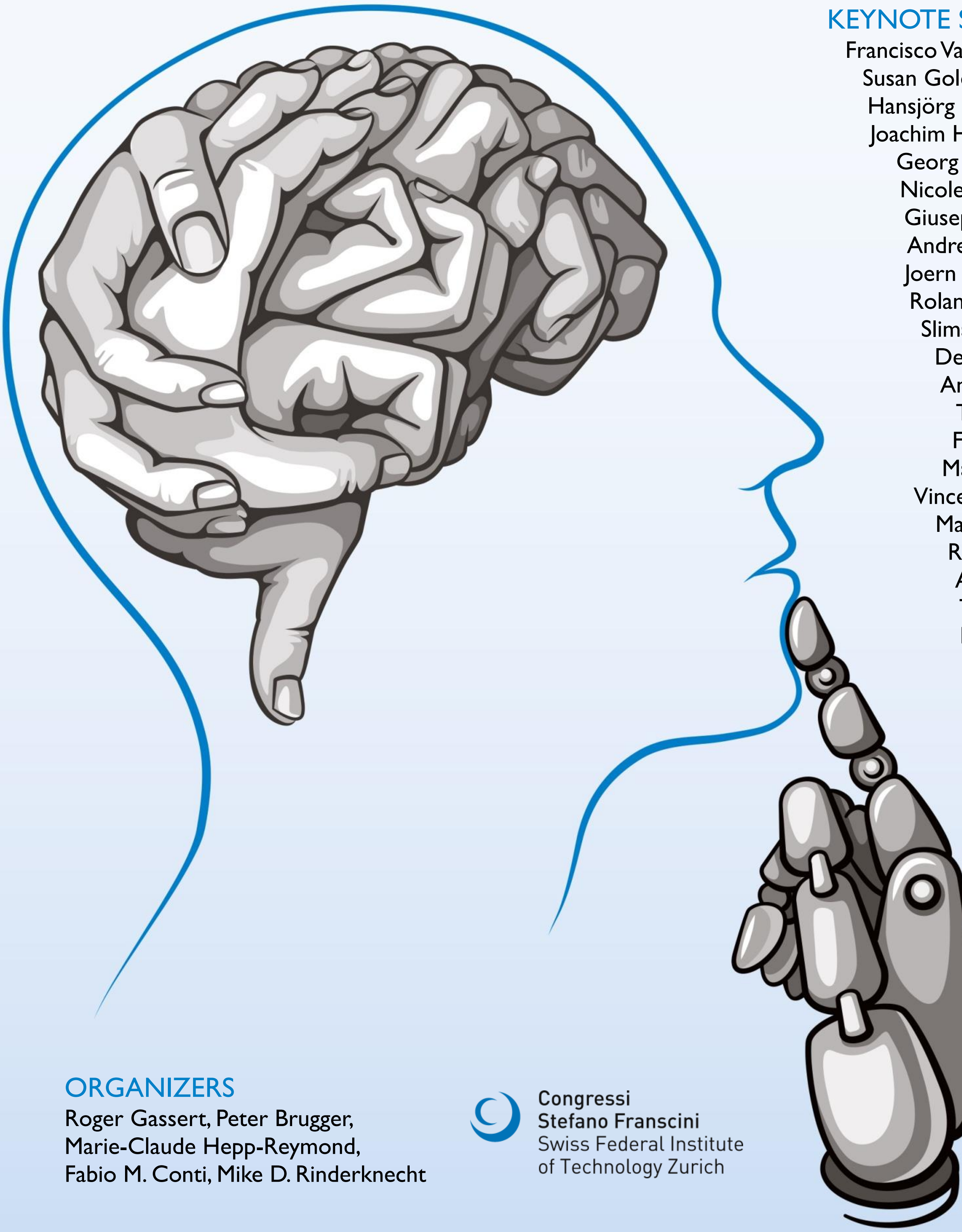
HAND, BRAIN & TECHNOLOGY

Monte Verità, Ascona, Switzerland, September 7 – 12, 2014

KEYNOTE SPEAKERS

Francisco Valero-Cuevas
Susan Goldin-Meadow
Hansjörg Scherberger
Joachim Hermsdörfer
Georg Goldenberg
Nicole Wenderoth
Giuseppe Luppino
Andrew Schwartz
Joern Diedrichsen
Roland Johansson
Sliman Bensmaia
Derek Kamper
Andrea Serino
Tamar Makin
Frank Wilson
Marc Schieber
Vincent Hayward
Marco Santello
Roger Lemon
Angela Sirigu
Todd Kuiken
Eric Rouiller
Lee Miller



ORGANIZERS

Roger Gassert, Peter Brugger,
Marie-Claude Hepp-Reymond,
Fabio M. Conti, Mike D. Rinderknecht

Congressi
Stefano Franscini
Swiss Federal Institute
of Technology Zurich

WELCOME

Dear Attendees,

A warm welcome to the "Hand, Brain and Technology" Conference on Monte Verità, held within the Congressi Stefano Franscini conference series! The tight functional coupling between hand and brain has greatly shaped the evolution of language, culture and technology. Any reduction or loss of hand function, whether of central or peripheral origin, has devastating effects on the independence and social integration of the affected person. And any treatment, be it through human or technological intervention, must account for this unique coupling. As a result, hand and brain have drawn strong interest from the social, medical and engineering sciences alike. This conference brings together leading researchers from the multiple disciplines studying the unique dexterity and sensory abilities of the hand, its neuromechanical and physiological control, as well as its functional recovery and neuroprosthetic restoration following injury.

This is the third CSF conference on these topics, following two successful events organized by Mario Wiesendanger in 1994 (Sensorimotor Function of the Hand: Mechanics and Control) and 1998 in collaboration with Marie-Claude Hepp-Reymond (Neural Basis of Hand Dexterity), the former of which resulted in a book entitled "Hand and Brain – The Neurophysiology and Psychology of Hand Movements", which has become a seminal work in the field. This conference adds to the previous two by integrating an engineering component, with the aim of promoting interaction and collaboration across scientific disciplines.

Aligned with the philosophy of CSF conferences, there will be ample time for discussions, as well as for junior and advanced researchers to disseminate their work and interact with senior researchers. We thank you all for coming, many of you over great distances, for contributing to this unique event and for your time. We also thank our sponsors and the CSF for making this event possible, and wish you an intellectually stimulating and inspiring week on Monte Verità!

Sincerely,

The organizers

Prof. Roger Gassert
Rehabilitation engineering
Department of Health Sciences
and Technology, ETH Zurich

Prof. Peter Brugger
Neuropsychology
Department of Neurology
University Hospital Zurich

Prof. Marie-Claude Hepp-Reymond
Neural control of grasping
Institute of Neuroinformatics
ETH Zurich and University of Zurich

Dr. med. Fabio Mario Conti
Neurocognitive rehabilitation
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VENUE

The CSF (Congressi Stefano Franscini) conference Hand, Brain and Technology 2014 is held on the Monte Verità in Ascona, Switzerland.

TRANSPORTATION

There will be a **FREE SHUTTLE SERVICE** (from Locarno train station to Monte Verità). We are offering a limited number of seats (max 11 people every 60 min) in a shuttle from the train station in Locarno to the conference venue on Monte Verità on the arrival and departure day. This shuttle is based on a first-come, first-served basis, with the following departure timetable:

Sunday, September 7, 2014 (Departure from Locarno)	**Friday, September 15, 2014** (Departure from Monte Verità)
15:20	13:20
16:20	14:20
17:20	15:20
18:20	16:20
19:20	17:20
20:20	18:20

For public transportation throughout Switzerland consult www.sbb.ch/en.

WIRELESS LAN

You will find access information for the Wi-Fi in the conference bag. Additionally to the wireless LAN, a computer room at the conference venue is available for the participants.

EXCURSION & CONFERENCE DINNER

As one of the highlights of the "Hand, Brain and Technology" conference, we invite you to join us for a scenic excursion to discover the beautiful countryside of our region on the afternoon of Wednesday, September 10th. The program includes a journey by boat on Lago Maggiore departing from Locarno, followed by a lakeside dinner in the Camin Hotel in Colmegna, a historic villa set in an ancient park stretching along the Verbano bank on the Italian side of the lake. Sponsored by the Clinica Hildebrand Centro di riabilitazione Brissago and the Ente Ospedaliero Cantonale, this excursion promises to be a wonderful opportunity to engage with your fellow attendees around authentic Italian cuisine amongst unforgettable surroundings.

CLINICA HILDEBRAND
CENTRO DI RIABILITAZIONE BRISSAGO

SPECIAL LECTURE BY FRANK WILSON

KEYNOTE

Hand, Brain, and Self: What becomes of Homo sapiens in the age of the "smart" machine?

F. Wilson[1]*

[1] Stanford University, Professor Emeritus

Abstract

In 1511, when Michelangelo painted the hand of God reaching toward the hand of Adam on the ceiling of the Sistine Chapel, he gave the Renaissance not just its single most iconic image but its most potent spiritual and psychological message: the human hand is an instrument whose highest use requires more than mere physical control. Michelangelo's message has resonated deeply with both religious and secular thinkers for over 500 years, but this may not be the time to discard it. Indeed, it is Dr. Wilson's thesis that this message has acquired renewed importance by challenging us to think critically (and humanly) about the science and technology that are revolutionizing our understanding of ourselves, our lives, and our future.

Short Biography

Frank Wilson is an American neurologist whose decades of clinical work and research involving artists with hand problems have been influential in bringing researchers in anthropology, evolutionary biology, and neuroscience into closer theoretical and practical contact. Now retired from active practice, he was Visiting Professor of Neurology at the University of Düsseldorf; medical director of the Health Program for Performing Artists at the University of California, San Francisco; and Clinical Professor of Neurology at Stanford University School of Medicine; and is the author of The Hand: How Its Use Shapes the Brain, Language, and Human Culture. He was awarded an Honorary Doctorate in Fine Arts by the Massachusetts College of Art and Design in Boston in 2012.

SOCIAL EVENT – DIMITRI & COMPAGNIA DUE

Dimitri was born in Ascona and decided to become a clown at the age of seven. While becoming an apprentice potter, he took theatre classes, studied music, ballet and acrobatics. He studied mime with Etienne Decroux, became a member of Marcel Marceau's troupe and appeared as "Auguste" with the famous white clown Maïss at Circus Medrano in Paris. In 1959 he appeared for the first time in a programme of his own in Ascona and soon followed tours throughout the world and with Circus Knie. In 1971, together with his wife Gunda, he founded the Teatro Dimitri in Verscio, in 1975 the Scuola Teatro Dimitri and in 1978 the Compagnia Teatro Dimitri. In the year 2000 *Dimitri* founded together with Harald Szeemann the Museo Comico in Verscio. *Dimitri* is still considered one of the world's best clowns who not only makes his public laugh but with his poetic mind and generous heart also deeply touches his audience. *Dimitri* will give a speech "in plain clothes" about "The hand and the brain".

The group *Compagnia DUE* presents dexterity numbers, magic, dance, and live acrobatics, all in a non-verbal manner and therefore very understandable to all guests. Andreas Manz and Bernard Stöckli from *Compagnia DUE* have been in the humor business for many years, with a blatant theatricality and slapstick comedy as trademark, spiced with poetry, clowning, improvisation and a captivating humor. The two professional artists successfully blend the comic entertainment with the demanding art of the theater, mastering both fields with great skill. The show will comprise a variety of comic numbers centered around the theme "The hand and the brain".

More information about *Dimitri* and *Compagnia Due* can be found under www.clowndimitri.ch and www.compagniadue.com.

PROGRAM

Time	Monday: Cortical Control	Tuesday: Cognitive & Clinical Neuroscience	Wednesday: Neuroprosthetics	Thursday: Haptics & Dexterity	Friday: Neurorehabilitation
09h00–09h20	Welcome address	Susan Goldin-Meadow	Andy Schwarz	Roland Johansson	Joachim Hermsdörfer
09h20–09h40	Roger Lemon				
09h40–10h00		Georg Goldenberg	Sliman Bensmaia	Michael Dimitriou	Ted Milner
10h00–10h20	Thomas Brochier			Ian Bullock	Margaret Duff
10h20–10h50	Coffee	Coffee	Coffee	Coffee	Coffee
10h50-11h00	Giuseppe Luppino	Nicole Wenderoth	Lee Miller	Eric Rouiller	Derek Kamper
11h00–11h20					
11h20–11h40	Marc Schieber	Noëmi Eggenberger	Hansjörg Scherberger	Poster session	Alejandro Melendez-Calderon
11h40–12h00		Silvio Ionta			Arno Stienen
12h00–12h20	Rijk Intveld	Zdravko Radman	Todd Kuiken		CSF Junior Award ceremony & closing words
12h30–14h30	Lunch	Lunch		Lunch	Lunch
14h30–14h50	Poster FF	Angela Sirigu	13h: Lunch	Francisco Valero-Cuevas	Departure Shuttles leaving at: 13:20 14:20 15:20 16:20 17:20 18:20
14h50–15h10	Marco Santello		15h: Excursion & Conference dinner		
15h10–15h30		Andrea Serino		Aaron Dollar & Thomas Feix	
15h30–15h50	Marco Davare				
15h50–16h20	Coffee	Coffee		Coffee	
16h20–16h40	Poster FF	Tamar Makin		Vincent Hayward	
16h40–17h00	Joern Diedrichsen				
17h00–17h20		Elena Rusconi		Sarah Wohlman	
17h20–17h40	Anne-Dominique Gindrat	Stefan Vogt		Andreas Thomik	
17h40–18h00	Miriam Schrafl-Altermatt	Jennifer Gurd		General discussion	
18h00–18h20		General discussion			
18h30–20h30	Dinner	Dinner		Dinner	
20h30–21h30	Poster session	Frank Wilson		Dimitri & Compagnia Due	

CORTICAL CONTROL

Monday, September 8, 2014

09h00 – 09h20	Welcome address	
09h00 – 10h00	**Roger Lemon** (U College London) *Corticospinal systems for movement generation and action observation*	KEYNOTE
10h00 – 10h20	Thomas Brochier (CNRS Marseille) *Mapping horizontal cortical connections in primate motor cortex using intracortical micro-stimulation*	A13T
10h20 – 10h50	Coffe	
10h50 – 11h20	**Guiseppe Luppino** (U Parma) *Cortical circuits for purposeful hand actions*	KEYNOTE
11h20 – 12h00	**Marc Schieber** (U Rochester) *Spatiotemporal distribution of object versus location in kinematics, EMG and motor cortex activity during reach, grasp and manipulation*	KEYNOTE
12h00 – 12h20	Rijk Intveld (German Primate Center) *Grasp force coding in F5 and AIP in a delayed grasping task*	A07T
12h30 – 14h30	Lunch	
14h30 – 14h50	Poster fast-forward	
14h50 – 15h30	**Marco Santello** (Arizona State U) *Sensorimotor mechanisms for control and learning of dexterous manipulation*	KEYNOTE
15h30 – 15h50	Marco Davare (U College London) *Effect of visuo-haptic conflicts on grasping movements in virtual reality*	A05T
15h50 – 16h20	Coffe	
16h20 – 16h40	Poster fast-forward	
16h40 – 17h20	**Jörn Diedrichsen** (U College London) *The cortical representation of hand movements*	KEYNOTE
17h20 – 17h40	Anne-Dominique Gindrat (U Fribourg) *Effect of primary motor cortex lesion on cortical processing of tactile finger stimulation in adult monkeys: an EEG study*	A10T
17h40 – 18h00	Miriam Schrafl-Altermatt (Balgrist University Hospital) *Neural Coupling of Cooperative Hand Movements*	A15T
18h30 – 20h30	Dinner	
20h30 –	Poster session (Sala Balint)	

COGNITIVE & CLINICAL NEUROSCIENCE

Tuesday, September 9, 2014

09h00 – 09h40	**Susan Goldin-Meadow** (U Chicago) *From action to abstraction: Gesture as a mechanism of change*	KEYNOTE
09h40 – 10h20	**Georg Goldenberg** (Bogenhausen Hospital Munich, TU Munich) *Apraxia tears apart the neural substrates of instrumental and communicative functions of the hand*	KEYNOTE
10h20 – 10h50	Coffee	
10h50 – 11h20	**Nicole Wenderoth** (ETH Zurich, KU Leuven) *Making and breaking motor memories*	KEYNOTE
11h20 – 11h40	Noëmi Eggenberger (University Hospital Bern) *Visual exploration of co-speech hand gestures in aphasic patients: An eye-tracking study*	B04T
11h40 – 12h00	Silvio Ionta (ETH Zurich, CHUV) *Neuroplastic sensorimotor adaptations after spinal cord injury*	B01T
12h00 – 12h20	Zdravko Radman (Zagreb, U Split) *The "enhanded" mind: An attempt for a reconception of agency*	B06T
12h30 – 14h30	Lunch	
14h30 – 15h10	**Angela Sirigu** (CNRS Lyon) *Varieties of movement representations in the human brain*	KEYNOTE
15h10 – 15h50	**Andrea Serino** (EPFL, U Bologna) *Neural mechanisms, functions and plasticity of peripersonal space representation in humans*	KEYNOTE
15h50 – 16h20	Coffe	
16h20 – 17h00	**Tamar Makin** (U Oxford) *Bridging the gap between cortical reorganisation and rehabilitation in arm amputees*	KEYNOTE
17h00 – 17h20	Elena Rusconi (U Parma) *Neural correlates of finger gnosis*	B12T
17h20 – 17h40	Stefan Vogt (U Lancaster, U Liverpool) *Imitation learning of spatial sequences and rhythms: A FMRI study in musically naïves and drummers*	B03T
17h40 – 18h00	Jennifer Gurd (U Oxford) *Hand, brain, attention*	B07T
18h00 – 18h20	General discussion	
18h30 – 20h30	Dinner	
20h30 – 21h30	**Frank Wilson** (Stanford U, Professor Emeritus) *"The Hand: How its use shapes the brain, language, and human culture"*	KEYNOTE

