalus, the gait disorders, cognitive decline and incontinence may result in a worse functional status and poor rehabilitation outcome. In addition, cortical and subcortical components of motor learning and top-down control also contribute to the functional disability of the patients. During the rehabilitation of patients with severe brain injury, it is essential to consider the possibility of secondary hydrocephalus. Generally, there are no alarming signs and acute, life-threatening situations. Dysfunctions in motor control are important in early diagnosis. Detection and treatment in a right time may improve the functional status of the patients and finally lead to a better outcome of rehabilitation. We hypothesize that the amelioration of top-down motor control pathways over basal ganglia and brainstem effector systems, together with improved efference copy and corollary discharge, are essential in functional improvement and daily living.

A-0093

SUPPORTING REHABILITATION OF PATIENTS POST-STROKE WITH APPLICATION OF TASK-SPECIFIC EXERCISES IN HIGH REPETITION NUMBER

**Ibolya Tavaszi¹, Gabor Fazekas^{1,2}, Beata Karlik¹, Rahel Lukacs¹, Renata Steigervald¹,
Ferenc Szerencses¹**

¹ *National Institute for Medical Rehabilitation, Budapest, Hungary;*

² *Szent Janos Hospital, Budapest, Hungary*

INTRODUCTION: Upper-limb functions are often impaired as a consequence of stroke. The improvement of these functions involves not only the increase of the muscle power and range of motion, but also the improvement of manual dexterity. Task specific, goal oriented exercises can help to fulfil this aim. Executing such tasks in high repetition number can be exhausting for the therapist, for this reason more and more frequently robots are used for this purpose. In case of patients, whose upper limb function is moderately impaired, it is not necessary to use expensive robots. It seems to be reasonable to execute exercises with weight support of the upper limb without electromechanical assistance.

METHODS: Authors executed a cross-over pilot study with a gravity-supporting exoskeleton device (ArmeoSpring®) involving 12 patients post-stroke. All of them received a four-week-long rehabilitation programme. It consisted of two parts: through two weeks each subject got only traditional physiotherapy, during the other two weeks they also underwent 10 sessions with the device. The improvements seen in the two parts of the trial were compared. The subjects' mean age was 56 (24-86) years, the mean time since onset of the stroke was 32 months (12-50). Upper limb subsection of Fugl-Meyer (FM), Modified Ashworth Scale, Functional Independence Measure, Bathel Index were assessed before and after each phase of the therapy programme. Applying this device requires a relatively good upper limb function.

RESULTS: FM (maximum score 66) improved in 5 patients (3-8 points) during the experimental phase and in 2 cases (7-7 points) during the control phase, while in 5 cases there were no improvement. There were no considerable changes in the other scores (regarding the functional scales patients have quite high scores even at the inclusion). All subjects found this therapy useful and they would take part in such trial again with pleasure.

CONCLUSIONS: This pilot study suggests that supplementation of the traditional rehabilitation programme of patients post-stroke with goal-oriented repetitive exercises applying a gravity-supporting exoskeleton may present some further advantages for patients even those with moderate impairments. A limitation of this study is the relatively low number of training sessions. For this reason a trial with higher numbers of subjects and more therapy sessions are required to verify these results.

A-0051

THE FINGER FORCE MANIPULANDUM: A NOVEL DEVICE FOR MEASUREMENT OF MANUAL DEXTERITY AFTER STROKE

Maxime Térémetz¹, Florence Colle^{2,3}, Marc Maier^{1,4}, Pålvel Lindberg^{1,3}

¹ Université Paris Descartes, FR3636 CNRS, Paris, France;

² Hôpital Sainte-Anne, Paris, France;

³ Centre de Psychiatrie et Neurosciences, Inserm U894, Paris, France;

⁴ Université Paris Diderot, Sorbonne Paris Cité, Paris, France

Background: Stroke often leads to impaired manual dexterity and negatively impacts independence by limiting activities of daily living. Clinically, there is a lack of quantitative multi-dimensional measures of manual dexterity. We therefore developed the Finger Force Manipulandum (FFM), which allows quantification of key components of dexterity. This first study aimed to validate the feasibility of the method and to describe how these components are affected in stroke.

Methods: 10 stroke patients with mild-to-moderate hemiparesis and 10 healthy age-matched controls were recruited. Clinical measures of hand function included the Action Research Arm Test and the Moberg Pick-Up Test. Four FFM tasks were used:¹ Finger Force Tracking to measure force control,² Sequential Finger Tapping to measure the ability to perform motor sequences,³ Single Finger Tapping to measure timing effects, and⁴ Multi-Finger Tapping to measure the ability to selectively move fingers in specified combinations (independence of finger movements).

Results: The task was feasible, with most patients being able to perform the tracking, single and multi-finger tapping tasks. Six patients had difficulty in performing the sequence task. Stroke patients were less accurate showing 130% more force tracking error. Patients had a slower maximal tapping rate (reduced by 50%). Patients also had a reduced multi-finger tapping success rate (by 60%), reflecting a reduced independence of finger movements compared to controls. Finally Patients had 40% more unwanted finger taps and had ten times more overflow to non-tapping fingers. Dexterity components were differently affected across subjects. Some of the FFM measures correlated with clinical arm function and pick-up scores.

Conclusion: This study shows that the FFM method is feasible for measurement of manual dexterity components in moderately affected hemi-paretic patients. At the group level, the FFM detects reduced performance in various tasks and control variables. At the individual level, the FFM provides individual profiles of deficient dexterity. These findings suggest that the FFM is a promising tool for the measurement of dexterity components after stroke.

A-0042

MODULATION OF 5-30 HZ EMG-EMG COHERENCE DURING HIGH PRECISION GRIP FORCE TASKS

Robert Tibold, Simon F. Farmer, Marco Davare*Sobell Department of Motor Neuroscience and Movement Disorders, UCL Institute of Neurology, University College London, London, United Kingdom*