NEUROPROSTHETICS

Wednesday, September 10, 2014

09h00 – 09h40	**Andrew Schwarz** (U Pittsburgh) *Recent progress toward a high-performance neural prosthesis*	KEYNOTE
09h40 – 10h20	**Sliman Bensmaia** (U Chicago) *Biological and bionic hands: Natural neural coding and artificial perception*	KEYNOTE
10h20 – 10h50	Coffee	
10h50 – 11h20	**Lee Miller** (Northwestern U) *Restoring hand function with a biomimetic neural interface and Functional Electrical Stimulation*	KEYNOTE
11h20 – 12h00	**Hansjörg Scherberger** (German Primate Center) *Grasp predictions from motor, premotor, and parietal population signals*	KEYNOTE
12h00 – 12h40	**Todd Kuiken** (RIC, Northwestern U) *Developing neural interfaces for powered prosthetic limbs*	KEYNOTE
13h00 – 15h00	Lunch	
15h00 – 21h30	Excursion & conference dinner	

HAPTICS & DEXTERITY

Thursday, September 11, 2014

09h00 – 09h40	**Roland Johansson** (Umeå U) *Edge-orientation processing in first-order tactile neurons*	KEYNOTE
09h40 – 10h00	Michael Dimitriou (Umeå U) *Human muscle spindles preferentially encode imposed movement*	D04T
10h00 – 10h20	Ian Bullock (Yale U) *Kinematics of two- and three-fingered dexterous precision manipulation*	D11T
10h20 – 10h50	Coffee	
10h50 – 11h20	**Eric Rouiller** (U Fribourg) *Behavioral variability of manual dexterity in macaques*	KEYNOTE
11h20 – 12h20	Poster session (Sala Balint)	
12h30 – 14h30	Lunch	
14h30 – 15h10	**Francisco Valero-Cuevas** (U Southern California) *Moving beyond a cortico-centric view of dexterity*	KEYNOTE
15h10 – 15h50	Aaron Dollar & Thomas Feix (Yale U) *Modeling of precision grip in primates*	D10T
15h50 – 16h20	Coffe	
16h20 – 17h00	**Vincent Hayward** (UPMC Paris) *Mechanics of the fingertip and its impact on the prehensile and sensory function of the hand*	KEYNOTE
17h00 – 17h20	Sarah Wohlman (Northwestern U, RIC) *Subject variability during maximum lateral pinch*	D06T
17h20 – 17h40	Andreas Thomik (Imperial College London) *Symbolic representation of complex action sequences*	D07T
17h40 – 18h20	General discussion	
18h30 – 20h30	Dinner	
20h30 – 21h30	Social Event: **Dimitri & Compagnia Due** (Sala Balint)	

NEURO-REHABILITATION

Friday, September 12, 2014

09h00 – 09h40	**Joachim Hermsdörfer** (TU Munich) *Deficits of tool use following stroke: Neural correlates and technological approaches to assist in activities of daily living*	KEYNOTE
09h40 – 10h00	Ted Milner (McGill U, CRIR Montreal) *Coordination of grip force and load force during submovements in normal and post-stroke subjects*	E02T
10h00 – 10h20	Margaret Duff (RIC) *A portable, low-cost system for evaluating hand function during natural movement*	E03
10h20 – 10h50	Coffee	
10h50 – 11h20	**Derek Kamper** (Illinois Institute of Technology, RIC) *Neurological interactions among thumb and fingers*	KEYNOTE
11h20 – 11h40	Alejandro Melendez-Calderon (Hocoma, Northwestern U) *Assistance and rehabilitation of hand function using a robotic glove*	E06T
11h40 – 12h00	Arno Stienen (U Twente) *Symbionic hand orthoses for Duchenne and stroke*	E09T
12h00 – 12h20	CSF Junior Award ceremony & closing words	
12h30 – 14h30	Lunch	

TALKS

Section	Page

CORTICAL CONTROL

Monday, September 8, 2014

09h00 – 09h20	Welcome address		
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17h20 – 17h40	Anne-Dominique Gindrat (U Fribourg) *Effect of primary motor cortex lesion on cortical processing of tactile finger stimulation in adult monkeys: an EEG study*	A10T
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18h30 – 20h30	Dinner	
20h30 –	Poster session (Sala Balint)	

Corticospinal systems for movement generation and action observation

R. N. Lemon[1]*

[1] UCL Institute of Neurology, Queen Square, London, UK

Abstract

The corticospinal tract is derived from multiple regions of the cerebral cortex and through its descending collaterals and terminations makes connections with multiple levels of the sensorimotor system, and exerts a wide degree of influence over different spinal circuits. Although all mammals possess a corticospinal tract, this system actually shows a remarkable degree of variation across species, which probably reflects the relative importance to those species of the different functions to which it can contribute. Our recent analysis suggests that existing neurophysiological knowledge of the corticospinal system is restricted to the 3-5% of the fibres which are relatively fast-conducting [2]. The functions of the huge majority of the fibres, conducting below 5 m/s, are so far unstudied, which should be a real challenge for the future!

In primates, the fast corticospinal projections from the primary motor cortex have long been implicated in the generation of movement, and a large body of work has shown strong relationships between corticospinal discharge and various parameters of movement, such as the force and direction. It has also been possible to show direct causal effects of corticospinal activity on motor output. Nevertheless, it is clear that the motor cortex can also be active during processes that do not require movement generation per se. These include mental rehearsal of motor acts and, intriguingly, observation of the actions of others. Recent work shows that even M1 corticospinal neurons are active during action observation, that is, they behave like 'mirror neurons' [1]. The study of the discharge of identified corticospinal neurons during action observation and during action execution by the monkey itself provides some clues as to what distinguishes the level of corticospinal activity normally associated with the generation of a voluntary movement. It also reveals the key role of suppression of corticospinal neuron activity during certain types of movement, observed and executed.

Funding: The Wellcome Trust, UCL Grand Challenge Scheme

References

[1] Vigneswaran G, Philipp, R, Lemon, RN and Kraskov, A (2013) M1 corticospinal mirror neurons and their role in movement suppression during action observation. Current Biology 23, 236-243.

[2] Firmin L, Field P, Maier MA, Kraskov A, Kirkwood PA, Nakajima K, Lemon R. N. and Glickstein M. Axon diameters and conduction velocities in the macaque pyramidal tract. J Neurophysiol (in press).

Short Biography

After a PhD in England, I have worked in primate labs in Melbourne, Rotterdam, Cambridge and finally London. My main research interest is the control of skilled hand movements by the brain and is prompted by the need to understand why hand and finger movements are particularly affected by damage to the cortex and its major descending pathways, for instance as a result of stroke or in spinal injury. I have worked with amazing people and trained amazing students. Although I am now partly retired, I am still very much involved and am now in my 40th year of running a monkey lab! I am actively engaged in the public dialogue on the responsible use of animals in biomedical research.

Mapping horizontal cortical connections in primate motor cortex using intracortical micro-stimulation

T. Brochier[1]*, Y. Hao[1], A. Riehle[1,2,3]

[1] INT, UMR7289 Aix-Marseille Université, CNRS, Marseille, France
[2] RIKEN Brain Science Institute, Wako-Shi, Japan
[3] Inst of Neuroscience & Medicine (INM-6), Research Center Jülich, Jülich, Germany

Abstract

Distant cortical points of the motor cortex are interconnected through long range axon collaterals of pyramidal cells [1]. However, the functional properties of these intrinsic synaptic connections and their spatial organization are still debated. We mapped the horizontal connections between distant cortical sites by combining single unit recording and single pulse intracortical microstimulation (spICMS) using Utah arrays chronically implanted in the motor cortex of two rhesus monkeys. At each electrode one by one, spICMS was applied for 5 minutes at low frequency (10 Hz) and fixed intensity (40 µA). During stimulation, the evoked effects were recorded on all the other electrodes of the array. We measured the response of isolated single units by computing peri-stimulus time histogram (PSTH) triggered on spICMS. We analyzed how the excitatory or inhibitory nature of the response, its latency and its strength modulated in relation to the distance and location of the stimulating electrode. Significant responses to spICMS could be evoked from long distances up to 5 mm, but the most powerful effects were evoked by stimulation applied within 1 to 2 mm around the recording electrode. The strength of the response decreased and the latency increased with the distance between the stimulating and recording electrodes. Notably, the excitatory effects were broadly distributed in space whereas the inhibitory effects were restricted to a smaller area (around 2,5mm) around the recording electrode. These results suggest that depending on their excitatory or inhibitory properties, the horizontal connections have different range of influence. We also discuss how this organization may relate to the spatial organization of the motor cortex revealed by motor responses evoked by train of ICMS to or by sensory receptive field testing. These observations provide a unique insight into the topological organization of intrinsic cortical connections in the motor cortex.

This work was partly supported by Helmholtz Alliance on Systems Biology, European Union (FP7-ICT-2009-6, BrainScales), Collaborative Research Agreement Riken-CNRS, ANR GRASP, CNRS (PEPS, Neuro_IC2010) and INM6, Jülich Forschungszentrum (Pr Sonja Grün).

References

[1] Capaday C, Ethier C, Van Vreeswijk C, Darling WG. On the functional organization and operational principles of the motor cortex. Front Neural Circuits. 2013 Apr 18;7:66.

Short Biography

Thomas Brochier has been studying motor control in human and animal models over the past 15 years. Following two post-docs in Allan Smith (Université de Montréal) and Roger Lemon (UCL) labs, he moved to Marseille to study the cortical control of hand movements in non-human primates. He has some a strong expertise in using multielectrode recordings and invasive electrical stimulation techniques to probe the motor system at the local and network levels.

Cortical circuits for purposeful hand actions

G. Luppino[1]*

[1] Dipartimento di Neuroscienze, Sezione di Fisiologia, Università di Parma; Via Volturno 39, I-43100 Parma, Italy

Abstract

Highly evolved neural mechanisms allow primates to use their hands as very powerful tools for interacting with the environment. Previous research has highlighted the primary role of specific parieto-premotor cortical circuits in sensorimotor transformations for grasping, usually meant as an unconscious process in which sensory coding of objects features automatically triggers hand motor programs. However, until recently, the neural substrate for perceptual and cognitive control of hand actions has been poorly understood.

In this lecture, I will review research in which, by combining anatomical with functional data, we have aimed to define the cortical circuits of the macaque brain involved in selecting, generating and controlling hand actions.

Specifically, I will first briefly summarize the available evidence for a crucial role of parieto-frontal circuits linking inferior and opercular parietal areas with rostral ventral premotor (PMv) subdivisions in sensorimotor transformations for grasping and for a role of the PMv area F5p in putting into action grasping motor programs through projections to M1 and subcortical motor centers. Then, I will focus on more recent connectional evidence showing that inferior/opercular parietal-PMv circuits involved in sensorimotor transformations for grasping are at the core of a cortical network including specific temporal and ventrolateral prefrontal sectors involved in object recognition and executive functions, respectively.

Based on these data and on the available functional evidence, I will suggest that this network, designated as “lateral grasping network”, is a possible substrate for integration of cognitive with hand-related sensorimotor processes. This integration could underlie the control of hand actions based on behavioral goals and memory-based or contextual information, and the role of sensorimotor signals in cognitive motor functions.

These data can be useful for building up more comprehensive, anatomically plausible, models of control of voluntary motor behavior for guiding anatomical and functional investigations in humans and for supporting theoretically sound, culturally sensitive, research–based clinical practices.

References

[1] Gerbella M, Borra E, Tonelli S, Rozzi S, Luppino G. (2013) Connectional heterogeneity of the ventral part of the macaque area 46. Cereb Cortex, 23:967-987.

[2] Borra E, Gerbella M, Rozzi S, Luppino G. (2011) Anatomical evidence for the involvement of the macaque ventrolateral prefrontal area 12r in controlling goal-directed actions. J Neurosci. 31:12351-12363.

Short Biography

Professor of Physiology at the School of Medicine of the University of Parma and Director of the Department of Neuroscience. Medical Degree (cum laude) in 1982 and Degree in Neurology in 1986, both at the University of Parma. PhD in Neurological Sciences in 1988. Visiting scientist at the Dept. of Psychology, Duke University, Durham, NC, USA (1985). Visiting scientist at Dept of Physiology, Nihon University (1992). More than 60 papers published in international peer-reviewed journals (Sum of the Times Cited: 7754; h-index: 41; Web of Science). Member of the Editorial Board of Brain Structure and Functions and of Frontiers in Neuroanatomy.

Main scientific interests in the field of anatomical and functional organization of the primates cortical motor system.

Spatiotemporal distribution of object versus location in kinematics, EMG and motor cortex activity during reach, grasp and manipulation

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Abstract

As we reach to, grasp, and then manipulate an object, our hand must be transported to the correction location, and shaped to grasp the object. Whereas reaching to a given location and shaping the hand to grasp commonly are thought to proceed simultaneously but independently, a number of studies have indicated that these two processes may not be simply parallel and independent. Here we tested the hypothesis that reaching and grasping are *inter-dependent*. We examined the effects of different locations and objects on joint angles, EMG activity, and neuron spikes in the primary motor cortex (M1) as subjects reached, grasped and manipulated.

Individual joint angles, muscles, and spike recordings, whether proximal or distal, often showed significant variation depending on both location and object. Nevertheless, kinematics, EMG, and spikes each varied in two phases. The first phase peaked shortly after movement onset and showed variation that depended somewhat more on location than on object. The second phase peaked just before object contact and depended largely on the object about to be grasped. Each phase involved both proximal and distal joints and muscles, as well as neurons widely distributed in the M1 upper extremity representation. Interestingly, the activity of many EMG recordings and M1 spikes, though peaking during each phase, increased from before movement onset until just prior to object contact. Hence the amplitude of later, object-related activity often was larger than that of the earlier, location-related activity.

Our findings suggest that the seamless execution of reach to and grasp of different objects in different locations actually utilizes two sequential phases of activity, the first more location-related and the second more object-related. Both phases require simultaneous variation in proximal and in distal muscles and joints. Control therefore requires sequential processing by the same neurons, distributed widely in the M1 upper extremity representation.

Short Biography

Adam Rouse received his B.S. and Ph.D. degree in biomedical engineering as well as his M.D. from Washington University in St. Louis. His doctoral work with Daniel Moran examined electrocorticographic brain-computer interface design. He is currently a post-doctoral fellow with Marc Schieber at the University of Rochester. His research interests include cortical control of integrated arm, hand, and finger movements, as well as brain-machine interface development.. Marc H. Schieber also received his A.B., Ph.D and M.D. from Washington University in St. Louis. He currently is a Professor of Neurology, Neurobiology, and Biomedical Engineering at the Unversity of Rochester.

Grasp force coding in F5 and AIP in a delayed grasping task

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Abstract

Studies focusing on the neural representation of hand forces have traditionally targeted the primary motor cortex (M1) due to its direct connections to the corticospinal tract. Few studies have also looked at premotor areas, where a stronger representation of movement planning is found. In this study we focused on the macaque ventral premotor cortex, also known as area F5, because of its strong relation to grasping movements, and at the anterior intraparietal area (AIP) that is directly connected to F5. AIP is highly active during the planning and execution of grasping movements, but its role in the control of grasp force is virtually unknown.

We trained a macaque monkey on a delayed grasping task, in which a manipulandum (handle) was grasped with the right hand with two grip types, a power and a precision grip. Every grip had to be held for 1 second at one out of three force levels. Both the particular grip type and the required amount of force were cued to the monkey in the beginning of each trial. We then recorded neural activity from F5 and AIP in the left hemisphere, contralateral to the moving arm, with chronically implanted floating microelectrode arrays (FMAs). Two 32-channel FMAs were implanted in each area (total of 128 electrodes).

We found that single unit activity in F5 and AIP was strongly modulated by both grip type and grasping force. Response to grip type was similar in both areas. However, grasping force was more strongly coded in F5 than in AIP during most epochs of the task. Only during the holding phase, when the monkey was actively maintaining the force level, AIP neurons were also strongly force-modulated.

These preliminary results demonstrate a clear, but potentially different involvement of AIP and F5 in the planning and execution of grasp forces.

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[2] Hepp-Reymond, M., Kirkpatrick-Tanner, M., Gabernet, L., Qi, H.X., and Weber, B. (1999). Context-dependent force coding in motor and premotor cortical areas. Exp Brain Res *128*, 123–133.

Short Biography

I obtained my Master degree at Utrecht University, where I studied the single unit activity in the macaque prefrontal cortex during a working memory task in the Van Wezel lab. As part of my Master's program I went to the Hatsopoulos lab at the University of Chicago, where I studied the role of feedback on the real-time control of a brain-machine interface. After my Master I started at the German Primate Center in Göttingen, where I am currently working on a PhD project that investigates grasping representations in the macaque frontal and parietal cortex.

Sensorimotor mechanisms for control and learning of dexterous manipulation

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Abstract

Anticipatory control of movement has been characterized in motor tasks as a way through which the central nervous system can bypass delays associated with reflex-based control. We have been studying how humans learn anticipatory control of manipulation tasks to characterize the mechanisms underlying the transformation from multiple sources of sensory feedback to the coordination of multiple degrees of freedom of the hand. In our approach, we have removed constraints on digit placement to study how subjects explore and choose relations between digit forces and positions. The main difference between grasp control at constrained vs. unconstrained contacts is that anticipatory control of grasping in the former scenario can rely on sensorimotor memory of digit forces built through previous manipulations. In contrast, trial-to-trial variability of digit placement associated with grasping at unconstrained contacts limits the extent to which force planning can rely on sensorimotor memories of digit forces and would require integration of digit position feedback.