The planning and execution of grasping movements involve an extensive parieto-frontal cortical network and the cerebellum. However, the neural mechanisms by which these structures cooperate spatio-temporally are not fully understood. One way to investigate how these different areas interact is to analyse common oscillatory drive in the electromyogram (EMG). Oscillatory activity facilitates synchrony between neuronal pools. This process plays an important role in establishing communication between multiple cortical or subcortical areas. In this study, we varied the precision demand of the task to test whether different levels of activity in sensorimotor loops could alter the oscillatory interactions between the neural sources that underlie grip force control. In our adult subjects, significant coherence of motor unit firing recorded on pairs of synergistic muscles was demonstrated in the 1-45 Hz range; with typically two local maxima: 5-15 Hz and 16-30 Hz frequency bands. Our hypothesis was the common oscillatory drive to synergistic muscles would increase with higher precision task demands and that this would provide new information as to the functional significance of a given oscillatory rhythm generated in the neural structures controlling grip force. We quantified changes in EMG-EMG coherence between rectified surface EMG signals acquired simultaneously from dorsal interosseous and abductor pollicis brevis while healthy individuals ($n=9$) performed visuomotor grip force tracking tasks at distinct force levels requiring either low precision or high precision. In an "isometric task" subjects had to squeeze with their index finger and thumb a manipulandum mounted with 2 force sensors (ATI mini40-E) in order to move a cursor on a computer screen along a predefined force target path by varying their force. In an "isotonic task" two Phantom Desktop (Geomagic) haptic robots were attached to the index finger and thumb and subjects were asked to vary their grip aperture so as to move the cursor along the target path whilst the force exerted by the robots was kept constant. We found that tracking performance was improved as precision constraints increased in the isotonic, but not isometric task, suggesting that, in our task, sensorimotor loops were more efficient in processing position rather than force signals. A pooled coherence analysis (extended χ^2) revealed the followings:¹ a significant increase in the magnitude of coherence at 9-11 Hz frequencies when comparing the high precision to the low precision isotonic task,² a suppression of the coherence at 16-30 Hz frequencies in the isotonic task for both precision levels and³ an overall lack of coherence changes in the isometric task. We suggest that the increased common drive at 9-11 Hz frequencies (alpha-band) is a signature of an increased oscillatory activity in the sensorimotor loops controlling position signals. It is plausible that alpha-band oscillations mediate suppression of neuronal ensembles interfering with high precision requirements, hence allowing focusing the computational power on the sensorimotor control of grip force.

A-0106

EFFECT OF SUBSENSORY ELECTRICAL NOISE ON KINESTHETIC PERCEPTION
IN OLDER ADULTS**Diana R. Toledo¹, José A. Barela^{2,3}, André F. Kohn¹**¹ Biomedical Engineering Laboratory, University of São Paulo, EPUSP, PTC, São Paulo, Brazil;² Institute of Physical Activity and Sport Sciences and Graduate Program in Human Movement Sciences,
Cruzeiro do Sul University, São Paulo, Brazil;³ Institute of Bioscience, São Paulo State University, Rio Claro, Brazil

Introduction: Recent studies have shown that optimal levels of electrical or mechanical noise can enhance the detection and transmission of neural signals, thereby improving the performance of nonlinear systems. For instance, cutaneous and proprioceptive perception were improved in young adults due to the application of an appropriate noise stimulus. It is still unknown if similar effects can be obtained in older individuals and this is the question that guides the present study. We investigated whether the application of electrical noise stimulation (ENS) in the posterior region of the legs improves kinesthetic perception at the ankle joint in both young and older adults. Methods: The kinesthetic threshold was assessed in fourteen older (70.68 ± 4.72 years) (OA) and 14 young adults (29.79 ± 2.12 years) (YA). Their right ankle was passively dorsiflexed at $0.5^\circ/\text{s}$, performed at random starting times (3-7 seconds after a verbal preparatory signal). Participants were instructed to respond by pressing a button with their right thumb as fast as possible whenever the onset of the movement was detected. The response time (RT) to kinesthetic perception was assessed under two conditions: with and without ENS. The ENS consisted of a band-pass filtered noise with a bandwidth from 5 to 2,000 Hz. Pairs of flexible silicon stimulating electrodes were fixed over the triceps surae muscle. The stimulus intensity was individually set at 90% of the sensory threshold, thus the subjects were not aware of the treatment condition. A two-way ANOVA was conducted with age group and condition as the factors, the latter being treated as a repeated measure. Results: Comparisons between the groups confirmed previous studies, showing that the RT was delayed for the OA, compared to the YA ($P < 0.0001$). Moreover, the results indicated that ENS applied over the legs led to a reduction in the RT to kinesthetic perception in both young and older adults ($P = 0.047$). No significant interaction between the factors (group vs condition) was found ($P = 0.303$). Conclusion: From the present results, we conclude that the application of ENS improves the kinesthetic perception of the ankle joint in both young and older adults. We suggest that the decrease in the RT found here is associated with improved peripheral signaling and transmission of proprioceptive information due to stochastic resonance. These findings may have important clinical implications specially for older adults, whose proprioceptive loss has been associated with postural instability.

A-0028

MOTOR EQUIVALENCE DURING REACHING FROM STANDING IN HEALTHY ADULTS

Yosuke Tomita^{1,2}, Anatol G. Feldman^{2,3}, Mindy F Levin^{1,2}¹ McGill University, Montréal, Québec, Canada;² Center for Interdisciplinary Research in Rehabilitation (CRIR)-Jewish Rehabilitation Hospital, Laval, Québec, Canada;³ Université de Montréal, Département de neuroscience, Montréal, Québec, Canada

The large number of kinematic degrees of freedom (DFs) of the body allows tasks to be accomplished using different combinations of joint rotations (motor equivalence). Despite this kinematic redundancy, certain movement features may remain invariant, like endpoint trajectories and movement precision. For example, hand trajectory and endpoint precision remained invariant when trunk movement was unexpectedly prevented during reaching to a target within arm's reach from a sitting position. The invariance can be explained by referent control. Specifically, the actual hand trajectory during reaching emerges following the tendency to minimize, in the limits defined by external forces, its deviation from the referent hand trajectory specified by neural control levels. We hypothesized that due to this minimization process, the actual hand trajectory may remain invariant regardless of the number of DFs involved in reaching. This hypothesis has been confirmed in trunk-assisted reaching in sitting subjects. Now we tested this hypothesis in a more challenging task of reaching beyond the arm's reach from standing, with and without perturbations applied to the body and forcing subjects to make a step.

Healthy young subjects reached from a standing position toward a remembered target placed beyond the arm's reach (130% arm length) with their right arm. Reaching the target required combining arm motion with forward trunk bending by flexing from the hip (free-hip trial; FH). In 30% of randomly chosen trials, hip flexion was unexpectedly prevented by an electromagnetic device, forcing the subject to take a step to prevent falling while reaching the target (blocked-hip trial; BH). Furthermore, to estimate the influence of the step independently from the BH trial, reaching movements were repeated when subjects intentionally made a step (intentional-step trial; IS). Endpoint trajectory, upper/ lower limb and trunk kinematics and ground reaction forces were recorded and analysed. Reaching trajectories and endpoint precision were invariant in all three conditions. Invariance in endpoint trajectory was maintained by condition-dependent changes in elbow-shoulder interjoint coordination initiated after the time of endpoint peak velocity. Stepping reactions resulting from the perturbation were also initiated after the time of the endpoint peak velocity in BH trials. In IS trials, stepping occurred before or simultaneously with the onset of the endpoint movement. Thus, the potential influence of recruitment of additional DFs on the endpoint trajectory and precision during reaching from a standing position was prevented by compensatory changes in the interjoint coordination. Results confirmed our hypothesis that the minimization process underlying referent control maintains the invariance of the reaching trajectory despite the involvement of new DFs elicited by additional task demands.

A-0087

RELATIONSHIP BETWEEN THE STRUCTURE OF VARIABILITY AND INTENTIONALITY DURING A POINTING TASK

Tomás Urbán, David Barbado, Carla Caballero, Francisco J. Moreno

Sport Research Center, Miguel Hernández University of Elche, Spain

Recent works have proposed that the complexity of the biological variability can reveal signs of a healthy vigilant system [1]. Specifically, studies that have assessed the long-range autocorrelation have related alpha values close to 1 (1/f noise) to a sign of interdependent feedback processes among system components and voluntary control [2]. However, the role of intentions in movement control is not currently clear [3]. The aim of this study was to analyze the relationship between the structure of movement variability and intentionality during a pointing task.

Forty-two volunteers were asked to perform three sets of pointing movements under different task constraints (without target, with target and with rewards depending on the accuracy). Participants perform 600 continuous cycles for each condition (1Hz pace). A 3D-polhemus sensor recorded movement kinematics. Time series (TS) of the end points in X and Y-axis were analyzed to compute Radial Error (RE). The structure of the variability was computed through Detrended Fluctuation Analysis (DFA). All variables were calculated in the overall series and in three intervals of trials comprising 1st to 200th, 201th to 400th and 401th to 600th trial. Repeated measures ANOVAs were performed.

Participants showed lower error when they had to adjust their movement to a target. In addition, the error was significantly reduced when the participants were rewarded ($F=16.416$; $p<.001$). DFA on the three experimental conditions showed a reduction increment of the autocorrelation from alpha values close to 1 on unconstrained task condition to alpha values close to 0.5 on the condition with a target and with rewards, being only significant on the Y-axis ($F=8.952$; $p=.005$). Regarding the analysis of the trials intervals, an increase of the RE along the trials was found in every task ($F=7.529$; $p<.001$) as an increase of DFA alpha values from the first to the third interval ($F=3.641$; $p=.031$).

The presence of task constraints modified the variability structure of error TS due to the explicit accuracy requirements. The addition of rewards seems to be related with a higher participant implication, and it is related to lower values of RE in achieving the goal. Nevertheless, the autocorrelation of the TS decreased. Therefore, DFA showed departures from pink noise towards white noise when accuracy was required and feedback was provided [4] suggesting that white noise could be considered as a sign of high alertness and attention allowing a higher flexibility to perform motion adjustment. The analysis of intervals of the trials showed an increase of the error and an increase of DFA values. These results could be related with the difficulty to maintain the attention in a repetitive task due to the fatigue caused by the high number of trials, which would support that the departure from white noise would be related with less system ability to perform motion adjustments [5].

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A-0056

THE EFFECT OF FES-ASSISTED CYCLING ON THE CARDIOPULMONARY SYSTEM OF CNS INJURED INDIVIDUALS

Peter Katona², Krisztina Uto¹, Emese Trajer², Edit Bosnyak², Anna Protzner², Jozsef Laczko³, Miklos Toth²

¹ Semmelweis University, Budapest, Hungary;

² University of Physical Education, Budapest, Hungary;

³ University of Pécs, Pécs, Hungary

Our study aims to investigate the functional electrical stimulation (FES) assisted cycling's effects on respiratory parameters and heart frequencies of paraplegic individuals. Among respiratory parameters, we examined oxygen consumption (VO₂), oxygen consumption per kilogram (VO₂/kg) and ventilation (VE). We would like to prove that the use of FES assisted cycling is practically a type of workout.

To prove FES cycling's effects on the cardiopulmonary system, we tested spirometric parameters and heart rate during the use of FES bikes. 5 paraplegic men participated in our research, their level of injury were between C5 and Th6, and there were complete lesion in all cases. Their average age was 41,1. They have been training with FES assisted cycling for at least 1 year.

The data analysis (Wilcoxon signed-rank test) (n=320) showed the following results: in case of oxygen consumption (VO₂) values Z=- 5,843, in case of oxygen consumption per kilogram (VO₂/kg) values Z=- 5,779, and in case of ventilation (VE) Z=- 6,154. These parameters show significant difference (p<0.05) between the resting period and the period of activity. In case of heart rate (HR) Z=- 2,047, p = 0,041, therefore significant difference was found in these data too.

It can be stated that use of FES bikes has effects on cardiopulmonary system and it increases endurance. Probably more heart rate measurements should have been done during the workout. To say undoubtedly that use of FES assisted cycling is an effective therapeutic possibility to paraplegic patients, as regards of cardiopulmonary system, the same examination should be done with a larger experimental group.

A-0105

CENTRAL RESETTING OF SPATIAL THRESHOLDS FOR MOTONEURONAL RECRUITMENT SUPPRESSES ACTIVATION OF MUSCLES DURING PROLONGED LENGTHENING

Nicolas A. Turpin^{1,2,4}, Rim Rahal², Sandeep K. Subramanian^{1,4}, Mindy F. Levin^{1,3,4}, Anatol G. Feldman^{1,2,4}

¹ Department of Neuroscience;

² Institute of Biomedical Engineering, University of Montreal;

³ School of Physical and Occupational Therapy, McGill University;

⁴ Center for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR), Montreal, QC, Canada

Since the work of Sherrington (1906), it has been recognized that, together with other proprioceptive reflexes, the stretch reflex (SR), i.e. position- and velocity-dependent resistance to muscle lengthening, plays a fundamental role in the control and stability of posture and movement. The spatial threshold of the SR, i.e. the muscle length or respective joint angle at which the SR begins to act is broadly regulated by spinal and supra-spinal systems in a task-specific way. By resetting the SR threshold, the nervous system converts posture-stabilizing to movement-producing mechanisms, thus solving the

classical posture-movement problem. We tested the hypothesis that the SR threshold can be reset to suppress muscle activation in response to high amplitude lengthening, thus preventing damage of active sarcomeres due to overstretching. The forearm and hand of subjects ($n=12$) were placed on a horizontal manipulandum. Elbow flexor or extensor muscles were pre-activated by compensating an external load (1, 2 or 3 Nm) applied to the manipulandum by a torque motor. The pre-activated muscles were stretched by rotating the manipulandum by 60° at different peak velocities (30-120°/s) randomly selected for each trial. EMG signals (biceps brachii, brachioradialis, triceps brachii lateralis and medialis), displacement and velocity were recorded. In preliminary training trials, subjects were instructed to abstain from intentionally modifying their responses to perturbations, and trials in which subjects changed EMG levels prior to stretch onset were excluded. In this condition, SR responses to muscle lengthening were practically absent. In addition, the initial muscle activation was suppressed at a minimal latency of 60 ms. Muscle activation resumed during the ongoing muscle lengthening. Results are consistent with the notion of SR threshold resetting, rather than suppression (gating) of the SR in time. In general, SR resetting can be used in converting posture-stabilizing to movement-producing mechanisms and in preventing muscle damage as well as in preventing falls. The possible relationship between the notion of SR threshold resetting and the clasp-knife phenomenon in some neurological conditions is discussed.