I will review recent work from my laboratory on the problem of digit position/force coordination during learning of dexterous manipulation and using tasks that allow, or interfere with, the retrieval of learned manipulations. A key concept is that subjects build high-level task representations that allow control of manipulation in an effector-independent fashion. The extent to which these representations can be successfully used depends on several factors, including the frame of reference in which manipulations are learned, time-dependent motor bias from based on most recent hand-object interactions, and potential conflicts that may arise between visual cues versus implicit knowledge of object dynamics. Sensorimotor memories can facilitate or interfere with the coordination of multiple degrees of freedom of the hand for dexterous manipulation. This framework is helping to identify the neural mechanisms underlying learning and generalization of complex movements characterized by high-dimensionality in the sensory and motor domains.

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Short Biography

Marco Santello received a Bachelor in Kinesiology from the University of L'Aquila, Italy, in 1990 and a Doctoral degree in Sport and Exercise Science from the University of Birmingham (U.K.) in 1995. After a post-doctoral fellowship at the Department of Physiology (now Neuroscience) at the University of Minnesota, he joined the Department of Kinesiology at Arizona State University (ASU) (1999-2010). He is currently Professor of Biomedical Engineering, Director, and Harrington Endowed Chair at the School of Biological and Health Systems Engineering. His main research interests are motor control, learning, and biomechanics of object grasping and manipulation, haptics, and multisensory integration.

Effect of visuo-haptic conflicts on grasping movements in virtual reality

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[2] Faculty of Engineering, Kagoshima University, Kagoshima, Japan

Abstract

Grasping and manipulating objects require the brain to extract useful information from multiple sensory sources, in particular vision and haptics. When lifting objects, fingertip forces rely on the integration of a sensorimotor memory acquired from previous visuo-haptic experience and online visual cues [1]. However, how the cortical grasping circuit [2] combines vision to haptics with a dynamic gain during planning and execution of grip-lift movements is still unknown. Here we used conflicts between vision and haptics to test their relative gain in biasing force planning for the next lift. Subjects (n=12) interacted with a virtual reality environment to grasp haptic objects simulated by two Phantom robots while they received online visual feedback via a 3D screen. Object size (2 or 7 cm height) and weight (1 or 3.5 N) were varied pseudoramdomly. In 20% of trials, size and weight were incongruent (i.e. small-heavy or large-light objects). We quantified grip force rate peak (GFr) as a behavioural read-out of force planning. We also used transcranial magnetic stimulation (TMS) to test the gain of the effect of vision and haptics on corticospinal excitability.

As expected, we first found that GFr was significantly higher (23% increase) for large objects compared to small ones, irrespective of the size or weight of previous objects. Interestingly, a visuo-haptic conflict in the previous trial biased the sensorimotor memory effect. GFr was significantly lower (11% decrease) when the previous object was large-light compared to small-light. Conversely, there was a significant increase in GFr (16%) when the previous object was small-heavy compared to large-heavy. Corticospinal excitability changes paralleled behavioural effects on force planning.

These results show that the cortical grasping circuit can rapidly adapt to a new mapping between size and weight by tuning its corticospinal output and biasing the relative effect of vision and haptics on sensorimotor memory.

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[2] Davare, M., Kraskov, A., Rothwell, J.C. & Lemon, R.N. Interactions between areas of the cortical grasping network. Curr Opin Neurobiol 21, 565-570 (2011).

Short Biography

In 2008, Marco Davare obtained a PhD in Neuroscience from Université catholique de Louvain (Belgium). He then joined the Institute of Neurology at University College London (United Kingdom) as a post-doctoral fellow in Prof. Roger Lemon’s laboratory. The exposure to single unit studies of premotor-motor interactions in non-human primates led him to pioneer transcranial magnetic stimulation techniques for investigating cortico-cortical connectivity in humans. He received the Magstim Young Investigator Award. In 2012, Marco Davare became a principal investigator at the Institute of Neurology, focusing his research on how the brain integrates multiple sensory inputs to control skilled hand movements.

The cortical representation of hand movements

J. Diedrichsen[1]*, N. Ejaz[1]

[1] Institute of Cognitive Neuroscience, University College London

Abstract

The production of finger movements is directly controlled by the population activity of neurons in the hand knob area of the primary motor cortex (M1). Experiments involving micro-stimulation and single-neuron electrophysiology strongly suggest that it is not single finger movements, but rather co-articulated gestures of the hand, that are represented cortically. However, we still do not understand the underlying principles that shape these representations. Using functional magnetic resonance imaging (fMRI), we analyzed the neural activation patterns associated with the production of movements involving single and multiple fingers. While the exact spatial shape of these activity patterns differed widely across individuals, the relative similarity of the patterns – i.e. their representational structure - was highly invariant across individuals. This similarity relationship between fingers does not result from the co-activation of muscles required to produce movement, but instead, is best explained by the way we use our hands in everyday life. I will also present new data on how the structure of these representations changes through short-term training and how it is altered in clinical conditions, such as stroke and focal dystonia.

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[1] Diedrichsen J, Wiestler T, Krakauer JW (2013) Two distinct ipsilateral cortical representations for individuated finger movements. Cereb Cortex 23:1362-1377.

Short Biography

Dr. Jörn Diedrichsen received a PhD in cognitive neuroscience from the University of California, Berkeley and worked as a postdoctoral fellow with Prof. Reza Shadmehr at Johns Hopkins University, Baltimore. In 2009, he started as group leader at the Institute of Cognitive Neuroscience of the University College London, UK. His research group uses a combination of robotics, functional brain imaging, brain stimulation techniques and computational methods to uncover the representation of motor skills in the human brain in health and disease. He received an APA early career award and a James S. McDonnell scholar award for his work.

Effect of primary motor cortex lesion on cortical processing of tactile finger stimulation in adult monkeys: an EEG study

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[2] Institute of Neuroinformatics, University of Zürich and ETH Zurich, Zürich, Switzerland
[3] Neuroscience Center Zurich, University of Zürich and ETH Zurich, Zürich, Switzerland

Abstract

Tactile information from the fingertips is crucial for motor control underlying manual dexterity [1]. How these inputs are integrated in sensorimotor processing is not entirely clear. Using the high temporal resolution and non-invasiveness of high-density scalp EEG (32 channels) [2], the goal was to study how tactile information processing from the fingertips is affected by unilateral lesion of the hand area in the primary motor cortex (M1) in non-human primates. The neuronal activity elicited by tactile stimulation of the fingertips was assessed in one macaque monkey before and then at several time points (5-week interval) after lesion. Tactile stimulations (2-ms duration) were applied with solenoid tappers over the thumb, index finger and middle finger tips. Pre-lesion, the electrodes over the contralateral somatosensory cortex exhibited a prominent positive peak at 30 ms post-stimulus. The theoretical sum of the individual peaks associated with separate stimulation of the thumb and index finger was substantially larger than the peak obtained after simultaneous stimulation of both fingers, in line with the notion of inhibitory sensory interaction between neighboring fingers. The M1 lesion substantially altered the cortical responses to tactile stimulation. For instance, in response to thumb stimulation, positive peaks were recorded from the frontal electrodes pre- lesion, which turned into prominent negative peaks post-lesion. Several posterior electrodes were considerably more responsive post-lesion than pre-lesion. Nevertheless, in spite of these changes in signal polarities and amplitudes, the inhibitory interactions were preserved post-lesion. In conclusion, normal tactile sensory processing is modulated by motor cortical outputs. These alterations in sensory processing may contribute to the motor deficits observed after M1 lesion and appear to evolve in parallel with the functional recovery for a manual dexterity task executed in absence of visual control, relying mostly on tactile feedback.

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Short Biography

I studied Biology at the University of Fribourg (MSc in 2010), with a particular interest in Neuroscience. I have been a student in the lab of Prof. Eric Rouiller since 2008. I am now a PhD student and I am working on the reorganisation of the sensorimotor system following a motor cortex lesion in macaque monkeys. We developed on the one hand whole-scalp EEG mapping of somatosensory evoked potentials. On the other hand, we designed a behavioural task to specifically challenge the somatosensory component of the sensorimotor system.

Neural Coupling of Cooperative Hand Movements

M. Schrafl-Altermatt[1]*, V. Dietz[1]

[1] Spinal Cord Injury Center, Balgrist University Hospital, Zürich, Switzerland

Abstract

The neural control of “cooperative” hand movements reflecting “opening a bottle” was explored in human subjects by electromyographic (EMG) and functional magnetic resonance imaging (fMRI) recordings. EMG responses to unilateral nonnoxious ulnar nerve stimulation were analyzed in the forearm muscles of both sides during dynamic movements against a torque applied by the right hand to a device which was compensated for by the left hand. For control, stimuli were applied while task was performed in a static/isometric mode and during bilateral synchronous pro-/supination movements. During the dynamic cooperative task, EMG responses to stimulations appeared in the right extensor and left flexor muscles, regardless of which side was stimulated. Under the control conditions, responses appeared only on the stimulated side. fMRI recordings showed a bilateral extra-activation and functional coupling of the secondary somatosensory cortex (S2) during the dynamic co-operative, but not during the control, tasks. This activation might reflect processing of shared cutaneous input during the cooperative task. Correspondingly, it is assumed that stimulation-induced unilateral volleys are processed in S2, leading to a release of EMG responses to both fore- arms. This indicates a task-specific neural coupling during cooperative hand movements. This neural coupling has further been investigated in post-stroke subjects. While stimulation of the unaffected arm led to the same responses observed in healthy volunteers, stimulation of the affected arm did not elicit any responses. These findings indicate a defective neural coupling after stroke which has implications on stroke rehabilitation.

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[2] Schrafl-Alterrmatt M, Dietz V (2014) Cooperative hand movements in stroke patients: Impaired neural coupling. Neurology, Under Review

Short Biography

Miriam Schrafl-Altermatt (born December 23rd 1986, married in May 2012, mother to a son born November 28th 2013) did her Bachelor’s (2006-2009) and Master’s (2009-2011) in Human Movement Sciences and Sport at ETH Zurich, Switzerland. Her research interest during her master’s was the effect of transcutaneous spinal direct current stimulation on spinal circuitries in paraplegic patients. For her ongoing PhD (started August 2012) she investigates recovery of upper limb motor function after stroke. In particular, she focusses on the differences between coupled and uncoupled bimanual movements and establishes a rehabilitative training with a new device which enables these particular movements.

COGNITIVE & CLINICAL NEUROSCIENCE

Tuesday, September 9, 2014

09h00 – 09h40	**Susan Goldin-Meadow** (U Chicago) *From action to abstraction: Gesture as a mechanism of change*	KEYNOTE
09h40 – 10h20	**Georg Goldenberg** (Bogenhausen Hospital Munich, TU Munich) *Apraxia tears apart the neural substrates of instrumental and communicative functions of the hand*	KEYNOTE
10h20 – 10h50	Coffee	
10h50 – 11h20	**Nicole Wenderoth** (ETH Zurich, KU Leuven) *Making and breaking motor memories*	KEYNOTE
11h20 – 11h40	Noëmi Eggenberger (University Hospital Bern) *Visual exploration of co-speech hand gestures in aphasic patients: An eye-tracking study*	B04T
11h40 – 12h00	Silvio Ionta (ETH Zurich, CHUV) *Neuroplastic sensorimotor adaptations after spinal cord injury*	B01T
12h00 – 12h20	Zdravko Radman (Zagreb, U Split) *The "enhanded" mind: An attempt for a reconception of agency*	B06T
12h30 – 14h30	Lunch	
14h30 – 15h10	**Angela Sirigu** (CNRS Lyon) *Varieties of movement representations in the human brain*	KEYNOTE
15h10 – 15h50	**Andrea Serino** (EPFL, U Bologna) *Neural mechanisms, functions and plasticity of peripersonal space representation in humans*	KEYNOTE
15h50 – 16h20	Coffe	
16h20 – 17h00	**Tamar Makin** (U Oxford) *Bridging the gap between cortical reorganisation and rehabilitation in arm amputees*	KEYNOTE
17h00 – 17h20	Elena Rusconi (U Parma) *Neural correlates of finger gnosis*	B12T
17h20 – 17h40	Stefan Vogt (U Lancaster, U Liverpool) *Imitation learning of spatial sequences and rhythms: A FMRI study in musically naïves and drummers*	B03T
17h40 – 18h00	Jennifer Gurd (U Oxford) *Hand, brain, attention*	B07T
18h00 – 18h20	General discussion	
18h30 – 20h30	Dinner	
20h30 – 21h30	**Frank Wilson** (Stanford U, Professor Emeritus) *"The Hand: How its use shapes the brain, language, and human culture"*	KEYNOTE

From action to abstraction: Gesture as a mechanism of change

S. Goldin-Meadow[1]*

[1] Department of Psychology, University of Chicago

Abstract

The spontaneous gestures that people produce when they talk have been shown to reflect a speaker's thoughts—they can index moments of cognitive instability and reflect thoughts not yet found in speech. Gesture can go beyond reflecting though to play a role in changing that thought—the gestures we see other produce can change our thoughts, and the gestures we ourselves produce can change our thoughts. In this talk, I consider whether gesture effects these changes because it itself is an action and can thus bring action into our mental representations. But gesture is a special kind of action—it spatializes ideas, even ideas that are inherently non-spatial, and it is representational and thus more abstract than direct action on objects. Gesture's representational properties may thus allow it to play a role in learning by facilitating the transition from action to abstraction.

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Short Biography

Susan Goldin-Meadow is the Beardsley Ruml Distinguished Service Professor in the Departments of Psychology and Comparative Human Development, and the Committee on Education at the University of Chicago. Her research focuses on the home-made gestures profoundly deaf children create when not exposed to sign language, and the gestures hearing speakers around the globe spontaneously produce when they talk, with an eye toward what gesture can tell us about how we talk and think.

Apraxia tears apart the neural substrates of instrumental and communicative functions of the hand

G. Goldenberg[1]*

[1] Department of Neuropsychology Bogenhausen Hospital Munich;
Department of Neurology, Technical University Munich

Abstract

Apraxia is a disorder on the border between cognition and motor control. It is predominantly caused by left brain damage and frequently associated with aphasia. Apraxia manifests itself in 3 domains of manual actions: Imitation of gestures, performance of communicative gestures, and use of tools and objects. A traditional model of apraxia ascribes disturbances of these domains to interruptions of consecutive stages in a unique stream of action control. This postulate is refuted by double dissociations between manifestations that should have their origin at the same step of the stream.

My contribution will concentrate on pantomime of tool use. Pantomime of tool use is a communicative gesture. It does not alter the state of external objects but can communicate the identity of the tool and the manner of its use to another person. Intuitively pantomime may appear as an empty handed replication of the motor program of real use, but close observation and kinematic measurement of real use and pantomime reveal important differences. Moreover, many patients with disturbed pantomime can use the same tools flawlessly while, on the other hand, most people can pantomime the use of tools which they are unable to handle in reality, like playing a violin. There is a closer association of pantomime with other communicative gestures and with language. In right handed patients disturbance of pantomime is regularly associated with aphasia. However, the association is not mandatory as there are single cases of left handed patients who have disturbed pantomime but preserved language.

Lesion analysis by means of voxel based lesion symptom mapping reveals the neural basis of the association between pantomime and language. In the temporal lobe there is overlap between the location of pantomime disturbance and of language comprehension. Presumably the common function underlying this overlap is the need to retrieve knowledge from semantic memory. By contrast, parietal lesions associated with defective use of real tools are not major sources of pantomime deficits.

Short Biography

Georg Goldenberg was trained as a clinical neurologist in Vienna. He was habilitated in 1986 with a thesis on the neurological basis of visual imagery. Since 1995 he is head of the Department for Neuropsychological Rehabilitation at the Bogenhausen Hospital in Munich and affiliate professor of the Technical University Munich. He published papers on different aspects of apraxia in Brain, Journal of Neuroscience, Cerebral Cortex, Neuropsychologia, Cortex, and other core journal and recently published a monograph "Apraxia – the Cognitive Side of Motor Control" at Oxford University Press.

Making and breaking motor memories

N. Wenderoth[1,2]*

[1] Neural Control of Movement Laboratory, Dept. Health Sciences and Technology, ETH Zürich, Switzerland
[2] Centre for Movement Control and Neuroplasticity, KU Leuven, Belgium

Abstract

Skillful movements are acquired due to repeated practice and cause the formation of motor memories. Most of these memories are powerful and long-lasting, for example, once learned how to ride a bicycle this skill is never forgotten. During the last years, much research has been devoted to modulating neuroplasticity within the healthy or damaged motor system.

In the first part of my talk I will show that transcranial direct current stimulation (tDCS) is an effective tool to facilitate plasticity within the motor system of severely to moderately impaired chronic stroke patients. In this double-blind, randomized, clinical trial, patients were assigned to a real tDCS (2mA, bihemispheric montage) or a sham tDCS group and were stimulated while the paretic wrist extensor was trained using a Muscle Computer Interface (MCI). Despite a short training period of 3 days, patients that received real tDCS but not those that received sham tDCS exhibited significant functional improvements (Fugl-Meyer Score for the upper extremities, anodal tDCS: 5.88 ± 0.7; sham: 1.5± 0.6).)

In the second part of the talk I will show how stable motor memories can be experimentally manipulated such that they become once again labile and can be partly erased. Using mechanisms related to memory reconsolidation, motor performance can be partly degraded if a skill is briefly reactivated and subsequently exposed to an interfering intervention. However, whether or not an existing motor memory can be erased depends strongly on the reactivation-interference schedule, such that, for example, reactivation length represents a crucial boundary condition.

In summary, there are experimental tools available that enable researchers and therapists to either make or break motor memories. These insights open new perspectives for modulating neuroplasticity in a clinical setting.

Short Biography

Nicole Wenderoth is Professor for Neural Control of Movement in the Department of Health Sciences and Technology at ETH Zurich, Switzerland. Her lab addresses fundamental questions on how the brain controls movement, how new memories are formed and maintained, whether the motor system can be driven by sensory input, and how motor control interacts with cognitive functions and emotions. Here goal is not only to better understand the human brain but also to modulate brain function using non-invasive brain stimulation as well as new training paradigms that can be applied in healthy individuals as well as in patients recovering from neural damage.

Visual exploration of co-speech hand gestures in aphasic patients: An eye-tracking study

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[2] Division of Cognitive and Restorative Neurology, Department of Neurology, Inselspital, University Hospital Bern, Switzerland

Abstract

Gesturing, including co-speech gestures, is a crucial part of human communication. Aphasia as a consequence of left hemispheric brain damage may result in impaired speech perception and production, frequently accompanied by limb apraxia. Healthy subjects spend about 88-95% of the time fixating a speaker's face, while only a minority of fixations is directed at gestures [1]. It is unclear whether aphasic patients display a similar pattern.

29 aphasic patients and 31 controls participated. Short video sequences varying in the level of congruity between speech and gestures (congruent, incongruent and meaningless speech-gestures combinations) were presented and subjects had to judge this congruity by keypress. A remote eye-tracking device allowed gaze tracking and off-line analysis of parameters on predefined areas of interest (AOIs), such as the hands and the face of the speaker.

Repeated measures ANOVAs yielded a significant interaction between the factors AOI x Group, indicating that aphasic patients spent more time fixating the hands compared to healthy controls, while controls fixated more on the speaker's face compared to patients.

Aphasic patients showed a different visual exploration pattern insofar as they looked less on the speaker's face but more on the gesturing hands compared to controls. Aphasic patients might thus rely more on the additional (nonverbal) information presented by gestures in order to understand verbal utterances and to judge increasingly complex sequences. Presuming a generally reduced information processing capacity in patients with brain lesions, it could also be assumed that the visual attention of aphasic patients shifts unconsciously to gestural movements which attract attention.

References

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Short Biography

Noëmi Eggenberger obtained her Master's degree in Neuropsychology at the University of Bern in 2010. She started her PhD project in Neurosciences in 2012 and is focusing on clinical research with aphasic and apractic patients. Her research interests are the reciprocal relationship between language and gestures and possible implications for neurorehabilitation.

Neuroplastic sensorimotor adaptations after spinal cord injury

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R. Gassert[1]

[1] Rehabilitation Engineering Laboratory, Swiss Federal Institute of Technology (ETHZ), Zurich, Switzerland
[2] Laboratory for Investigative Neurophysiology, Centre Hospitalier Universitaire Vaudois (CHUV), University of Lausanne, Lausanne, Switzerland
[3] Spinal Cord Injury Center, Balgrist University Hospital, University of Zurich, Zurich, Switzerland

Abstract

According to the "Simulation Theory", peripheral proprioceptive information influences centrally-processed mental transformations of bodily images. In particular, hand postural changes specifically affect mental rotation, both at the behavioral [2] and the neural level [1]. Spinal cord injury (SCI) determines a communication breakdown between the central and the peripheral nervous system. However, the influence of modified bottom-up input on body-related central processing is still largely under debate. We hypothesized that during mental rotation of visual bodily stimuli, the reduction of sensory input in SCI patients would determine a weaker reliance on proprioceptive information as a function of the type of lesion, and therefore on the amount of residual sensory input itself.

To test this hypothesis we elicited mental transformations of bodily images in complete and incomplete SCI patients and healthy controls by asking them to verbally judge the laterality of visually-presented hands, feet, and full bodies while keeping their corresponding body parts (hands, feet) either straight or crossed. During mental transformation of feet, with respect to controls, complete paraplegic SCI patients failed to show the typical stimulus-specific increased response times in the crossed condition. Conversely, the effect of proprioceptive changes was preserved in the mental processing of hand images. Incomplete SCI patients' performance reflected the typical profile of response times, but with increased latencies. The control condition (full body) confirmed the absence of proprioceptive effects in both patients and controls. The present data highlight the relative weight of proprioceptive information on mental processing of visual stimuli, show the effects of compensatory mechanisms in the continuous updating of the body representation, and drive attention to the potential application of the present experimental protocol in clinical assessment of central nervous system plasticity.

References

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Short Biography

Silvio Ionta received the MSc in Experimental Psychology at the University of Rome "La Sapienza", Italy. He accomplished the PhD in Functional Neuroimaging at the Institute of Advanced Bio-Medical Technologies, University of Pescara-Chieti "G. D'Annunzio", Italy. Between 2008 and 2012, he worked as post-doctoral researcher at the Laboratory of Cognitive Neuroscience, EPFL, Switzerland. In 2012, he worked as research assistant at the Rehabilitation Engineering Lab, ETH Zurich, Switzerland. In 2014 he took up his lecturer position at the Centre Hospitalier Universitaire Vaudois and the University of Lausanne, Switzerland.

The “enhanded” mind: An attempt for a reconception of agency

Z. Radman[1,2]*

[1] Institute of Philosophy, Zagreb
[2] University of Split

Abstract

Our culture is dominantly thought- and conscious-centered and such is also our understanding of agency. According to it, to perform an action means to realize some (propositional) preconceived plan. My focusing on the hand in this paper has double motivation: to show that manual perception does not conform to the ‘intellectualist’ cannon and also to draw a possible conclusion about the nature of agency that proves to be hand-centered in a largely autonomous way.

Once we realize that the mind is in an important way ‘enhanded’ we are in a position not only to grant embodiment a more specific domain of application but also to give it additional signification.

After contemporary cognitive science has discovered embodiment it is easy to conceive that technology, and specifically robotics, will not be able to avoid it either. Any such attempt will have to face the following: on the one hand, the mind is not merely a computation processing but is in an important sense embodied, and, on the other hand, one has to realize that the body is ‘enminded’, in the sense that it possesses own know how that provides the cognitive organism a capacity to do more than the thinking ‘self’ can possibly realize. It becomes particularly evident when we focus on manipulation. We then realize that in much of our motor behavior the manual has the lead and that it is done in an effortless and automatic way, without engaging in conscious deliberation or contemplation. Thus what an agent can, or cannot, do is ultimately decided according to the “knowledge in the hands” (M.Merleau-Ponty); it alone is the final arbiter on doability.

Short Biography

Zdravko Radman is a Research Fellow at the Institute of Philosophy, Zagreb, and a Professor of Philosophy at the University of Split, Croatia. As an Alexander von Humboldt and a William J. Fulbright Fellow he was affiliated with the University of Konstanz and the University of California, Berkeley; as a visiting scholar he conducted research at the Australian National University, the University of Tokyo, and University College London, among others. He has published in the philosophy of mind, aesthetics, and the philosophy of language. He is the author of Metaphors: Figures of the Mind (Kluwer, 1997, Springer 2010), and editor of Horizons of Humanity (Peter Lang, 1997), and From a Metaphorical Point of View (Walter de Gruyter, 1995). His most recent publications include: Knowing without Thinking: Mind, Action, Cognition, and the Phenomenon of the Background (Palgrave Macmillan, 2012): http://us.macmillan.com/knowingwithoutthinking/ZdravkoRadman
and The Hand, an Organ of the Mind; What the Manual Tells the Mental (MIT Press, 2013): https://mitpress.mit.edu/books/hand-organ-mind

Varieties of movement representations in the human brain

A. Sirigu[1]*

[1] Institut des Sciences Cognitives Marc Jeannerod, CNRS, Lyon, France

Abstract

I will discuss the role of parietal and motor regions in movement representation and movement prediction. I will present findings obtained in patients with selective lesions of the parietal or premotor cortex using task requiring attention *to* onset of intention or attention *to* onset of movement. I will also show how direct cortical stimulation (during neurosurgery) of the inferior parietal regions produces the 'desire to move' and at higher intensities illusion of movement even when no motor act actually occurs as shown by EMG recording. The opposite patterns will be described during stimulation of the premotor cortex where patients produce movements but the experience of movement doesn't reach consciousness. I will argue that the inferior parietal regions play a key role for anticipating the future states of our own movements and for bringing them into awareness.

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[2] Desmurget M, Sirigu A. (2012) Conscious motor intention emerges in the inferior parietal lobule. Curr Opin Neurobiol. 6:1004-11.

Short Biography

My training and core research domain is in Neuropsychology and Cognitive Neuroscience. With my collaborators we use an array of behavioural and neuroimagery (fMRI, EEG, TMS, cortical stimulation) techniques, to understand the functions of different brain regions. I have a longstanding interest in the role of parietal cortex in motor functions and motor plasticity. My research also focuses on decision making processes and on the effect of hormones such as oxytocin in the regulation of social interaction in healthy subjects and in patients with autism.

Neural mechanisms, functions and plasticity of peripersonal space representation in humans

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[2] Dipartimento di Psicologia, Università di Bologna

Abstract

The space immediately surrounding the body, i.e., peripersonal space (PPS), is represented by a dedicated neural system of fronto-parietal areas, which integrate tactile, auditory and visual stimuli presented on or close to the body.

In this talk, I will present neuroimaging evidence showing how, in humans, premotor and posterior-parietal areas integrating multisensory stimuli within PPS directly project to the motor system to trigger appropriate responses. I will also show that PPS representation is plastic, as its boundaries adapt as a function of experience (such as after tool-use) or changes in structure and function of the psychical body, such as amputation, prosthesis implantation and immobilization. Finally, I will demonstrate that PPS boundaries are sensitive to the presence of and interaction with other people. I will conclude that PPS represents a multi-sensory-motor interface between the individual and the environment.

References

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Short Biography

Andrea Serino is Senior Scientist at the Center for Neuroprothetics at the EPFL since 2012 and Assitant Professor at the Department of Psychology, University of Bologna, since 2006.

His main research question is how the brain generates the experience of "being here and now" by integrating multisensory information related to the body and to the space immediately surrounding the body, i.e. Peripersonal Space. To answer this question he has been used different techniques, namely Psychophysics, Neuropsychology, TMS, tDCS, fMRI and Neural network models.

Bridging the gap between cortical reorganisation and rehabilitation in arm amputees

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Abstract

Amputation provides a powerful model for studying plasticity, as it involves both sensory deprivation (associated with nerve deafferentation) and adaptive motor behavior: Following arm amputation, individuals need to develop new strategies and motor skills to compensate for their disability. The contribution of this considerable behavioural pressure, which is key for rehabilitation, has been largely neglected from research of plasticity in amputees. Instead, neuroscience research has been mostly restricted to maladaptive plasticity, with a focus on phantom pain. Here I will test the extent to which experience relating to rehabilitation alters brain structure and function in individuals with unilateral hand absence, using neuroimaging approaches. I will challenge the proposed link between cortical reorganisation and phantom pain, and instead demonstrate that phantom pain is associated with maintained representation of the missing ('phantom') hand. Using 7T technology I will provide new insight into the limitations of brain plasticity, by uncovering latent digit topography of the phantom hand, maintained decades following amputation. I will next demonstrate how preserved motor control of the phantom hand can be exploited to experimentally induce and relieve phantom pain. Finally, I will show that adaptive behaviour in amputees can drive plasticity well beyond the "critical period" time-window, though such plasticity may be restricted to the deprived cortex. I will provide new evidence for the relationship between lateralised limb-use patterns and lateralised structural and functional plasticity. Together, these results demonstrate how experience-driven plasticity in the human brain can transcend boundaries that have been thought to limit reorganisation after sensory deprivation in adults. These finding could be utilized to improve future rehabilitation in amputees.

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[2] Makin TR, Scholz J, Filippini N, Henderson Slater D, Tracey I, Johansen-Berg H. Phantom pain is associated with preserved structure and function in the former hand area. Nat Comms 2013; 4: 1570.

Short Biography

I'm a Henry Dale Fellow at Oxford University's brain imaging centre (FMRIB). My group studies multisensory plasticity in body representation, using neuroimaging, psychophysics and brain stimulation techniques. I work closely with FMRIB's Plasticity (headed by Heidi Johansen-Berg) and Pain (headed by Irene Tracey) groups.

Neural correlates of finger gnosis

E. Rusconi[1]*, L. Tamè[2], M. Furlan[3], P. Haggard[4], G. Demarchi[2], M. Adriani[2], P. Ferrari[2], C. Braun[5], J. Schwarzbach[2]

[1] University of Parma, Italy
[2] University of Trento, Italy
[3] Royal Holloway, UK
[4] University College London, UK
[5] Eberhard-Karls University of Tuebingen, Germany

Abstract

Neuropsychological studies have described patients with a selective impairment of finger identification in association with posterior parietal lesions. However, confirmation of the role of these areas in finger gnosis from studies of the healthy human brain is still scarce. Here we used functional magnetic resonance imaging (fMRI) to identify the brain network engaged in a novel finger gnosis task, the intermanual in-between task (IIBT), in healthy participants. Several brain regions exhibited a stronger blood-oxygenation level-dependent (BOLD) response in IIBT than in a control task that did not explicitly rely on finger gnosis but used identical stimuli and motor responses as the IIBT. The IIBT involved stronger signal in the left inferior parietal lobule (IPL), bilateral precuneus (PCN), bilateral premotor cortex (PMC), and left inferior frontal gyrus (IFG). In all regions, stimulation of non-homologous fingers of the two hands elicited higher BOLD-signal than stimulation of homologous fingers. Only in the left antero-medial IPL (a-mIPL) and left PCN signal strength decreased parametrically from non-homology, through partial homology to total homology with stimulation delivered synchronously to the two hands. With asynchronous stimulation, the signal was stronger in the left a-mIPL than in any other region, possibly indicating retention of task-relevant information. We suggest that the left PCN may contribute a supporting visuo-spatial representation via its functional connection to the right PCN. The a-mIPL may instead provide the core substrate of an explicit bilateral body structure representation for the fingers that when disrupted can produce the typical symptoms of finger agnosia.

References

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[2] Rusconi, E., Gonzaga, M., Adriani, M., Braun, C., Haggard, P. (2009). Know thyself: behavioral evidence for a structural representation of the human body. PLoS ONE 4, e5418.

Short Biography

Elena Rusconi holds a laurea in General and Experimental Psychology, a PhD in Cognitive Sciences (both from University of Padova) and a PhD in Security Science (from University College London). Her basic research activity focuses on the cognitive mechanisms and the neural basis of higher functions such as visuospatial attention, mathematical cognition and body structure representation, as well as on the cross-talks between these domains. She uses a range of methods such as mental chronometry, neuropsychology, functional Magnetic Resonance Imaging and Transcranial Magnetic Stimulation. She also conducts translational research in the context of x-ray guided inspections at security checkpoints.

Imitation learning of spatial sequences and rhythms: A FMRI study in musically naïves and drummers

K. Sakreida[1,2], S. Higuchi[3,4,5], C. Di Dio[6], M. Ziessler[7], M. Turgeon[3], N. Roberts[8], G. Rizzolatti[6], S. Vogt[3,4]*

[1] Section Clinical-Cognitive Sciences–Department of Neurology, Medical Faculty, RWTH Aachen University, Aachen, Germany
[2] Department of Neurosurgery, Medical Faculty, RWTH Aachen University, Aachen, Germany
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[4] Magnetic Resonance and Image Analysis Research Centre, University of Liverpool, Liverpool, United Kingdom
[5] Center for Experimental Research in Social Sciences, Hokkaidō University, Sapporo, Japan
[6] Department of Neuroscience, University of Parma, Parma, Italy
[7] Department of Psychology, Liverpool Hope University, Liverpool, United Kingdom
[8] Clinical Research Imaging Centre (CRIC) and Queen's Medical Research Institute (QMRI), University of Edinburgh, Edinburgh, Scotland, United Kingdom

Abstract

Imitation learning involves the acquisition of novel motor patterns based on action observation. Previous studies have demonstrated that the human mirror neuron system (MNS) is essential for imitative learning of configural hand actions and that the MNS in interaction with the dorsolateral prefrontal cortex (DLPFC) activate more strongly for novel as compared to practiced actions [1]. In addition, there is evidence for a more specific involvement of the DLPFC in the acquisition of spatial as compared to temporal patterns. We address these issues by comparing regions of functional activation during the imitation of spatial sequences and rhythms, using event-related functional magnetic resonance imaging.

One day before scanning with a Siemens 3T Trio, participants practiced three spatial sequences (SEQ) and three rhythms (RHY) with their left index finger. They were then tested on these practised (PR) as well as on non-practised (NP) patterns in three presentation conditions: Observation, Rehearsal, and Execution.

Our results give rise to three main conclusions. First, imitation learning of spatial pattern of sequences engaged fundamentally the same areas as imitation learning of configural hand actions [1]. Secondly, our data revealed a clear dissociation between spatial sequence and rhythm representations (reduced PPC, enhanced BA44, SMA, and STG). Most likely, the visually presented rhythms were recoded as silent vocalization. Thus, according to the type of action observed, the mirror mechanisms involved can be remarkably different. Third, whilst a restricted differential activation of right DLPFC was indeed found during observation of novel spatial sequences (confirming [1]), practice-related prefrontal activation differences were overall more pronounced during execution. Here, activation differences in DLPFC were more distinct for the spatial sequences, particularly in the skilled drummers. One possible explanation is that rhythms are encoded in a specialised subsystem which requires less supervisory control than spatially oriented actions.

References

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Short Biography

Stefan Vogt is an experimental psychologist and neuroscientist and has widely published on action observation, imitation learning and automatic imitation. He gained a diploma in Psychology at Münster University and received his PhD at Bremen University in 1988. He then worked as a Senior Researcher at the Max-Planck-Institute for Psychological Research in Munich, before joining the Psychology Department at Lancaster University in 1995. His research is focussed on relationships between perception, motor imagery, and action, and he uses a range of behavioural and neuroscience methods, kinematic data, reaction times, and functional magnetic resonance imaging (fMRI).

Hand, brain, attention

J. Gurd[1]*, P. Vila[2], F. Essig[3], R. Rosch[4]

[1] University of Oxford, Nuffield Department of Clinical Neurosciences
[2] Green Templeton College, Oxford
[3] University of Hertfordshire
[4] King's College Hospital, Institute of Psychiatry, Department of Clinical Neurosciences

Abstract

Recent evidence from our group (Banissy et al., 2012) has demonstrated a right space advantage conferred on performance of a simple motor task. The significance of these findings is now further explored with reference to handedness and cerebral asymmetry (cf. Gurd et al., 2010). Studies of finger tapping in twins who are discordant for handedness permit computations of structure-function mapping (Gurd et al., 2013, 2014).