A-0114

ACUTE AND DELAYED NEUROMECHANICAL CHANGES AFTER INTENSIVE STRETCH-SHORTENING CYCLE EXERCISE TRAINING

Márk Váczai¹, Dan Río-Rodríguez², János Négyesi³, Miguel Angel Fernández del Olmo²

¹ *Institute of Sport Sciences and Physical Education, University of Pécs, Hungary*

² *Facultad de Ciencias do Deporte e a Educación Física, Universidad de A Coruna, Spain*

³ *Hungarian University of Physical Education, Budapest, Hungary*

INTRODUCTION

The stretch-shortening cycle (SSC), in forms of plyometric exercises, is extensively used by practitioners and athletes in performance training. During repetitive SSCs fibers are exposed to high mechanical tension, which contributes to acute fatigue and delayed myofibrillar damage, muscle soreness, and temporary strength loss. Here we investigated the acute and delayed changes in the neuromechanical properties of the quadriceps muscle after maximal intensity SSC exercise, using the conventional electrical stimulation and the transcranial magnetic stimulation (TMS) techniques.

METHODS

Ten non-athlete males performed 150 single-leg hurdle jumps. Maximal voluntary contraction (MVC) force in the quadriceps was determined using a modified leg extension machine attached to a cell force. Voluntary activation was determined using the twitch interpolation technique. Subjects also performed another MVC superimposed with 100-Hz doublet followed by a 10-Hz doublet delivered 4 s apart to determine high and low frequency fatigue, respectively. Electromyography (EMG) was recorded from the vastus lateralis muscle. Resting motor evoked potentials (MEP) were determined by stimulating the contralateral motor cortex using TMS. Perceived muscle soreness was evaluated using a visual analogue scale. All variables were measured before, immediately (IP), and 24h post-exercise.

RESULTS

MVC dropped 9% at IP ($p < 0.005$) and fully recovered at 24h. Voluntary activation dropped 6% at IP ($p < 0.05$) and recovered at 24h. Resting single twitch force dropped 23% at IP ($p < 0.005$) and

recovered at 24h. Low frequency fatigue was greater (28%, $p < 0.05$) than high frequency fatigue (5%, $p < 0.05$) at IP, however, these values recovered at 24h. Compared to the baseline, MEP amplitudes were 75% smaller at IP but recovered at 24h. Muscle soreness developed at 24h (from 0 mm to 12 mm on the 50 mm scale).

DISCUSSION

The intensive unilateral SSCs induced acute strength loss in the quadriceps due to neuromuscular fatigue. The reduced voluntary activation and motor cortex excitability indicate central fatigue, an insufficient driving of the motoneurons, however peripheral fatigue (reduced twitch force) seems to contribute more to the acute strength loss. Though mild soreness developed, indicating some muscle damage, neuromuscular performance recovered 24h post-exercise.

A-0084

TIMING CONTROL IN CYCLING AGAINST DIFFERENT RESISTANCES

Adam Valy¹, Jozsef Laczko^{1,2,3}

¹ Pázmány Péter Catholic University, Faculty of Information Technology and Bionics, Budapest, Hungary;

² University of Pécs, Faculty of Information Technology and Biorobotics, Pécs, Hungary;

³ HAS Wigner Research Centre for Physics, Budapest, Hungary

Maintaining a given speed during cycling exercises is a challenging task even for healthy subjects. This research examines the effect of speed and resistance on timing control of cycling movements on a stationary ergometer (SciFit ISO7000R).

A series of cycling exercises with varied speed and resistance was performed on 15 able-bodied subjects (age median 24, ± 4). Two different speed (45 and 60 rpm) and three resistance settings (designated low, medium and high) were used totalling 6 different cycling conditions (CC), each performed for 20 seconds. Kinematic data was recorded at 100 Hz using a Zebris CMS-HS ultrasonic measurement system with 7 markers, and data processing was performed by NI LabView software. Measurement errors were linearly interpolated.

Marker 1 was attached to the pedal axle of the ergometer, and the circular movement of the pedal allowed crank angle calculation. From this it was possible to calculate the complete kinematics of one subject for all 6 exercises.

For 45 rpm the crank has to return to the same angular position every 4/3 seconds, and for 60 rpm every 1 second, defining a cycle time for each speed. Using the cycle time, the time indices at which the crank would be at the same angular position can be calculated. The timing error (TE) of every participant in all conditions can be calculated by subtracting the desired cycle time index from the measured time index. Positive values indicate a slower cycling and negative values correspond to faster cycling.

For each subject, 15 TE data sets were acquired for each CC, totalling 90 measurements. In each CC, the timing error difference (TEd, in milliseconds) for a specific cycle is the difference between the maximum and minimum TE over all subjects.

For every CC the TEd steadily increases as time progresses, except for 45 rpm level 1 where there is a peak of 1240 ms after the 7th cycle, then the TEd decreases. At low resistance, the average cycling speed is slower, however at medium and high resistance, 13 out of 15 participants cycled faster than the desired speed would require. At slow speed, high resistance, the TEd at 15 seconds after the exercise started (760 ms) was lower than that of medium resistance (1120 ms). At fast speed however, the TEd for medium and high resistance was the same (1050 ms).

Therefore maintaining a certain speed during cycling is easier if the speed is lower and the resistance is higher.

A-0095

DOES INCREASED PRACTICE VARIABILITY MEAN INCREASED LEARNING?

Tibor Vámos^{1,2}, Kuniyasu Imanaka³¹*National Institute for Medical Rehabilitation, Budapest, Hungary;*²*Eötvös Loránd University Bárczi Gusztáv Faculty of Special Education, Institute for Methodology of Special Education and Rehabilitation, Budapest, Hungary;*³*Tokyo Metropolitan University Department of Health Promotion Science Perception and Action Laboratory, Tokyo, Japan*

The concept of the effect of variability in practice arose from Schmidt's schema theory (Schmidt, 1975). The variability of practice hypothesis proposes that by increasing the variability in practicing a given class of movement the development of a relevant motor schema is enhanced, which in turn results in better performance in the transfer and retention of an acquired skill. A special case of force production is the isometric force production where muscle contraction is not accompanied by the change in the joint angle, that is, no information available about the distance and location during the movement. Our question was whether greater variability during practice enhances retention and transfer of isometric force production. Furthermore, whether there is a plateau in increasing the variability.