Whilst the term 'attention' has been employed vis-à-vis hemi-spatial effects, confusion has arisen from its simultaneous usage within the verbal domain (Essig & Gurd, 2013). It is nonetheless possible to disentangle and clarify the debate: Using behavioural paradims of verbal and visuo-spaital attention in monozygotic handedness discordant twins, combined with magnetic resonance imaging of the brain (MRI, fMRI) allows the examination of within twin pair differences across tasks and their neural substrates (Lux et al., 2008; Rosch et al., 2010).

New data is presented relevant to frameworks of verbal and visuo-spatial attention and cerebral asymmetry of function. We examine novel relationships (hand, brain, attention) in a single twin pair with discordant handedness and cerebral asymmetry. Notably, performance of fine motor tasks including finger tapping (in right versus left hemi-space) and line-bisection (using right versus left hands) will be assessed in light of attentional performance in verbal task-switching.

References

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[2] Gurd, J.M. and Cowell, P.E. (2014) Discordant cerebral lateralization for verbal fluency is not an artifact of attention: Evidence from MzHd twins. Journal of Brain Structure & Function (in press).

Short Biography

Dr JM Gurd is a cognitive neuropsychologist with a background in experimental psychology and linguistics. She is currently a senior research associate in the Nuffield Department of Clinical Neurosciences at the John Radcliffe Hospital, Oxford. She works together with Fiona Essig (PhD candidate), Richard Rosch (clinical research fellow), and Pierre Vila (medical student). Their work focuses on cerebral lateralization for verbal and visuo-spatial processes in models of health and disease.

NEUROPROSTHETICS

Wednesday, September 10, 2014

09h00 – 09h40	**Andrew Schwarz** (U Pittsburgh) *Recent progress toward a high-performance neural prosthesis*	KEYNOTE
09h40 – 10h20	**Sliman Bensmaia** (U Chicago) *Biological and bionic hands: Natural neural coding and artificial perception*	KEYNOTE
10h20 – 10h50	Coffee	
10h50 – 11h20	**Lee Miller** (Northwestern U) *Restoring hand function with a biomimetic neural interface and Functional Electrical Stimulation*	KEYNOTE
11h20 – 12h00	**Hansjörg Scherberger** (German Primate Center) *Grasp predictions from motor, premotor, and parietal population signals*	KEYNOTE
12h00 – 12h40	**Todd Kuiken** (RIC, Northwestern U) *Developing neural interfaces for powered prosthetic limbs*	KEYNOTE
13h00 – 15h00	Lunch	
15h00 – 21h30	Excursion & conference dinner	

Recent progress toward a high-performance neural prosthesis

A. B. Schwarz[1]*

[1] Department of Neurobiology, Motor Lab, University of Pittsburgh, Pennsylvania, USA

Abstract

A better understanding neural population function would be an important advance in systems neuroscience. Neurons encode many parameters simultaneously, but the fidelity of encoding at the level of individual neurons is weak. However, because encoding is redundant and consistent across the population, extraction methods based on multiple neurons are capable of generating a faithful representation of intended movement. The realization that useful information is embedded in the population has spawned the current success of brain-controlled interfaces. Since multiple movement parameters are encoded simultaneously in the same population of neurons, we have been gradually increasing the degrees of freedom (DOF) that a subject can control through the interface. Our early work showed that 3-dimensions could be controlled in a virtual reality task. We then demonstrated control of an anthropomorphic physical device with 4 DOF in a self-feeding task. Currently, monkeys in our laboratory are using this interface to control a very realistic, prosthetic arm with a wrist and hand to grasp objects in different locations and orientations. Our recent data show that we can extract 10-DOF to add hand shape and dexterity to our control set. This technology has now been extended has been extended to a paralyzed patient who cannot move any part of her body below her neck. Based on our laboratory work and using a high-performance "modular prosthetic limb" she has been able to control 10 degrees-of-freedom simultaneously. The control of this artificial limb is intuitive and the movements are coordinated and graceful, closely resembling natural arm and hand movement. This subject has been able to perform tasks of daily living – reaching to, grasping and manipulating objects, as well as performing spontaneous acts such as self-feeding. Current work is progressing toward making this technology more robust and extending the control with tactile feedback to sensory cortex.

Short Biography

Dr. Schwartz received his Ph.D. in Physiology from the University of Minnesota in 1984. He then went on to a postdoctoral fellowship with Dr. Apostolos Georgopoulos, who was developing the concept of directional tuning and population-based movement representation in the motor cortex. He has been at the University of Pittsburgh since 2002. Through his research, Schwartz developed a paradigm to explore cortical signals generated during volitional arm movements. This effort showed that a high-fidelity representation of movement intention could be decoded from the motor cortex. This has enabled technology now being used by paralyzed subjects to operate a high-performance prosthetic arm and hand.

Biological and bionic hands: Natural neural coding and artificial perception

S. J. Bensmaia[1,2]*

[1] Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL
[2] Committee on Computational Neuroscience, University of Chicago, Chicago, IL

Abstract

Our ability to manipulate objects dexterously relies fundamentally on sensory signals originating from the hand. To restore motor function with upper-limb neuroprostheses requires that somatosensory feedback be provided to the tetraplegic patient or amputee. Given the complexity of state-of-the-art prosthetic limbs, and thus the huge state-space they can traverse, it is desirable to minimize the need of the patient to learn associations between events impinging upon the limb and arbitrary sensations. With this in mind, we seek to develop approaches to intuitively convey sensory information that is critical for object manipulation – information about contact location, pressure, and timing – through intracortical microstimulation (ICMS) of primary somatosensory cortex (S1). To this end, we first explore how this information is naturally encoded in the cortex of (intact) non-human primates (Rhesus macaques). In stimulation experiments, we then show that we can elicit percepts that are projected to a specific localized patch of skin by stimulating neurons with corresponding receptive fields. Similarly, information about contact pressure is conveyed by invoking the natural neural code for pressure, which entails not only increasing the activation of local neurons but also recruiting adjacent neurons to signal an increase in pressure. In a real-time application, we demonstrate that animals can perform a pressure discrimination task equally well whether mechanical stimuli are delivered to their native fingers or to a prosthetic one. Finally, we propose that the timing of contact events can be signaled through phasic ICMS at the onset and offset of object contact that mimics the ubiquitous on and off responses observed in S1 to complement slowly-varying pressure-related feedback. We anticipate that the proposed biomimetic feedback will considerably increase the dexterity and embodiment of upper-limb neuroprostheses and will constitute an important step in restoring touch to individuals who have lost it.

References

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[3] Berg, J.A., Dammann, J.F., Tenore, F.V., Tabot, G.A., Boback, J.L., Manfredi, L.R., Peterson, M.L., Katyal, K.D., Johannes, M.S., Makhlin, A., Wilcox, R., Franklin, R.H., Vogelstein, R.J., Hatsopoulos, N.G., & Bensmaia, S.J. (2013). Behavioral demonstration of a somatosensory neuroprosthesis, IEEE Transactions in Neural Systems and Rehabilitation Engineering, 21, 500-507.

Short Biography

I received a B.A. in Cognitive Science from the University of Virginia in 1995 and a PhD in Cognitive Psychology from the University of North Carolina at Chapel Hill. In 2003 I joined the lab of Dr. Kenneth Johnson at the Johns Hopkins University Krieger Mind/Brain Institute, as a postdoctoral fellow until 2006, at which time I was promoted to Associate Research Scientist. In 2009, I joined the faculty as Assistant Professor in the Department of Organismal Biology and Anatomy at the University of Chicago, where I also am a member of the Committees on Neurobiology and on Computational Neuroscience. The objectives of my lab are the neural basis of somatosensory perception using psychophysics, neurophysiology, and computational modeling. I also seek to apply insights from basic science to develop approaches to convey sensory feedback in upper-limb neuroprostheses.

Restoring hand function with a biomimetic neural interface and Functional Electrical Stimulation

L. Miller[1,2,3]*, C. Ethier[1], S. Naufel[3], B. Franco[3], N. Brill[4], D. Tyler[4]

[1] Department of Physiology, Northwestern University
[2] Physical Medicine and Rehabilitation, Northwestern University
[3] Biomedical Engineering, Northwestern University
[4] Biomedical Engineering, Case Western Reserve University

Abstract

Functional Electrical Stimulation offers the means to restore motor function to patients suffering paralysis due to spinal cord injury or other neurological disorders. Current FES devices must deliver preprogrammed stimulation to the many muscles necessary to allow even simple hand movement, as these patients lack the ability to control so many degrees of freedom using their own residual movements. We have developed an FES prosthesis controlled by signals recorded from neurons in the hand area of the motor cortex. We use a decoder consisting of multiple input impulse responses computed between M1 discharge and EMG, recorded during normal movement. We subsequently paralyze the forearm flexor muscles with a temporary peripheral nerve block, and use the decoder to compute stimulus pulse width commands that are delivered to implanted, intramuscular electrodes. The system essentially bypasses the spinal cord, allowing the monkeys to regain voluntary control of the paralyzed muscles, apparently by producing approximately “normal” patterns of cortical activity.

However, implanting electrodes within the large number of muscles necessary to allow even moderately dexterous movements is challenging. An alternative approach is to use multi-contact, peripheral nerve electrodes, which would potentially allow activation of many muscles from a single implant site. We are currently developing the methods necessary to control muscle activation from M1, using Flat Interface Nerve Electrodes (FINE) including the use of adaptive methods that will not require recorded EMG signals for decoder development.

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.

References

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[2] Brill N, Polasek K, Oby ER, Ethier C, Miller LE, Tyler DJ (2009) Nerve cuff stimulation and the effect of fascicular organization for hand grasp in nonhuman primates. In: Engineering in Medicine and Biology Society, Minneapolis, MN, pp 1557-1560

Short Biography

Lee E. Miller received a B.A. in physics from Goshen College, Goshen, IN, in 1980, an M.S. in biomedical engineering and a Ph.D. degree in physiology from Northwestern University, Evanston, IL, in 1983 and 1989, respectively. He completed two years of postdoctoral training in the Department of Medical Physics, University of Nijmegen, The Netherlands. He is currently the Stuntz Distinguished Professor of Neuroscience in the Departments of Physiology and Physical Medicine and Rehabilitation at Northwestern University. His primary research interests are in the cortical control of limb movement, and in the development of neural interfaces that attempt to mimic normal physiological systems.

Grasp predictions from motor, premotor, and parietal population signals

H. Scherberger[1]*

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Abstract

Hand function plays an important role in all primate species, and its loss is associated with severe disability. Grasping movements are complex motor acts for which the brain needs to integrate sensory and cognitive signals to generate behaviorally meaningful actions. To achieve this computation, specialized brain areas in the primate parietal (anterior intra-parietal area, AIP), premotor (area F5), and primary motor cortex (M1 hand area) are functionally connected. This presentation highlights recent experimental results in non-human primates to characterize how AIP, F5, and M1 generate grasping movements and how such movements can be decoded from spiking activity of these areas using permanently implanted electrode arrays while animals are grasping objects of various shape, size, and orientation. Besides understanding the underlying network structure and function, such characterizations are useful to evaluate the suitability of these preparatory and motor areas for the development of neural interfaces that aim to restore hand function in paralyzed patients.

References

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[2] Scherberger, H. (2012). BCIs that use signals recorded in parietal and premotor cortex. In: Brain-computer interfaces: principles and practice (Wolpaw JR, Wolpaw EW, eds), pp 289-299. New York: Oxford University Press.

Short Biography

Hans Scherberger received his Master degree in Mathematics (1993) and his Medical Doctor degree (1996) from Freiburg University, Germany. He currently heads the Neurobiology Lab at the German Primate Center and is Professor for Primate Neurobiology at Göttingen University (since 2008). He was trained in systems electrophysiology with post-doctoral positions at the University of Zurich (1995-1998) and at the California Institute of Technology (1998-2003) before becoming a research group leader at the Institute of Neuroinformatics at the University and ETH Zurich (2004-2009). His research is focused on the neural coding and decoding of hand grasping movements in the primate brain.

Developing neural interfaces for powered prosthetic limbs

T. Kuiken[1,2]*, G. Dumanian[3], L. Hargrove[1]

[1] Rehabilitation Institute of Chicago, Chicago Illinois
[2] Physical Medicine and Rehabilitation Dept., Northwestern Feinberg School of Medicine, Northwestern University, Chicago, IL
[3] Surgery Dept., Northwestern Feinberg School of Medicine, Northwestern University, Chicago, IL

Abstract

The ability to control complex robot prostheses is evolving quickly. Dr Kuiken will describe the research at the Center for Bionic Medicine/Rehabilitation Institute of Chicago and Northwestern University to develop a neural-machine interface to improve the function of artificial limbs. They have developed a technique called Targeted Reinnervation to use nerve transfers for improvement of robotic arm control and to provide sensation of the missing hand. By transferring the residual arm nerves in an upper limb amputee to spare regions of muscle it is possible to make new electromyographic (EMG) signals for the control of robotic arms. These signals are be directly related to the original function of the lost limb and allow simultaneous control of multiple joints in a natural way [1]. This work has now been extended with the use of pattern recognition algorithms that decode the user's intent, enabling the intuitive control of many more functions it the prostheses [2]. Similarly, hand sensation nerves can be made to grow into spare skin on the residual limb so that when this skin is touched, the amputee feels like their missing hand is being touched. This is a potential port to providing physiologically correct sensory feedback to amputees [1]. Our team is now also developing a neural interface for powered leg prostheses that enables intuitive mobility.

References

[1] Kuiken TA, Miller LA, Lipschutz RD, Lock B, Stubblefield K, Marasco P, Zhou P and Dumanian G. (2007) Targeted Reinnervation for Enhanced Prosthetic Arm Function in Woman with a Proximal Amputation: a case study. Lancet, 369(9558): 371-80

[2] Kuiken TA, Li G, Lock BA, Lipschutz RD, Miller LA, Stubblefield KA, and Englehart K. (2009) Targeted Muscle Reinnervation for Real-Time Myoelectric Control of Multifunctional Artificial Arms. JAMA 301(6):619-628, 2009.

Short Biography

Todd A. Kuiken received a B.S. degree in biomedical engineering from Duke University, a Ph.D. in biomedical engineering from Northwestern University in Evanston, Illinois and his M.D. from Northwestern University Medical School (1990). He is a board certified physiatrist. He is now the Director of the Center for Bionic Medicine at the Rehabilitation Institute of Chicago and a Professor in the Depts. of PM&R, BME and Surgery at Northwestern University. Dr. Kuiken is an internationally respected leader in the care of people with limb loss: both as an active treating physician and as a research scientist.

HAPTICS & DEXTERITY

Thursday, September 11, 2014

09h00 – 09h40	**Roland Johansson** (Umeå U) *Edge-orientation processing in first-order tactile neurons*	KEYNOTE
09h40 – 10h00	Michael Dimitriou (Umeå U) *Human muscle spindles preferentially encode imposed movement*	D04T
10h00 – 10h20	Ian Bullock (Yale U) *Kinematics of two- and three-fingered dexterous precision manipulation*	D11T
10h20 – 10h50	Coffee	
10h50 – 11h20	**Eric Rouiller** (U Fribourg) *Behavioral variability of manual dexterity in macaques*	KEYNOTE
11h20 – 12h20	Poster session (Sala Balint)	
12h30 – 14h30	Lunch	
14h30 – 15h10	**Francisco Valero-Cuevas** (U Southern California) *Moving beyond a cortico-centric view of dexterity*	KEYNOTE
15h10 – 15h50	Aaron Dollar & Thomas Feix (Yale U) *Modeling of precision grip in primates*	D10T
15h50 – 16h20	Coffe	
16h20 – 17h00	**Vincent Hayward** (UPMC Paris) *Mechanics of the fingertip and its impact on the prehensile and sensory function of the hand*	KEYNOTE
17h00 – 17h20	Sarah Wohlman (Northwestern U, RIC) *Subject variability during maximum lateral pinch*	D06T
17h20 – 17h40	Andreas Thomik (Imperial College London) *Symbolic representation of complex action sequences*	D07T
17h40 – 18h20	General discussion	
18h30 – 20h30	Dinner	
20h30 – 21h30	Social Event: **Dimitri & Compagnia Due** (Sala Balint)	

Edge-orientation processing in first-order tactile neurons

R. S. Johansson[1]*, J. A. Pruszynski[1]

[1] Physiology Section, Dept. of Integrative Medical Biology, Umeå University, Umeå, Sweden

Abstract

A fundamental feature of first-order neurons in the tactile system is that their distal axon branches in the skin and forms many transduction sites, yielding complex cutaneous receptive fields with many highly sensitive zones [1,2]. The functional consequences of this spatial arrangement are unknown. Here we demonstrate that this arrangement constitutes a peripheral neural mechanism that allows individual neurons to signal geometric features of touched objects. Specifically, we show that two types of first-order tactile neurons that densely innervate the glabrous skin of the human fingertips signal edge orientation via both the intensity and the temporal structure of their responses. Moreover, a neuron's sensitivity to edge orientation can be predicted from the spatial layout of its highly sensitive zones. We submit that peripheral neurons in the touch-processing pathway, like peripheral neurons in the visual-processing pathway, perform feature extraction computations typically attributed to neurons in the cerebral cortex.

References

[1] Johansson, R.S. (1978) Tactile sensibility in the human hand: receptive field characteristics of mechanoreceptive units in the glabrous skin area. J. Physiol. 281, 101-125

[2] Phillips, J.R., Johansson, R.S. and Johnson, K.O. (1992). Responses of human mechanoreceptive afferents to embossed dot arrays scanned across fingerpad skin. J. Neurosci. 12, 827-839

Short Biography

Roland S. Johansson is since 1988 Professor of Physiology at Umea University and since 2004 a member of The Royal Swedish Academy of Sciences. His primary research interests are in the organization and operation of neural sensory and motor mechanisms that endow human hands with their extraordinary ability to manipulate physical objects and tools. His work is cited >15 000 times and results are represented in several standard textbooks in Neuroscience and in Physiology.