32 university students participated in the study. They were randomly assigned to four practice groups. Specific practice group practiced only 25% of MVC (maximum voluntary contraction) as a target force. There were three variable groups that differed in the level of variability experienced during practice with increasing the range and inter-target difference of target forces. Variable 2.5% group practiced between 20% and 30% of MVC in 2.5% steps. Variable 5% group practiced between 15% and 35% of MVC in 5% steps. Variable 10% group practiced between 5% and 45% of MVC in 10% steps. Retention test was performed with the criterion task of 25% MVC, and transfer test was a novel task of 55% MVC.

Performance was measured by absolute error (AE), the difference of target force and actual force production on each trial and variable error (VE) that expresses performance variability. Results showed that AE level increased with increasing the inter-target difference during acquisition. Retention test showed no significant difference between the four practice groups. On the other hand, transfer test revealed significant difference between groups of low variability (specific and variable 2.5% group) and variable 5% group. VE showed similar pattern to AE during acquisition, retention and transfer tests. Variable 10% group showed higher error rate than other groups in the majority of acquisition blocks. Retention revealed no significant difference between groups, but transfer test performance was more consistent in variable 5% group than in specific and variable 2.5%. Increasing the variability in variable 10% group did not result in superior performance compared to variable 5% group.

The performance of the group practicing with small variability became similar to the performance of specific group. Furthermore, the greater inter-target differences resulted in more error but more effective learning in the means of transfer. Results suggest that practice variability beyond an optimum level does not lead to increase in learning.

A-0014

INVESTIGATION OF PHASE TRANSITION POINT PHENOMENA IN NOVICE PARTICIPANTS
OVER A PERIOD OF PRACTICE: A COMPARISON WITH SKILLED BEHAVIOUR**Wan Rizal Wan Zakariah¹, Jia Yi Chow¹, Robert Rein²**¹ *National Institute of Education-Nanyang Technological University, Singapore;*² *German Sport University, Cologne, Germany*

Over the years, studies on human movement coordination have been adopting cyclical movement models as the preferred choice over discrete movement models. This has resulted in a contrast in the volume of studies between the two models. Suggestively, less is known about the theoretical implications for discrete actions. From a dynamical systems perspective, self-organization is a key tenet in understanding human movement and is best examined via features at the phase transition point namely hysteresis and critical slowing down. The aim of this study is to examine hysteresis and critical slowing down through the investigation of movement patterns of novices over a period of practice and compare with skilled participants' results. Skilled (n=5) and novice participants (n=5) were required to return balls delivered in a scaling manner by a feeding machine to 9 locations back to a target. Novice participants undergo additional 12 sessions of practice over 4 weeks as well as a post- and retention test (2 weeks after post-test). 3D kinematic data of the upper body was captured and digitised and results were obtained using the cluster analysis approach. A six point nominal scale was used to record performance.

Post-hoc scores reveal significant differences in performance between skilled and novice at pre-test and practice sessions. Cluster analysis resulted in a total of 16 clusters. Kinematic data show clear differences between movement clusters; notably between cluster 2 (CL2) and the rest with respect to upper body rotation (z), elbow, wrist and bat flexion (x). CL2 was adopted by both skilled and novice participants whereas CL1 was adopted only by the skilled participants. Skilled participants displayed a 2 cluster solution as compared to the novice participants who adopted 9, 5 and 6 clusters at pre-, post- and retention tests respectively. 12 different clusters were observed in the practice sessions. Hysteresis region was limited to one location for skilled whereas hysteresis region for novices were wider at pre (4 locations), post³ and retention⁴ tests. In the practice sessions hysteresis region covered 6 locations. Critical slowing down for skilled participants was 0.88 as compared to the novice participants at pre- (1.62), post-¹ and retention (1.26) tests.

The variety of movement patterns adopted by novice participants during the practice sessions and the subsequent reduction of movement cluster from pre- to post- and retentions tests indicates the participants' exploration for the most suitable task solution and infers the presense of meta-stability and degeneracy expected from a discrete multi-articular action. Results for hysteresis and critical slowing down indicate that both phenomena may be an indicator of skill proficiency and may be used as a tool to dichotomise skill levels.

A-0120

UNINTENDED CONTRALATERAL ACTIVITY INCREASED DURING IPSILATERAL INTENDED CONTRACTIONS WITH GREATER TASK DIFFICULTY

Hironori Watanabe¹, Shobu Kurohara², Yasuhide Yoshitake²

¹ Graduate School of Physical Education, National Institute of Fitness and Sports in Kanoya, Kanoya, Japan;

² National Institute Fitness and Sports in Kanoya, Kanoya, Japan

Unintended muscle activity can be observed in contralateral muscles in most healthy adults during unilateral voluntary contractions of ipsilateral muscles. The unintended contralateral activity increased with the magnitude of voluntary muscle activity of ipsilateral muscles. Hence, intended contralateral activity is suggested to occur by spreading excitation within the central nervous system. The purpose of this study was to examine the effect of task difficulty during ipsilateral force control on the amount of unintended contralateral activity in homologous muscle.

Nine healthy male subjects (22.5 ± 2.9 yr) performed isometric abduction force with their index finger in the non-dominant hand (left hand) against a force transducer. Force feedback was given in the form of a cursor that moved across a computer monitor from left to right. Mean force subjects were required to exert was 20, 40, 60, 80% of maximal voluntary contraction force (MVC). Two horizontal bars were set at $\pm 2\%$ (Difficult task) and $\pm 7\%$ (Easy task) of the required mean force about the mean force in the computer monitor for the different task difficulties. Subjects were instructed to intentionally keep the abduction force within these limits for 12 s when exerting 20, 40, 60% of MVC and 6 s when exerting 80% of MVC. Surface electromyogram signals (EMG) were detected from the first dorsal interosseous muscle of the right hand to assess the degree of unintended contralateral activity. Root mean square amplitude value of EMG (aEMG) was calculated over a 4 s window centered about the middle of the intended contractions.

There was no interaction in aEMG between task difficulty and mean force ($P > 0.05$). There were main effects for task difficulty and mean force ($P < 0.05$). With respect to mean force, aEMG increased with mean force. With respect to task difficulty, aEMG during Difficult task was 1.47 times larger than that during Easy task.

These results indicated that unintended contralateral activity in homologous muscle increased when subjects performed ipsilateral intended contractions with not only the higher contraction force level but also with greater task difficulty.