Human muscle spindles preferentially encode imposed movement

M. Dimitriou[1]*

[1] Physiology Section, Department of Integrative Medical Biology, Umeå University, Sweden

Abstract

Muscle spindles are commonly considered as stretch receptors encoding movement, but the functional consequence of their motor control has remained unclear. Of the several hypotheses on spindle and fusimotor function, the α-γ co-activation hypothesis1 states that activity in a spindle-bearing muscle is positively related to its spindle afferent responses. However, given reciprocal inhibition, activity in one muscle should also be negatively related with spindle afferent activity from its antagonist. Taken together, the above suggest that spindle afferent responses should be affected by agonist/antagonist activation balance. Here, I show that spindle afferent firing is indeed affected by agonist/antagonist balance, in addition to muscle stretch. Specifically, spindle afferent activity from the common finger extensor muscle was recorded while alert human subjects constantly moved a single finger under external bias loads that either resisted or assisted finger flexion. Regardless of identical movement profiles across load conditions, stretch of the loaded antagonist muscle (i.e., extensor) was accompanied by increased spindle afferent firing from this muscle compared to a baseline case of no load. In contrast, spindle firing rates from the stretched extensor were lower than baseline when the agonist muscle powering movement (i.e., flexor) acted against an additional resistive load. Stepwise regressions confirmed that angular velocity, extensor and flexor muscle activity had a significant impact on spindle afferent responses, with flexor activity having a negative effect. The results therefore indicate that, as a consequence of their fusimotor control and basic spinal circuitry, spindle encoding of effortful self-generated motion is attenuated whereas externally imposed movement is preferentially encoded. In addition to offering a direct measure of movement 'exafference', such spindle signals can also allow reflexive fine-tuning of reciprocal inhibition during movement.

References

[1] Vallbo, A.B. (1970). Discharge patterns in human muscle spindle afferents during isometric voluntary contractions. Acta Physiologica Scandinavica. 80(4):552-66

Short Biography

Michael Dimitriou received his PhD degree from Umeå University (2009). His thesis work involved recording and characterizing the responses of sensory afferents from human muscles using the technique of microneurography. Between 2010 and 2012, he was a postdoc at the laboratory of Prof. Daniel Wolpert (Department of Engineering, University of Cambridge) looking into the task-dependency of reflex responses. Michael currently works at the Department of Integrative Medical Biology of Umeå University, and his research includes investigating how the nervous system itself shapes sensory output.

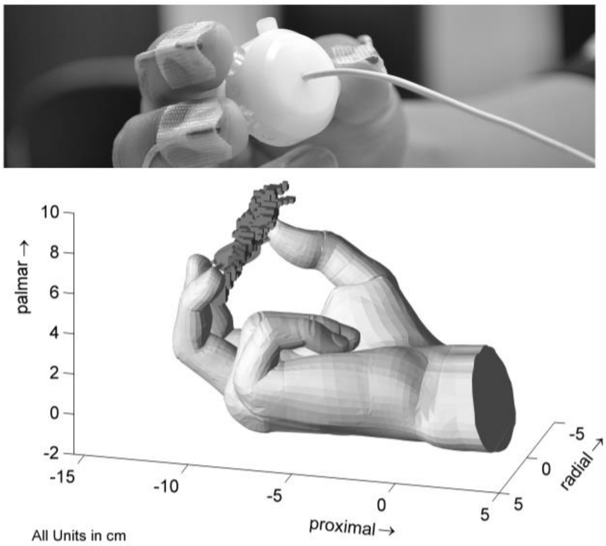
Kinematics of two- and three-fingered dexterous precision manipulation

I. M. Bullock*[1], T. Feix[1], A. M. Dollar[1]

[1] Department of Mechanical Engineering & Materials Science, Yale University

Abstract

Precision manipulation, in which an object held between the fingertips is translated and/or rotated with respect to the hand without sliding, is used frequently in everyday tasks such as writing, yet few studies have examined the experimental precision manipulation workspace of the human hand. This study evaluates the range of positions over which 19 participants manipulated a moderately sized (3.3-4.1cm diameter) object using either the thumb and index finger (2 finger condition) or the thumb, index and middle fingers (3 finger condition). The results show that the 2-fingered workspace is on average 40 % larger than the 3-fingered workspace (p<0.001), likely due to added kinematic constraints from an additional finger. Representative precision manipulation workspaces for a median 17.5cm length hand are analyzed to clearly illustrate the overall workspace shape, while the general relationship between hand length and workspace volume is evaluated. This view of the human precision manipulation workspace has various applications, ranging from motivating the design of effective, comfortable haptic interfaces to benchmarking the performance of robotic and prosthetic hands.



Pointed object used in the study, and a 3D view of the three-fingered workspace obtained from one participant.

References

[1] Bullock, I.M., Feix, T., and Dollar, A.M. (2014). Dexterous Workspace of Human Two- and Three-Fingered Precision Manipulation. IEEE Haptics Symposium, 41-47.

[2] Bullock, I.M., Feix, T., and Dollar, A.M.. Analyzing Human Fingertip Usage in Dexterous Precision Manipulation: Implications for Robotic Finger Design. In review.

Short Biography

Ian M. Bullock is a PhD candidate studying human grasping and dexterous manipulation at Yale University. He earned a B.S. in Engineering from Harvey Mudd College (Claremont, CA) and an M.S. and M.Phil. from Yale University. His research looks at the capabilities of the human hand from the perspective of trying to improve robotic hand design, haptic interfaces, and rehabilitation efforts.

Behavioral variability of manual dexterity in macaques

E. M. Rouiller[1]*

[1] Department of Medicine, University of Fribourg, Switzerland

Abstract

The aim of the present study was to investigate the behavioral variability of manual dexterity in non-human primates (macaque monkeys: macaca fascicularis) in order to assess whether the variability during learning and consolidation phases is a predictor of the extent of functional recovery following a lesion of the motor cortex and of the post-lesion variability. Moreover, the possible impact of hand dominance as well as hand preference was examined. Hand preference was quite variable across individuals and was task dependent. Hand dominance did not show a systematic lateralization at group level, but there was a tendency at individual level to show hand dominance, for the right hand in some animals and for the left hand in other animals. A high level of manual dexterity performance at consolidation phase pre-lesion is predicted by an also high initial score before learning, but not by the initial variability at the beginning of the training. Motor habit, corresponding to the temporal order of free-will sequential grasping movements was established very early during the learning phase. The learning phase resulted in an optimization of manual dexterity attributes, such as score, contact time, and a decrease of intra-individual variability. Following unilateral lesion of the motor cortex, the duration of the incomplete recovery of manual dexterity of the affected hand to reach a post-lesion plateau was correlated with the volume of the lesion in the gray matter. This was also true for the post-lesion variability of the recovered manual dexterity. The pre-lesion variability of manual dexterity, either at the beginning of the learning phase or at plateau, is not a predictor of the variability post-lesion. Overall, the data emphasize the considerable inter-individual variability of manual dexterity in non-human primates, to be considered for further pre-clinical applications based on this animal model.

Short Biography

The author was trained as Biologist at the University of Lausanne (Switzerland), followed by a Ph.D. degree in Neurophysiology in the field of hearing (1981), a topic in which he spent then 2 years as post-doc at Harvard Medical School (1981-1983; Prof. N. Kiang's laboratory). After a second post-doc at University of Lausanne, a position of Junior Professor was occupied at the University of Fribourg (1989-1996) in the field of motor control on monkeys (laboratory of Prof. M. Wiesendanger), followed by a promotion as associate Professor (1996) and as full Professor (2003).

Moving beyond a cortico-centric view of dexterity

F. J. Valero-Cuevas[1]*

[1] Department of Biomedical Engineering, and Division of Biokinesiology & Physical Therapy University of Southern California, Los Angeles, CA, USA

Abstract

The literature in support of cortical involvement in dexterous manipulation is large. Our own fMRI studies [2] agree with many others showing differential activity across cortical networks depending on the level of difficulty of an unstable manipulation task. We have also proposed that competition between descending commands for manipulation likely involves the phylogenetically older reticulospinal and the newer corticospinal tracts [3]. But recent results [1] compel us to confront several inconvenient facts to the cortico-centric view of the neural control of the hand including time delays, our evolutionary history, and clinical symptomatology. For example, dynamic manipulation of unstable objects with the fingers and legs occur at time scales for which spino-cortico-spinal delays would compromise closed-loop control. These issues can be resolved by paying more attention—and due credit—to subcortical mechanisms. That is, neural control must involve sub-cortical and spinal-mediated control, as proposed by hierarchical, or at the very least distributed, perspectives on neural control. In fact, neuroanatomists and electrophysiologists since the time of Sherrington have sought to map the circuitry in the spinal cord to understand the spinally-mediated excitation-inhibition mechanisms that enable voluntary function—and produce the clinical symptomatology of, for example, dystonia in some neurological disorders including stroke, cerebral palsy, and spinal cord injury. These results compel future work to disambiguate among peripheral, spinal and cortical contributions to, and mechanisms for, finger and limb dexterity.

References

[1] Lawrence EL, Fassola I, Werner I, Leclercq C, Valero-Cuevas FJ. Quantification of dexterity as the dynamical regulation of instabilities: comparisons across gender, age, and disease. Frontiers in Neurology - Movement Disorders, 5:53. doi: 10.3389/fneur.2014.00053, 2014.

[2] Mosier K, Lau C, Wang Y, Venkadesan M, and Valero-Cuevas FJ. Controlling instabilities in manipulation requires specific cortical-striatal-cerebellar networks. Journal of Neurophysiology, 105: p.1295–305, 2011.

[3] Rácz K, Brown D, and Valero-Cuevas FJ. An involuntary stereotypical grasp tendency pervades voluntary dynamic multifinger manipulation. Journal of Neurophysiology, 108: p.2896-911, 2012.

Short Biography

Prof. Valero-Cuevas earned a BS in Engineering from Swarthmore College (USA), was a Thomas J Watson Fellow in the Indian subcontinent, and completed an MS and PhD in Mechanical Engineering, respectively, at Queen's University (Canada) and Stanford University (USA). He was Research Associate and Lecturer at Stanford University, and assistant and tenured associate professor at Cornell University. He is full professor in the Department of Biomedical Engineering, and the Division of Biokinesiology & Physical Therapy at the University of Southern California. He is a Senior Member of the IEEE, and Fellow of the American Institute for Medical and Biological Engineers.

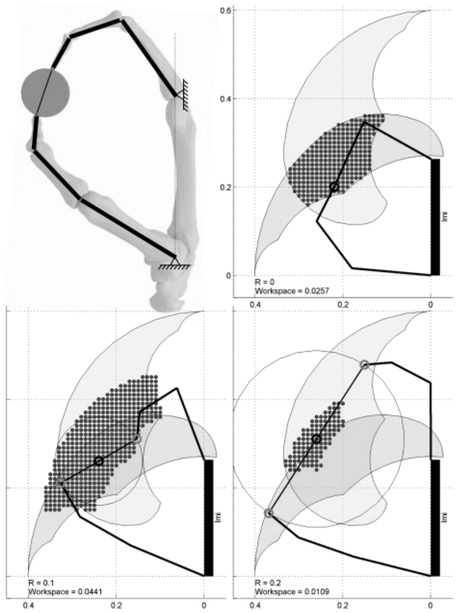
Modeling of precision grip in primates

T. Feix[1]*, A. M. Dollar[1]

[1] Department of Mechanical Engineering & Materials Science, Yale University

Abstract

For decades humans were considered to be the only primate species capable of dexterous precision gripping. However, recent behavioral studies have shown that other non-human primates, particularly extant great apes (hominoids) and some Old World and New World monkeys are also capable of precision gripping. We present a novel method based on robotic workspace modeling that allows us to estimate the precision grip capabilities between the thumb and index finger across a broad sample of primates. Although this kinematic model simplifies the complexity of morphology and movement typical of the primate hand, this simplicity enables the model to be applied to a wide range of associated fossil specimens in which knowledge about joint movements, soft tissue morphology, or other bones (e.g. carpals) are unknown. This model offers for the first time a method of assessing movement within the hand, rather than simply inferring function from the bony morphology (in the case of fossils).



We use the model to analyze the precision gripping behavior of 360 hand specimens from 38 different primate species. Within the hominoid group, the workspace of the human is the largest, implying that the human hand is best adapted for precision gripping. However, the results show that other non-hominoid species are able to achieve workspaces that are similar to the human, supporting the view that hands of other species are also capable of precision gripping. The model also shows that a longer thumb is a good predictor of thumb-index gripping potential.

References

[1] Feix, T., Kivell, T.L., Pouydebat, E., and Dollar, A.M. (2014). Estimating precision grip potential in extant Hominoids. In preparation

Short Biography

Thomas Feix received the M.Sc. degree in sports equipment technology from the University of Applied Sciences Technikum Wien, Vienna, Austria, and the Ph.D. degree from the Vienna University of Technology, in 2011. He is a Postdoctoral Associate with the GRAB Lab, Department of Mechanical Engineering, Yale University, New Haven, CT. His research is focused on human grasping and manipulation and its application to robotics and prosthetics.

Mechanics of the fingertip and its impact on the prehensile and sensory function of the hand

V. Hayward[1]*

[1] Sorbonne Universités, UPMC Univ Paris 06, UMR 7222, ISIR, F-75005, Paris, France

Abstract

Recent studies pertaining to the detailed mechanics of the human fingertip have revealed a number of interesting and surprising properties of this organ. It is believed that these mechanical and tribological properties play a major role in the hand extremities' prehensile and sensory capabilities. These observations will be discussed in relation to the scientific study of touch and of its applications in the design of haptic interfaces.

References

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[2] Hayward, V., Terekhov, A. V., Wong, S.-C., Geborek, P., Bengtsson, F., Jörntell, H. (2014). Spatio-Temporal Skin Strain Distributions Evoke Low Variability Spike Responses In Cuneate Neurons. Journal of the Royal Society Interface, 11(93):20131015

Short Biography

Vincent Hayward joined CNRS, France, as Chargé de Recherches in 1983. In 1987, he joined the Department of Electrical and Computer Engineering at McGill University as assistant, associate and then full professor (2006). He was the Director of the McGill Center for Intelligent Machines from 2001 to 2004. Since 2008 is a Professeur at the Université Pierre et Marie Curie, Paris, France. Hayward is interested in haptic device design, haptic perception, and robotics. He is on editorial board of the ACM Transaction on Applied Perception and of the IEEE Transactions on Haptics and is a Fellow of the IEEE.

Subject variability during maximum lateral pinch

S. J. Wohlman[1,2]*, M. de Bruin[1,2], W. M. Murray[1,2,]

[1] Northwestern University, Department of Biomedical Engineering, Evanston, IL, USA
[2] Sensory Motor Performance Program, Rehabilitation Institute of Chicago, Chicago, IL, USA

Abstract

Recording experimental data from the thumb during lateral pinch is difficult. A highly variable range of forces and muscle activations have been observed across subjects [1]. The source of this variability is not clear. Here, we simultaneously record muscle activation, joint posture, and thumbtip force to analyze such variability during maximum lateral pinch.

Muscle activations were recorded via intramuscular EMG in the four extrinsic thumb muscles. Using a 27 gauge hypodermic needle, bipolar fine-wire electrodes were inserted in each muscle. Data were collected with a Delsys Bagnoli-16 system at 2000 Hz and filtered. Thumbtip forces were collected with a Biometrics Precision Pinchmeter P100, and joint posture was quantified using a Cyberglove. Subjects were given visual feedback and instructed to generate maximum force. Data were smoothed via a 750 ms moving average and maximum force was identified. Muscle activations and joint angles were calculated by averaging over the same 750 ms window as the maximum force. EMG data were normalized by each muscle's activation, quantified individually during maximum voluntary contraction testing.

Maximum lateral pinch force averaged 83 ± 17N across four subjects. In three male subjects, EPL, EPB, and APL were at most 25% of FPL activation (Fig. 1A bottom panel). In the female subject, muscle activations for these three muscles were 43% of FPL activation, on average (Fig. 1B bottom panel). This subject had substantial MCP joint extension with concurrent IP joint flexion (Fig. 1B). The male subjects adopted a less extreme posture (Fig. 1A).

We simultaneously recorded muscle activations, joint angles, and thumbtip forces while subjects produced maximum lateral pinch. A single female subject differed in muscle activation pattern and thumb posture from three male subjects. The posture she adopted is consistent with higher joint laxity, a proposed precursor to thumb osteoarthritis, a pathology more prevalent in women.

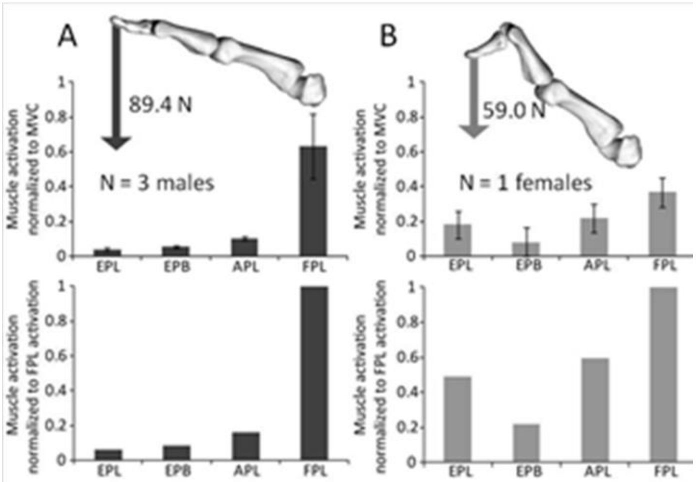

Fig 1. Force, posture, and activation data ± standard deviation for A) N = 3 males and B) N = 1 female.