Keywords: Task Difficulty, Mirror Movement, Motor Control, Involuntary Movement, Electromyography

A-0096

SPATIAL AND TEMPORAL REQUIREMENTS OF INSTANTANEOUS VISUAL FEEDBACK TO GUIDE ISOMETRIC FORCE PRODUCTION

Genevieve Williams¹, Amanda Chennavasin², Kristina Neely²

¹ Anglia Ruskin University, Cambridge, UK;

² The Pennsylvania State University, PA, USA

Previous work in motor psychophysics has demonstrated that the relationship between the spatial (gain) and temporal (frequency) parameters of visual feedback and isometric force output performance are nonlinear. Knowledge of how the spatial and temporal features of visual feedback

interact in relation performance outcome would increase our understanding of the key features of perception-action coupling within the visual motor system. The goal of this study was to determine how the spatial and temporal features of visual feedback effect performance outcome in a force production task with instantaneous feedback. Twelve participants (8 females; age 21.3 ± 2.1 years) completed an isometric precision grip force task to match 20 % of their maximum pinch grip for a duration of 20 s. Visual feedback was provided at four different gain levels (0.1, 0.2, 0.5, 1.7° visual angle) and five frequency levels (0.2, 0.4, 1.7, 10.0, 60 Hz). The results showed that performance error was greatest in the low gain condition (0.1°) compared to all other conditions. Similarly, performance error was greatest for the two lowest frequency levels (0.2 and 0.4 Hz) compared to all other frequency levels. However, no interaction between gain and frequency was observed for error. When provided with instantaneous feedback during isometric force production, increasing visual gain and frequency increases the accuracy of force output. However, increasing gain beyond 0.2° and feedback intermittency beyond 1.7 Hz did not significantly improve performance. This suggests that there is an optimal gain and frequency parameter to guide force production, and beyond these parameters, no additional improvements in performance are observed.

A-0057

EFFECTS OF MOTOR STROKE RECOVERY ON FINGER TAPPING-RELATED DYNAMICS OF BRAIN OSCILLATIONS: A CASE STUDY BASED ON HIGH-POWER EEG

Béla Weiss¹, János Körmendi^{2,3}, Anikó Papp², Zoltán Nagy^{2,3,4}

¹ Brain Imaging Centre, Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary;

² National Institute of Clinical Neurosciences, Budapest, Hungary;

³ University of Pannonia, Veszprém, Hungary;

⁴ Department-Section of Vascular Neurology, Semmelweis University, Budapest, Hungary

Complex mechanisms that regulate the capacity of the central nervous system to react to environmental changes, or injuries such as stroke, are described as brain plasticity. Reconstruction of motor functions in self-repair phenomena during stroke recovery could be related to activation of non-pyramidal cortico-spinal pathways, synaptogenesis, remodeling of dendritic arborization and activity-dependent reinforcement of previously existing functionally silent synaptic connections, however, the exact mechanisms and the alterations of associated brain activities are far to be well elucidated.

Here, we investigated the potential effects of motor stroke recovery on event-related brain dynamics in a broad frequency range by performing a single subject follow-up study using high-power EEG with 128 channels and 2048 Hz sampling rate. A 57 years old left-handed male patient with ischemic stroke in the right side of the pons and mild left side hemiparesis was instructed to perform finger tapping with his right or left index finger at a pace determined by a visual cue. The same experiment was carried out two times, one week after stroke injury (EXP1) and three months later (EXP2). Finger tapping-related spectral perturbations were estimated by time-frequency decomposition of scalp current density transformed EEG time-series in the 0.5-70 Hz range. To reveal significant event-related synchronization/desynchronization (ERS/ERD) patterns and stroke recovery effects in the spatial-temporal-frequency domain, within-trial and within-subject comparisons were carried out using cluster-based permutation testing.

Within-trial analysis revealed earlier onset of ERD for lower frequencies (1-12 Hz) and spatially more localized ERD clusters (1-30 Hz) for EXP1 as compared to EXP2, regardless the finger tapping side. Considering left tapping, no significant within-trial ERS was found for EXP1, while significant ERS clusters appeared in the 0.5-8 Hz frequency range for EXP2. Significant ERS in the 1-8 Hz range was localized in the right primary sensory and motor cortices (PSMC) and peaked around the finger tapping execution time with duration of about 1 s. The slower ERS (0.5-1 Hz) was significant in the [-2 1] s time interval and had a fronto-central location. For right tapping, significant ERS was found only for EXP1 in the 1-4 Hz frequency range within the [-0.3 0.6] s time interval. This cluster was localized in the left PSMC. Considering left tapping, within-subject analysis revealed significantly higher ERS in the 0.5-8 Hz frequency range and significantly higher ERD in the 4-30 Hz range for EXP2 as compared EXP1. Significant ERS clusters were found fronto-centrally (0.5-1 Hz) and in the right PSMC (1-8 Hz), while significant ERD clusters were mainly located in the left and central parietal regions. Within-subject testing found significant clusters also for right side tapping. Significantly higher ERS was revealed for EXP1 in the 4-8 Hz frequency range in the left PSMC, and significantly higher ERD was obtained for EXP2 in the 4-30 Hz frequency range in the parietal zone. Our results indicate restoration of ERS/ERD dynamics in the 1-30 Hz frequency range as well as development of finger tapping-related slow cortical oscillations (0.5-1 Hz) in the fronto-central region during motor stroke recovery.

A-0038

MOTOR CONTROL DURING DUAL-TASK SITUATIONS IN WILLIAMS SYNDROME

Kati Wuebbenhorst¹, Norman Holl²

¹ *Department of Physiotherapeutical Research (PIN.FOR) Faculty of Applied Public Health, EUFH MED Rostock, Germany*

² *University Medicine Rostock, Germany*

Human motor functions comprise the planning, the realization and the control of movements. The motor functions of patients with Williams-Beuren Syndrome underlie identical mechanisms like their peers. Nevertheless, several alterations in movement execution are existent. Differences in motor execution in patients with WBS restrain their everyday life in different ways. The origin of these differences is diverse since there is not one, but many causes for motor deficits. In particular, difficulties in tasks with motor and cognitive requirements like climbing stairs are attributed to functional deficits in visuospatial processing (Meyer-Lindenberg et al., 2006). However, the often occurring change from hypotonic to hypertonic muscle tone during adolescence can be caused from deficits in processing motor commands. This leads to the high importance of the motor development and the necessity of its comprehensive and long-term promotion. Therefore, the 'right' support and the 'proper' therapy can be formulated when the motor, postural, conditional and cognitive capacities are evaluated and integrated in the therapy planning.

In this study 27 subjects between the ages from 7 to 30 participated for the evaluation of static and dynamic postural control. We organized the participants in three age groups for better within group comparisons (age group I children 7-13, age group II adolescents 14-17, age group III young adults/adults 18-24). Since patients with the WB-Syndrome constitute deficits in visuospatial planning of movements (Hocking et al., 2013) we introduced a motor-cognitive dual-task-situation in addition to a single-task-situation. Children under 7 were able to perform the static dual-task but not the

dynamic. Therefore, they had to be excluded. The measurements of the static postural control were performed on a balance coordination system (GKS-1000, Meditech, Germany). The measurements of the dynamic postural control were performed in terms of functionality through a gait analysis using the optogait system (Microgate, Italy).