References

[1] Valero-Cuevas, F.J., Johanson, M.E., and Towles, J.D. (2003). Towards a realistic biomechanical model of the thumb: the choice of kinematic description may be more critical than the solution method or the variability/uncertainty of musculoskeletal parameters. Journal of Biomechanics, 36(7): 1019-30.

[2] Buffi, J.H., Sancho Bru, J.L., Crisco, J.J., and Murray, W.M. (in review). Evaluation of hand motion capture protocol using computed tomography: application to an instrumented glove. Journal of Biomechanical Engineering.

Short Biography

Sarah is a PhD candidate in the Department of Biomedical Engineering at Northwestern University. She received her MS from Northwestern in 2012. Her research focuses on thumb biomechanics.

Symbolic representation of complex action sequences

A. Thomik[1]*, A. A. Faisal[1,2,3]

[1] Dept. of Bioengineering, Imperial College London
[2] Dept. of Computing, Imperial College London
[3] MRC Clinical Sciences Centre, Imperial College London

Abstract

A fundamental problem in neuroscience is to understand how the brain translates a symbolic sequence of action descriptors, or high-level motor intention, into the appropriate muscle commands. This is of particular interest in the context of brain-machine interfaces and neuroprosthetics, where attempts to achieve functionality comparable to natural limbs have failed so far. This is not a mechatronic limitation but the robotic control and coordination of so many degrees of freedom (21 in the hand alone) is beyond the capabilities of current computers and algorithms. We take the view that the brain achieves this feat by mapping the necessary computation onto a finite and low-dimensional subset of control building blocks of movement, characterised by high correlation between a subset of the joints involved – kinematic primitives.

To investigate this possibility, we collected a data set of annotated hand movement from subjects wearing lightweight and unobtrusive data gloves while going about their daily life. We process this data by applying a method which extracts kinematic primitives by analysing the local correlation structure of the data. This yields a dictionary of kinematic primitives which could be used by the brain to generate the necessary motor commands. Crucially, this technique also allows computation of the reverse problem by asking at any point in time which primitive was most likely to have produced the data observed. In this way, we can translate the time-series of joint movements into a symbolic sequence ("behavioural barcode"), compressing the very complex movement necessary to achieve a given task into a sequence of actions. From a scientific perspective, this step from raw movement to behavioural grammar may give us some insight into the neural computations underlying our motor system, while from a technical point of view this compression may provide us with a more sophisticated way of controlling robotic limbs or prostheses.

Short Biography

Andreas Thomik received his B.Sc. in Microengineering from EPFL in 2010, followed by a M.Sc. in Biomedical Engineering from Imperial College London in 2011 where he stayed to pursue a Ph.D. in the field of Neurotechnology at the Brain & Behaviour Lab. His research interests range from the neuroscience of sensorimotor control to applications in prosthetics and assistive devices. The main focus of his PhD thesis is the hierarchical structure and grammar of human behaviour, for which he has developed computational and experimental techniques.

NEURO-REHABILITATION

Friday, September 12, 2014

09h00 – 09h40	**Joachim Hermsdörfer** (TU Munich) *Deficits of tool use following stroke: Neural correlates and technological approaches to assist in activities of daily living*	KEYNOTE
09h40 – 10h00	Ted Milner (McGill U, CRIR Montreal) *Coordination of grip force and load force during submovements in normal and post-stroke subjects*	E02T
10h00 – 10h20	Margaret Duff (RIC) *A portable, low-cost system for evaluating hand function during natural movement*	E03
10h20 – 10h50	Coffee	
10h50 – 11h20	**Derek Kamper** (Illinois Institute of Technology, RIC) *Neurological interactions among thumb and fingers*	KEYNOTE
11h20 – 11h40	Alejandro Melendez-Calderon (Hocoma, Northwestern U) *Assistance and rehabilitation of hand function using a robotic glove*	E06T
11h40 – 12h00	Arno Stienen (U Twente) *Symbionic hand orthoses for Duchenne and stroke*	E09T
12h00 – 12h20	CSF Junior Award ceremony & closing words	
12h30 – 14h30	Lunch	

Deficits of tool use following stroke: Neural correlates and technological approaches to assist in activities of daily living

J. Hermsdörfer[1]*

[1] Department of Movement Science, Faculty of Sport and Health Science, Technische Universität München, Munich, Germany

Abstract

Stroke frequently causes apraxia, particularly if it affects the left-hemisphere. A frequent symptom of apraxia is impaired use of tools performed as a pantomime as well as during actual use. We studied the neural correlates of tool use in healthy subjects using functional magnetic resonance imaging (fMRI) and a tool-carousel that allowed us to investigate the actual use of tools. We compared actual tools use with goal-directed movements of a neutral object that did not encompass knowledge about use. We also compared use with a simple transport movement. We found a left lateralized brain network responsible for planning and execution of the task with a stronger leftward shift the more the task involved actual use of a tool compared to a neutral object and simple transport. In addition, we found characteristic brain areas active that could be related to the dorso-dorsal stream for online grasp control, to the ventro-dorsal stream for tool manipulation, and the ventral stream for object recognition and tool semantics.

Damage to the neural substrates controlling tool use may substantially limit the capacity of stroke patients to live independently in their home environment. The second part of the presentation introduces the CogWatch project that provides technology based means of assistance and rehabilitation for patients with ADL impairments due to tool use and action organization deficits. The system bases on instrumented objects and ambient devices that are part of patients' everyday environment and can be used to monitor behavior and progress as well as re-train them to carry out ADL through persistent multimodal feedback.

References

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[2] Hermsdörfer J., Bienkiewicz, M., Cogollor, J., Russel, M., Jean-Baptiste, E., Parekh, M., Wing, A., Ferre, M., Hughes, C. (2013). "CogWatch - Automated assistance and rehabilitation of stroke-induced action disorders in the home environment." Lecture Notes in Computer Science 8020 LNAI (PART 2): 343-350.

Short Biography

Joachim Hermsdörfer received his PhD at the Institute for Medical Psychology in the Ludwig-Maximilians-University in Munich in 1993. He headed the research group “Sensorimotor Disturbances” at the Clinical Neuropsychology Research Group in the Hospital München-Bogenhausen. In 2010 he was appointed as Full Professor and Chair of Movement Science in the Faculty of Sports and Health Sciences at the Technische Universität München. His main interest is sensorimotor-control in healthy individuals and in patients with neurological diseases using behavioral as well as neuroimaging approaches.

Coordination of grip force and load force during submovements in normal and post-stroke subjects

T. Milner[1,3]*, H. Kazemi[2,3]

[1] Department of Kinesiology and Physical Education, McGill University
[2] Department of Biomedical Engineering, McGill University
[3] Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain

Abstract

A feature of twisting movements against a spring load is that grip force increases linearly with load force in a tightly coordinated manner. This tight coordination is frequently absent following stroke [1]. However, movements in post-stroke (PS) subjects are characterized by a series of submovements similar to movements performed at slower than normal speed by neurologically normal (NN) subjects. We investigated whether grip force (GF) and load force (LF) were tightly coupled in NN subjects during slow movements where submovements were present and compared the results when PS subjects performed the same movements at normal speed with their contralesional hand. For NN subjects, GF increased linearly ($r>0.9$) with LF during more than 50% of submovements made with the dominant (right) hand. However, when movements were made with the non-dominant (left) hand we found $r>0.9$ for less than 25% of the submovements. For a small number of submovements, (6% right, 12% left) GF decreased linearly as LF increased (i.e., $r<-0.9$).

In the case of PS subjects, the overall distribution of correlation coefficients was more similar to that of the non-dominant than the dominant hand of age-matched NN subjects. PS subjects appeared to fall into two broad categories. In one category, subjects modulated GF linearly with LF, although unlike NN subjects, they tended to increase or decrease GF with almost equal frequency as LF increased. The correlation coefficients had a bimodal distribution where the majority fell in the ranges $-1<r<-0.8$ and $0.8<r<1$. Even subjects who appeared to have completely recovered upper limb function following the stroke (perfect scores of 63 on the 9-component CAHAI) showed this abnormal tendency to reduce GF as LF increased during submovements. In the other category, modulation of GF was quite variable during submovements such that the distribution of correlation coefficients was relatively uniform.

References

[1] Kazemi, H., Kearney, R.E. and Milner, T. (2013) Characterizing coordination of grasp and twist in hand function of healthy and post-stroke subjects. ICORR 2013.

Short Biography

Ted Milner is a professor in the Department of Kinesiology and Physical Education at McGill University. He is currently visiting professor and Marie Curie Fellow at ETH-Zurich. He and his former research trainees, Etienne Burdet and David Franklin have recently written a book titled Human Robotics Neuromechanics and Motor Control. He has been investigating the control of upper limb movements for the past 30 years with a recent focus on rehabilitation of hand function after stroke. He is currently investigating how the brain processes and transforms somatosensory information in the control of dexterous hand movements.

A portable, low-cost system for evaluating hand function during natural movement

M. Duff[1]*, J. Hudson[1], W. Z. Rymer[1]

[1] Rehabilitation Institute of Chicago, Chicago, IL

Abstract

Tangible interaction with external objects in one's environment is crucial to participating in many activities of daily living, yet this capacity can be severely compromised after a stroke1. Currently there are few ways to consistently and comprehensively measure hand function during natural movement, which makes providing real-time feedback during repetitive task therapy difficult. A low-cost and portable system was developed for recording and analyzing key kinematic and kinetic features of reaching, grasping and object transportation tasks after stroke, as a means to rapidly and economically quantify hand impairment. The system is comprised of one depth sensor motion capture camera that provides non-contact tracking of hand and finger movements. This camera provides spatial resolution comparable to marker-based optical camera capture, with slightly reduced temporal resolution of approximately 30 frames per second. The system also incorporates custom objects that mimic objects used in activities of daily living and can wirelessly sense touch, applied force and object acceleration and orientation. Initial data collected from unimpaired participants is being used to develop quantitative measures of hand use and function during reaching tasks. The raw data is transformed into useful metrics such as: hand speed, hand trajectory, wrist rotation, hand aperture, grasp force and object movement and orientation. These metrics will be the basis of an evaluation framework of hand impairment after stroke, which will drive engaging and informative audio and visual feedback during therapy. Data is collected and analyzed through a web-based software interface, creating a suitable structure for home-based tele-rehabilitation systems and monitoring of how therapy translates to hand use in everyday life.

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Short Biography

Margaret Duff received her PhD in biomedical engineering from Arizona State University where she developed and evaluated mixed reality rehabilitation systems for use after stroke. She is currently a post-doctoral fellow at the Rehabilitation Institute of Chicago with Dr. Zev Rymer. Her research includes computational modeling of motor learning through kinematic measurements, replicating clinician decision making through machine-learning algorithms and developing inexpensive and easy to use hardware and software infrastructures for unsupervised interactive therapy.

Neurological interactions among thumb and fingers

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Abstract

Coordinated movement of the thumb and fingers is one of the hallmarks of human motor control. The flexibility of these patterns is striking in that thumb and finger movements can be highly independent when typing or playing an instrument, yet highly coupled when grasping an object. The range of possible interactions is fundamental to dexterous hand manipulation in humans, yet questions regarding these capabilities remain. We have been exploring these issues in a series of studies, ranging from reflexive to voluntary to learning paradigms. Using a novel finger exoskeleton, we were able to examine reflexive coupling between index finger and thumb muscles. Stretch of either the index finger flexors or extensors was applied during performance of voluntary pinching movements with the index finger and thumb. Reflex responses of similar latency were seen in both the stretched muscles of the index finger and the non-stretched muscles of the thumb. Another experiment employed the same device to arrest movement of specific index finger joints during voluntary pinching. During pinch closing, impedance of index finger movement led to corresponding reductions in thumb movement. In another study, we assessed transfer of motor adaptation from the index finger to the thumb and vice versa. Preliminary analysis suggests that learning of a novel motor task with one digit – in this case involving movement of a haptic object with novel dynamic properties – led to faster adaptation with the other digit despite a difference in required digit kinematics. Yet, a functional magnetic resonance imaging study we conducted revealed distinctive cortical regions for thumb and finger activation, especially for the dominant hand. Additionally, EMG-EMG coherence between thumb and finger muscles can be quite small for cortically derived signals. Thus, non-cortical pathways, such as from brainstem [1,2], may play important roles in coordinating finger and thumb movement.

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Short Biography

Dr. Derek Kamper received a B.E. in Electrical Engineering from Dartmouth College and M.S. and Ph.D. degrees in Biomedical Engineering from Ohio State University. He is currently an Associate Professor in the Department of Biomedical Engineering at the Illinois Institute of Technology and a Research Scientist at the Rehabilitation Institute of Chicago. His research focuses on hand neuromechanics and rehabilitation of hand motor control following neurological injury.

Assistance and rehabilitation of hand function using a robotic glove

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Abstract

Good hand function is paramount to the performance of almost all tasks in everyday life. After a neurological disorder (e.g. stroke) or age-related conditions (e.g. sarcopenia, rheumatoid arthritis), our capability to manipulate, explore and acquire objects, or even to communicate with the hands is lost or limited. The HandinMind [1] and IronHand [2] projects aim at minimizing the loss of quality of life after hand impairments by facilitating active execution of hand movements during everyday activities or therapeutic practice. HandinMind focuses on the needs of stroke patients for activities of daily life, while IronHand focuses on supporting work and leisure activities of ageing individuals with various limitations, such as weak grip or arthritis. Our approach is based on a grip enforcing robotic glove [3] with added hand-opening functionalities for the stroke population and specific intention detection for each target population. The glove can be used in two different modalities: i) assistive, in which the glove is worn as any other glove and supports active execution of hand opening and closing during every day or work activities and ii) therapeutic, in which the glove is connected to an external computer and facilitates therapeutic practice at home or small clinic. In this session we will present advances of the HandinMind and IronHand projects; in particular: i) mechanisms to provide extra force for opening and closing the hand, ii) advances in an “intention detection” logic that activates the support if and only if the user initiates the movement, depending on specific needs of either stroke or elderly, and iii) therapeutic exercises and assessment of hand function using our robotic glove tailored to either stroke or elderly population.

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[2] IronHand - Smart glove with intention detection and mechatronic finger actuation supporting elderly occupation (www.ironhand.eu). Project co-funded by Ambient Assisted Living (European Union), State Secretariat for Education, Research and Innovation (SERI, Switzerland), Swedish Governmental Agency for Innovation Systems (Vinnova, Sweden) and the Netherlands Organisation for Health Research and Development (ZonMW).

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Short Biography

Alejandro Melendez-Calderon received his doctoral degree from Imperial College London for research at the interface of robotics, rehabilitation and human motor control. After his studies, he joined the Rehabilitation Institute of Chicago and Northwestern University as postdoctoral research fellow. Since January 2014, he works at Hocoma AG as Technical Project Manager. He is also an Adjunct Assistant Professor at Northwestern University.

Symbionic hand orthoses for Duchenne and stroke

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Abstract

Ever more people rely for their independence on wearable assistive devices that improve functional capabilities. Traditionally, these assistive devices are adapted to the patient upon delivery but remain static during their lifetime. In our view, devices should continuously adapt to the user according to a therapy plan or to compensate for user changes, changing environment, or changing tasks. The objective of the Symbionics program (STW, NL) is to create systems that co-adapt automatically, either intrinsically by design, by control, or their combination. Furthermore, we aim to create assistive devices that completely fit underneath regular clothing, which is key to social acceptance.

Human hands are versatile organs that can manipulate a wide range of objects in our environment. The complexity of control over these prehensile, multi-fingered extremities is illustrated by the large size of the sensorimotor cortex our brain has reserved for it. In the Symbionics program, two projects focus on the development of hand orthoses for individuals after stroke or those suffering from Duchenne Muscle Dystrophy. We will develop algorithms that can be used in combination with advance hand exoskeletons to simulate assistive performance of proposed hand orthoses. We will also develop algorithms that can detect user intention despite the presence of debilitating movement impairments. The results of these will be used to develop hand orthoses that focus on robot rehabilitation after stroke and on assistance in activities of daily living for DMD patients.

It is especially important to balance the crossover from function recovery (rehabilitation) to compensation (permanent assistance). Too much assistance will result in undesired disuse or accelerated degeneration in the individual. On the other hand, too little assistance will cause errors in movement execution. In other words, recovery and retention of function requires as little assistance as possible to maximize the involvement of the user, whereas compensation requires that performance errors be minimized for successful use with activities of daily living. This balance needs to be adjusted for each joint in the human hand at each stage of the impairment.

Short Biography

Arno Stienen acquired a PhD in biomechatronic engineering and rehabilitation robotics under the guidance of prof. Frans van der Helm and prof. Herman van der Kooij. Currently, he is an Assistant Professor at the University of Twente, specializing in upper extremity motor learning and rehabilitation. He is also an Adjunct Assistant Professor at Northwestern University in Chicago (IL, USA), where he works with prof. Jules Dewald. The Symbionics projects on the hand are supported by STW (NL, #12479, #13524 and #13525), Hankamp Rehabilitation (Enschede, NL), Hocoma (Volketswil, CH), TMSi (Oldenzaal, NL), Moog (Nieuw Vennep, NL), FESTO (Delft, NL), and multiple Duchenne foundations (NL & USA).

POSTERS

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CORTICAL CONTROL

Task difficulty modulates left inferior frontal cortex during matching of hand posture to object use

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Abstract

The present study aimed to identify modulation in human brain areas sensitive to the difficulty level of tool object - hand posture matching. We hypothesized that conditions where demands on differentiation of hand posture and finger composition were higher, would show enhanced modulation in the neural region responsible for hand posture selection, and that this region would most likely correspond to the ventral premotor cortex [1].

Seventeen healthy right handed participants had to decide if a hand posture matched a tool object for its functional use (experimental conditions) or if two images were identical (control condition) while undergoing fMRI. Pairings could be within grasp types (difficult 'Within grasp type' decision) resulting in a Match or Mismatch decision (the latter termed the Mismatch Hard condition). Alternatively, pairings could be between grip types (easy 'Between grasp type' decision). In that case the pairing is always a mismatch, and this condition was termed the Mismatch Easy condition.