In this poster we present the outcome of the evaluation of the static postural control. The area represents the surface covered by the displacement of the body's center of gravity. The medial-lateral-velocity (ML-velocity) and the anterior-posterior-velocity (AP-velocity) represent the mean displacement velocity of the body's center of gravity when travelled at equal measuring time. The area increased for every age group when compared with the single-task and dual-task-situation. We found the highest increase with age group I from 5.1 ± 1.7 SE to 9.6 ± 3.2 SE for the dual-task-situation ($p=0.01$). The same results were obtained for the ML-velocity and AP-velocity. For instance, we found an increase of the ML-velocity in age group I from 14.7 ± 1.7 SE to 21.5 ± 2.8 SE ($p<0.001$). These results indicate that when confronted with a motor-cognitive dual-task-situation, the motor task is compromised for the cognitive task. Following these results, training of visuospatial perception along with a combination of sensorimotor training with cognitive involvement might improve the observed deficits in task execution.

A-0027

RAMBLING AND TREMBLING DECOMPOSITION OF SWAY IN QI GONG EXPERTS DURING QUIET STANDING UNDER DIFFERENT FOCUS CONDITIONS

Martin Wünnemann, Dorothee Neuhaus

University of Paderborn, Germany

The constrained-action-hypothesis (Wulf, McNevin & Shea, 2001) implies that focusing attention internally on aspects of the movement process disrupts automatic control processes and hence leads to worse performance. Experiments by Neuhaus (2014) imply that additional strategic instructions may have an even larger influence on postural sway than the focus of attention. Maybe, the focus effect might come into existence because the external focus is more usual in daily life. Qi Gong experts, on the other hand, focus internally without attentional strategies in quiet standing during their exercises. Thus, they might show good performance in quiet standing when focusing internally without additional strategic instructions. This should appear particularly in the trembling component (Zatsiorsky & Duarte, 2000) of the stabilogram.

20 subjects (13 f/7 m, mean age = 49.5 years, SD = 9.8 years) with at least 3 years of experience in Qi Gong completed 4 test blocks (each 3 x 30 s) of bipedal standing on a force plate. The 4 test blocks differed in the instructions used. A 2-factorial design was applied, factor 1: focus instruction (FI) [internal (int)/external (ext)]; factor 2: additional instruction (AI) (without/with). The FIs related to the feet (int) or to marks underfoot (ext). The AI was "...try to apply the same pressure on them". Dependent variables are the standard deviations (SD) of the rambling and trembling components in medio-lateral (ml) and anterior-posterior (ap) direction.

There are larger SDs for trembling in ap with AI, $F(1, 19) = 7.7$, $p = .012$, part. $\eta^2_{sq} = .287$. The larger SDs for trembling in ap under the use of ext FIs fail to reach significance shortly, $F(1, 19) = 4.2$, $p = .054$, part. $\eta^2_{sq} = .182$. There are no significant effects in ml.

Maybe differences in the base of support cause that the effects of the instructions are reflected mainly in the ap-direction. Although not significant, the results indicate that there is no general advantage

of an external focus of attention. Instead, which focus of attention leads to better performance may be dependent on the experience with the respective foci.

Neuhaus, D. (2014). Zum Einfluss von zusätzlichen Instruktionen bei unterschiedlichen Aufmerksamkeitsfokusbedingungen auf das bi- und monopedale Stehen. Hamburg: Dr. Kovac.
Wulf, G., McNevin, N., Shea, C. H. (2001). The Automaticity of Complex Motor Skill Learning as a Function of Attentional Focus. *Quarterly Journal of Experimental Psychology [A]*, 54, 1143-1154
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A-0091

INFLUENCE OF BREATH SYNCHRONIZATION ON AN INTERPERSONAL TASK

Naoko Yamane, Hiromichi Suenaga, Jun Nishii

Yamaguchi University, Yamaguchi, Japan

In Japan, we say "match the breath" when we perform cooperative tasks that require precise synchronization among the participants, e.g., carrying large baggage and playing musical instruments. When we lift a heavy baggage with others, we often say "Yo-ho!" in order to match the breath, by which we can make forces at a same moment. Then, does breath synchronization bring some benefits in other cooperative tasks in which not impulsive but continuous force is required. In this study, we examined if breath synchronization improves the performance of such an interpersonal task.

Participants were 10 pairs by 20 people in their twenties. Two participants sat on chairs face-to-face and had metal rods of which tip was an L-shaped hook and a 3 cm loop in diameter, respectively. They were required to move the rods from side to side between two targets of the distance of 45 cm for 60 seconds with inserting the hook of a rod in the loop of another without contacting them. When the rods contact, a LED light on the top of the grip of each rod was turned on as an alert. A microphone was attached underneath each subject's nose to record the breath. In condition 1, no breath sound was presented to them. In condition 2 and 3, subjects performed the task with listening the partner's breath sound. Additionally, in condition 3 they were instructed to synchronize own breath with the sound. The subject pairs were divided into two groups, and the task was performed in the order of the condition 1, 2, 3, and 1 in one group and 1, 3, 2, 1 in another group.

The ratio of the number of the rod contact under the condition 3 to the number under the first condition 1 was 0.955 on average among all pairs, i.e., only a slight improvement of the performance was observed. However, the averaged ratio was 0.587 for the pairs who reported not to have felt stress in listening to the partner's breath (non-stress group), on the other hand, the average was 1.312 among the pairs at least one of whom reported to have felt stress. The difference was significant between the two groups ($p=0.0291<0.05$ by t-test) when we neglect the data by the pair whose the worst in the first condition 1. Furthermore, the performance by the non-stress group under the condition 3 was significantly better than the performance under the condition 2 ($p=0.0280<0.05$ by t-test). These results suggest that breath synchronization in an interpersonal task brings good influence when participants feel no stress in listening to partner's breath. Furthermore, the correlation coefficient was 0.838 between the condition 3 and second condition 1, and 0.690 between the condition 2 and second condition 1. These results show that the experience of breath synchronization improves the task performance even when no breath sound was given. We are analyzing the correlation between breath sounds of each pair and will report how the correlation affects the task performance.

A-0012

UNDER THRESHOLD POSITION CONTROL, PERIPHERAL MECHANISMS COMPENSATE EFFICIENTLY FOR SMALL PERTURBATIONS OF ARM MOVEMENTS

Lei Zhang, Andreas Straube, Thomas Eggert*Department of Neurology, Ludwig-Maximilians-University, Munich, Germany*

Unexpected small perturbations during reaching movements are normally compensated for automatically. Previous studies with such perturbations observed that the movement trajectory converges back to the preplanned end position. The question remains whether peripheral mechanisms formed by intrinsic muscle properties and stretch reflex are efficient for compensating for such perturbations. Even though this is suggested by a threshold position control model (Pilon and Feldman 2006) highlighting the role of peripheral mechanisms under central control in movement generation, it is neither developed nor extensively tested for this capability. The present study tests how this model can account for the compensation during single-joint fast reaching. Motor responses to transient, unpredictable, small perturbations at different movement phases were measured and compared with the model predictions. The results show good agreement concerning kinematic and dynamic responses. Simulations with altered mechanical parameters of the model suggest that reflexive responses are well tuned to the intrinsic muscle properties. We conclude that under central control, peripheral mechanisms cope efficiently with small transient perturbations.

A-0059

VARIABILITY OF THE OCCURRENCE OF PEAK MUSCLE ACTIVITY OF THE EQUINE LONGISSIMUS DORSI DURING TROT

Rebeka R. Zsoldos¹, Björn Krüger², Anna Vögele², Schröder Ulrike³, Theresia F. Licka^{4,5}¹ *University of Natural Resources and Life Sciences Vienna, Vienna, Austria;*² *Multimedia, Simulation and Virtual Reality Group, Institute of Computer Science II, University of Bonn, Bonn, Germany;*³ *Department for Small Animals and Horses, University of Veterinary Medicine Vienna, Vienna, Austria;*⁴ *Movement Science Group, University of Veterinary Medicine Vienna, Vienna, Austria;*⁵ *Royal (Dick) School of Veterinary Studies, The University of Edinburgh, Edinburgh, Scotland, United Kingdom*

AIM: To identify the variability of the occurrence of peak muscle activity of equine longissimus dorsi muscle in trot, one of the main spinal stabilizers of horses; this was done to identify whether measures of variability are comparable between individuals, and comparable between the different aspects of motion e.g. electromyography (EMG) and previously reported kinematics.

METHODS: Surface electromyography (sEMG) measurements were taken in eight horses without lameness, trotting on a treadmill. The electrodes were placed over both the left (LDL) and right (LDR) longissimus dorsi muscle at the level of the 16th thoracic vertebra, where the maximum lateral movement of the spine occurs in this gait. The resulting EMG signal was rectified and sampling rate was reduced to 120 Hz. A Butterworth low-pass filter was applied (fourth order; cut-off frequency, 20 Hz). The occurrence of the consistent first maximum muscle activation within the motion cycle was determined for each electrode as a percentage of the total duration of the respective motion cycle (%MC). For each horse three trials with a minimum of 8 motion cycles were evaluated.

RESULTS: The standard variation of the occurrence of the peak muscle activity ranged from 1% to

10% between horses, varying up to 7% between trials of the same horse. The biggest difference between the left and right side standard deviation within the same horse was 4%. The range of peak activity occurrence is larger than the variation of the occurrence of other locomotion characteristics reported for the equine back on the treadmill at the same location. Over all horses, the standard deviation of the occurrence of the peak activity was 7.1% on the left (mean 29%), and 2.1% on the right (mean 27%), both of them notably larger than the previously reported standard deviation of the lateral movement of this location at the trot 0.65% (mean 1.85%) or the standard deviation of the dorsoventral movement of the same location at the trot, which was found to be 0.77% (mean 4.94%) of the horse's height at the withers. As the horses were moving at the same speed throughout the trials, this variation of muscle use was considered relevant; it was shown in most horses, and usually similarly between the left and the right side.

CONCLUSION: Although the inter-subject variability of the occurrence of the first peak activity within the motion cycle seems to be relatively small, the intra-subject variability shows higher variability than the reported effect of this activity i.e. the kinematic pattern of back movements at the trot. This shows that spinal stabilisation is effected by variable longissimus activity, at this stage it is unknown whether this is due to the difference in forces that require counteraction to achieve stabilisation or whether this is due to a more efficient muscle use if the pattern of fibre activation is varied.

A-0060

SIDEWAYS STABILISATION EFFECT OF THE EQUINE LONGISSIMUS DORSI MUSCLE IN TROT

Rebeka R. Zsoldos¹, Björn Krüger², Anna Vögele², Schröder Ulrike³, Theresia F. Licka^{4,5}

¹ University of Natural Resources and Life Sciences Vienna, Vienna, Austria;

² *Multimedia, Simulation and Virtual Reality Group, Institute of Computer Science II,
University of Bonn, Bonn, Germany;*

³ *Department for Small Animals and Horses, University of Veterinary Medicine Vienna, Vienna, Austria;*

⁴ *Movement Science Group, University of Veterinary Medicine Vienna, Vienna, Austria;*

⁵ *Royal (Dick) School of Veterinary Studies, The University of Edinburgh, Edinburgh, Scotland, United Kingdom*

AIM: To identify the chronological order and the time delay between the maximum activity of the equine longissimus dorsi muscle and the maximum lateral acceleration of the equine spine at the trot at the same location of the mid-back (T16); this is the movement that this muscle's activity is considered to stabilise against.

METHODS: Surface electromyography (sEMG) and spinal acceleration measurements were taken in eight horses without lameness, trotting on a treadmill. The electrodes and accelerometers were placed over both the left (LDL and LDLAccY) and right (LDR and LDRAccY) longissimus dorsi muscle at the level of the 16th thoracic vertebra. The resulting EMG signal was rectified and sampling rate was reduced to 120 Hz. A Butterworth low-pass filter was applied (fourth order; cut-off frequency, 20 Hz). The occurrence of the maximum muscle activation within the motion cycle was determined for each electrode as a percentage of the total duration of the respective motion cycle. The time points of the occurrence of the two maximum (peak) activities of LDL and LDR were then compared with the respective spinal accelerations within each muscle during each motion cycle. For each horse three trials, each with twelve motion cycles was considered.

RESULTS: Within horses, standard deviations of the timing delay between peak muscle activity and maximum lateral acceleration were considerable, ranging from 1% to 21%. In the vast majority of the motion cycles of all horses (251/288 left side and 233/288 right side), the maximum muscle

activity occurred prior to the maximum lateral acceleration of the spine, on average by 10% of the motion cycle (standard deviation between horses 2%). This further illustrates the stabilising effect of this muscle against the lateral excursion of the spine, as pre-emptive contraction is a well-known phenomenon of a functioning spinal stabilisation mechanism. However, it is interesting to note, that in two of the eight horses, this stabilisation seemed dysfunction on one side only – with the majority of motion cycles showing first maximum lateral acceleration and only shortly after that maximum activity of the muscle that should have stabilised against this acceleration. Even though all horses were examined to exclude clinical changes of back function prior to inclusion in this study, these two horses appeared to have unilateral abnormalities in the complex pattern required to stabilise the healthy equine spine.

CONCLUSION: The system of pre-emptive muscle activation to achieve vertebral stabilisation appears to be similar in the horse as described in other mammals. Horses should probably not be considered to have a healthy, fully functioning back based on clinical examination alone, but sEMG analysis may be helpful to further determine the functionality of muscle activation; changes in which cannot be appreciated in the absence of clinically painful consequences of this lack of prevention of joint movements at the end or outside the physiological range of motion of these joints.

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1146 Budapest, Istvánmezei út 1-3.

Telefon/Fax: +36 1 460-6980

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