The behavioral data revealed a successful manipulation of the mismatch conditions' difficulty level. Comparison of easy versus more difficult conditions was taken to reflect selective modulation in those brain areas that would have to deal with this increased task demand.

In the Mismatch Hard > Mismatch Easy contrast, substantial response to task difficulty was elicited in the left ventral premotor cortex, in particular in pars opercularis (BA 44) of the inferior frontal gyrus. The same region was active in the more general Within > Between Grasp type choice contrast.

These findings are in agreement with other studies that targeted the hand posture selection process and found vPMC activation among other activated regions. The merit of the present study is that it highlights the selective response of this region to differing demands in the discrimination of hand posture choice [2]. The selective involvement of vPMC in hand posture discrimination relative to object properties remains in agreement with the functional role of primate F5 as proposed by Fagg & Arbib [1], despite the increased complexity of transitive actions in humans.

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Short Biography

Guy Vingerhoets, PhD, was trained as a clinical neuropsychologist and worked for over 20 years with patients suffering from a broad range of neurodegenerative diseases including Alzheimer's disease, Parkinson's disease, epilepsy, and stroke. He also investigated cognitive sequelae in patients following different types of cardiovascular surgery. In addition, he specialized in functional brain imaging using transcranial Doppler ultrasonography and magnetic resonance imaging. Over the last 7 years his research has focused primarily on brain imaging, motor cognition, and hemispheric specialization. Dr. Vingerhoets is Full Professor of Neuropsychology at the Department of Experimental Psychology, Faculty of Psychology and Educational Sciences at Ghent University, Belgium.

A unilateral lesion of the hand representation in the primary motor cortex in macaques affects the interhemispheric ratio of SMI-32 stained neurons in premotor cortical areas

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Abstract

The primary motor cortex (M1) is interconnected with premotor areas, in both hemispheres, such as the rostral part of the ventral premotor cortex (PMv-r) and the supplementary motor area (SMA). To assess possible effects of a permanent unilateral lesion of M1 (hand area) on PMv-r and SMA, we counted in these 2 areas in each hemisphere the number of long projecting neurons, specifically immunostained with the marker SMI-32, targeting neurofilaments in layer V, in three subpopulations of adult macaque monkeys: (i) two intact control animals (ii) three animals with a unilateral lesion of M1; (iii) two animals with a similar M1 lesion but treated with an antibody directed against the neurite growth inhibitor Nogo-A. Preliminary data show that the lesion in M1, affecting the cortico-cortical interconnections between M1 and the premotor cortical areas, resulted in a marked inter-hemispheric difference in the expression of the SMI-32 immunostaining in layer V in SMA and PMv-r, as observed in all M1 lesioned animals. In contrast, there was no significant interhemispheric difference in the two intact animals. In addition, in the majority of cases, the ipsilesional hemisphere showed a decreased number of SMI-32 stained neurons, as compared to the contralesional hemisphere. We also observed a direct correlation between the extent of the lesion and the amplitude of the interhemispheric difference of SMI-32 positive neurons, both for SMA and PMv-r.

The role played in functional recovery from M1 lesion by premotor cortices (SMA, PMv-r) either in the ispilateral or in the contralateral hemisphere is still not clear. Further investigations are needed to determine if the observed differences in SMI-32 staining are due to indirect, remote changes of layer V neurons' phenotype due, or to a change of metabolism in SMA and PMv-r during the recovery phase until a post-lesion plateau of performance is reached.

Short Biography

Eric Schmidlin is actually involved in a research project in Non-human primates (NHP) at the University of Fribourg in Switzerland, trying to understand the mechanism behind functional recovery after permanent lesion of the hand representation in the primary motor cortex, using behavioral, and histological investigations techniques.

He made his PhD in Prof Eric Rouiller's lab in Fribourg in 2004 on the consequences of a spinal cord hemisection at cervical level in NHP, and then moved to UCL in Roger Lemon's Lab as a research fellow between 2005 and 2006. He received an Ambizione grant from the SNF in 2009.

Hand usage shapes finger representations in the primary motor cortex

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Abstract

The organizational structure of the primary motor cortex (M1) is currently poorly understood. Experiments involving single-neuron electrophysiology [1] and micro-stimulation across sites in M1 [2] both suggest that co-activated finger movements rather than single fingers are represented in the neural population code. Here we asked whether the representation of co-activated hand movements in M1 follows an organizational principle.

Eight healthy participants were asked to perform isometric finger presses with the right hand while undergoing an fMRI scan. Participants were instructed to produce all combinations of 1-, 2-, 3-, 4- and 5-finger presses, giving a total of 31 chords that together span the entire space of possible finger movements. The resulting activity patterns for each chord were projected unto the reconstructed cortical surface for each subject. We observed that while activation patterns in M1 for similar chords were highly variable across subjects, the 465 Mahalanobis distances between all possible pairs of activation patterns were remarkably stable (average inter-subject correlation $r=0.77$, $p<<0.0001$). This finding strongly suggests the existence of an invariant organization principle of hand movement representation in M1 across subjects. Furthermore, we found that the observed fMRI distances did not result from the co-activation of muscles required to produce movement, but instead, were best explained by how we use our hands in everyday life. Together, our results provide the first steps towards uncovering organizational principles across healthy subjects and assessing the effects of disease related changes.

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Short Biography

Naveed Ejaz is a post-doctoral researcher at the Institute of Cognitive Neuroscience, UCL, and has a PhD. in Systems Neuroscience from Imperial College London. He uses a combination of fMRI, EMG and motion-capture equipment to study the representation and control of hand function in healthy and diseased populations.

Fine manual dexterity is affected by transient inactivation of primary motor cortex (M1) using repetitive transcranial magnetic stimulation (rTMS)

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Abstract

The aim of this study is to assess the role played by M1 in the execution of a behavioral task involving a synergic action of proximal and distal muscles called the "reach and grasp" drawer task, before and after transient inactivation of M1 using rTMS.

We analyzed several motor aspects: 1) the temporal unfolding of the task; 2) the continuous recordings of the force needed to grasp the button of the drawer (grip force) and the force needed to open the drawer against adjustable levels of resistance (load force); 3) the electromyographic (EMG) activity of eight arm and hand muscles; 4) the acceleration in 3D of the hand's movement.

To specifically inactivate the area of M1 involved in hand movements, we defined M1 hand region where single pulses of TMS stimulation elicited motor evoked potentials with the largest amplitude and the highest probability, and we applied series of burst (3 pulses with 33.3 ms interval during 33.3 seconds), corresponding to theta burst stimulation.

Preliminary results show a decrease of EMG activity of hand and arm muscles, as well as a decrease of grip and load forces applied to perform the task at higher level of resistance, associated with longer forces application durations, and also changes of acceleration during the displacements of the hand to perform the task.

In future studies, inactivating other motor areas involved in the control of manual dexterity, such as the premotor cortex and the supplementary motor area, should assess the exact implication of those areas in manual dexterity.

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Short Biography

After her formation in Psychology and Philosophy, Mélanie Kaeser made her PhD Thesis in Prof. Eric M. Rouiller's laboratory of Neurophysiology of Action and Hearing in the University of Fribourg in collaboration with the Neurosurgical Research Group of Drs. Jocelyne Bloch and Jean-François Brunet in the CHUV hospital in Lausanne. Her main topic was the assessment of autologous brain cell transplantation therapy to enhance functional recovery following motor cortex lesion affecting manual dexterity. She is now Postdoc in Eric Rouiller's lab, where she continues research on mechanisms underlying functional recovery following brain injury, as well as therapeutical strategies effects.

Effects of permanent or reversible inactivation of the hand representation in the primary motor (M1) cortex on precision grip performance in various motor tasks

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Abstract

Fine manual dexterity is a complex motor skill under control of M1 hand area via direct corticomotoneuronal projections, representing a prerogative of primates. Using transient and permanent inactivations of M1 hand area in adult macaque monkeys, this study aimed at quantitatively assessing different aspects of grasping and precision grip movements based on a palette of manual tasks. A modified version of the "Brinkman board" task assessed the number of pellets retrieved using precision grip from vertical and horizontal wells, the latter requiring additional wrist rotations. A modified version of the "Klüver board" task assessed different types of grasping using various combinations of fingers' association, by measuring the retrieval time from wells of different sizes. The "reach and grasp" drawer task assessed the load and grip forces to open a drawer against different levels of resistance, involving precision grip in a supination movement. The performance during the modified Klüver board and the drawer task were correlated to EMG activity exhibiting the time course of involved muscles. A permanent inactivation with ibotenic acid infusion in M1 hand area led to a dramatic modification of all motor parameters, followed by a slow incomplete functional recovery. In contrast, transient inactivation produced by repetitive transcranial magnetic stimulation affected more selectively and more less severely the different motor parameters. The cortical mapping changes following permanent inactivation was assessed using EEG recordings. These complementary approaches were developed to elucidate the mechanisms involved in motor recovery and to refine therapy improving rehabilitation. Because it was proposed that immediate adjacent spared cortical territories do not underlie the observed functional recovery following M1 hand area permanent inactivation [1], these complementary approaches will assess the still debated role of the contralesional M1 hand area, by transient inactivation with muscimol.

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Short Biography

Savidan Julie is a PhD student at the Laboratory of Neurophysiology of Action and Hearing directed by Prof. Rouiller E.M., of Fribourg University. She is graduated from Bordeaux University with a master in Neuropsychopharmacology and Addictology in 2007. She worked in Genfit, a biotechnological society, as research technician, to develop an animal model for Parkinson's disease in 2008. Since 2009, her PhD topic is to study spinal and cortical injury focused on fine manual dexterity impairment, to improve understanding of mechanisms underlying injury, the following recovery and the effect of different molecules as therapy.

A microcircuit model of primary motor cortex for the precision grip task

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Abstract

Primary motor cortex (M1) is the main origin of corticospinal and corticonuclear efferents. Corticomotoneuronal (CM) cells belong to the thick-tufted layer 5 pyramids and have a strategic position since they are the cortical output cells that target the spinal alpha-motoneurons directly. These CM projections are particularly important for independent finger movements. In thick-tufted layer 5 pyramidal cells (L5PC) the back-propagating action potential activated calcium spike firing provides an important non-linearity in processing long-distance inputs arriving at the apical tuft. Our modeling work aims at assessing how this characteristic spiking behavior influences the way in which the different inputs (from premotor cortex, somatosensory cortex, cerebellum and basal ganglia) are combined in M1.

Beginning with a highly detailed reconstruction of a thick-tufted L5PC in cat striate cortex, which had been stained in vivo, we collapsed the respective parts of the dendrite to their equivalent cable and doped it with known conductances. Our model cell reproduces the spiking behavior of the thick-tufted L5PC from biological in vitro experiments. This reduced model neuron is the core and first stage in the development of a biologically realistic model of the microcircuit in M1 whose output is the control of the precision grip. The reference biological data are the anatomical connectivity data and the extracellular recordings in M1 made by Muir and Lemon [2] for the precision grip task. Our goal is to contribute to a mechanistic understanding of what M1 does that will contribute in the long term to applications like brain-machine interfaces for human patients.

Acknowledgements: FS is supported by a SNSF grant, anatomical reconstructions by SNF Sinergia and HFSP.

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Short Biography

FS got a medical degree from the University of Zurich in 2009. Subsequently, he worked in the Ospedale Civico in Lugano as an intern for 2 years including the stroke unit and the neurological ward. The neurological clinic of the Ospedale Civico is the reference center for acute neurological diseases of the canton of this conference location. Since 2012 he is a PhD student at the Institute of Neuroinformatics in Zurich, exploring in more detail the neural basis of movements.

Neural correlates of passive forefinger kinematics: effects of amplitude, velocity and direction

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[3] Institute of Neuroinformatics, University of Zürich and ETH Zürich
[4] Department of Neuroradiology, University Hospital Zürich
[5] Department of Psychiatry, Psychotherapy, and Psychosomatics, Psychiatric Hospital, University of Zurich

Abstract

While the differential neural responses to passive and active movement have been well studied [1,2], there is little understanding about the relationship between the degree of passive movement and brain activity. The sense of position and movement involves the integration of different sensory modalities, some of which are mostly sensitive to dynamic movement, while others encode relative position. Thus, we hypothesized that these parameters are represented differently in the brain during passive forefinger movement. To confirm this assumption, we measured blood-oxygen-level dependent (BOLD) signal using functional magnetic resonance imaging (fMRI) in response to parametric changes in passively induced forefinger kinematics in a 2x3x3 factorial design. Nineteen right-handed healthy participants were exposed to combinations of forefinger flexion and extension imposed by an MR-compatible robotic manipulandum [3], which also measured forefinger interaction forces. Each subject was exposed to three levels of amplitude (10, 20 and 40% of maximum aperture) and three velocities (20, 40 and 80% of maximum aperture/sec), separately in flexion and extension. We found that contralateral primary and bilateral secondary somatosensory regions, as well as contralateral insula and ipsilateral cerebellum were positively linearly correlated with increases in passive movement velocity. This relationship also showed higher sensitivity during extension movement. Changes in amplitude did not show a linear relationship with BOLD response. This can be associated with the neural representation of muscle spindles, as they are mainly responsible for dynamic movement perception [4]. These insights will provide a greater understanding of the neural representation of kinematic variables, which could lead to improved therapeutic strategies for severely impaired patients following brain injury.

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Short Biography

Julio Duenas obtained his B.Sc. in biomedical engineering from the Universidad Iberoamericana, Mexico in 2009. He then worked as research engineer at EPFL under the supervision of professor Olaf Blanke. He obtained his M.Sc. in Robotics, Systems and Control from ETH Zurich in 2013. He is currently a research assistant at the Rehabilitation Engineering Lab at ETH Zurich working in the field of neuroscience robotics.

Area 3b neuronal responsiveness and hand use recovery after spinal cord injury in monkeys

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Abstract

It is well established that following damage to sensory inputs, the spared inputs expand their territory to the deprived zones in the target cortex. Studies are lacking, however, to quantify response properties of reactivated cortical neurons in the somatosensory system in monkeys and evaluate their relationships to functional recovery. We hypothesized that cortical reactivation was responsible, at least in part, for behavioral recovery after sensory loss. To test this hypothesis, we first train monkeys to perform reach-to-grasp tasks. When success scores reached a plateau, a unilateral dorsal column (DC) section at the C4-6 level of the spinal cord was made on the same side as the preferred hand in 5 monkeys. Five to 13 weeks after behavioral recovery, neural activities across the hand representation of area 3b were recorded with a 100-electrode array. This recording system offers the capacity to examine simultaneously the spikes from populations of neurons distributed across cortex with a known spatial arrangement, allowing us to visualize the cortical population or ensemble activity from an array of electrodes [1]. We found that even after extensive lesions, performance on reach-to-grasp tasks returned to pre-lesion levels; and the spared inputs from the hand expanded their territory to the deprived zones in area 3b. The neuronal response magnitudes to tactile stimulation on the hand in the partially deprived cortical region were usually weak, as reflected by slightly lower firing rates and slightly longer response latencies. Some digit representations were abnormal, such that receptive fields of presumably reactivated neurons were larger and more often involved discontinuous parts of the hand compared to controls (n = 5). We conlcude that the reactivation of neurons with near-normal response properties and the recovery of near-normal somatotopy likely supported the recovery of hand use [2].

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Short Biography

I, Hui-Xin Qi, obtained M.S. degree (1988) with Dr. Bin Wang from Beijing Normal University, China, and Ph.D. degree (1996) with Professor Dr. Marie-Claude Hepp-Reymond from Zurich University, Switzerland. My postdoctoral training was with Dr. Jon H. Kaas in Vanderbilt University, USA. Currently, I am a Research Assistant Professor in Vanderbilt University. For the past 2 decades, my main research interests have been focused on the anatomical and functional organization of the motor and somatosensory systems in normal, amputated, and spinal cord injured primates. Our ultimate goal is to uncover the mechanisms behind the plasticity after injury.

Mirror properties of macaque intra-cortical LFP

S. Waldert[1], R. Philipp[1], G. Vigneswaran[1], R. N. Lemon[1], A. Kraskov[1]*

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Abstract

It is well established that neuronal activity of cortical motor network of motionless observers is modulated by actions performed in front of them. Individual neurons with such properties are called mirror neurons and were discovered in macaque ventral premotor cortex (PMv). They have recently also been found in macaque primary motor cortex (M1) [1]. Since human EEG/MEG studies also described changes in beta oscillations in cortical motor areas during observation of an action [2], we investigated the mirror properties of the intra-cortical LFP recorded in hand regions of macaque PMv and M1 during action observation, i.e. while an experimenter grasped one of three different objects. Monkey arm/hand EMGs and eye movements were recorded simultaneously with LFPs.

LFP in PMv and M1 was clearly modulated by action observation. Modulations during observation were found in the low-pass filtered LFP (<5Hz) mainly when the experimenter grasped an object but also during release. Beta power decreased during observation of the grasping movement and increased or remained low during observation of the hold period. Modulations of LFP during observation were weaker than during execution but correlated in time. They differed between M1 and PMv and might indicate non-overlapping functional networks for execution and observation. Decoding LFPs during execution revealed more information about grasp-type in M1 than PMv-LFPs; decoding was reduced during observation.

Modulations in the LFP <5Hz during observation corroborate the genuine neuronal origin of this signal component, which has been shown to be a suitable control signal for BMIs.

Supported by Wellcome Trust, Marie Curie Postdoctoral Fellowship (S.W.)

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Short Biography

Alexander Kraskov is Wellcome Trust Senior Research Fellow at Sobell Department of Movement Neuroscience and Movement Disorders, UCL Institute of Neurology, Queen Square, London. He was originally trained in physics in Russia and received his PhD in statistical physics and data analysis methods in Germany. He recently completed his last postdoctoral training in non-human primate electrophysiology with Prof Roger Lemon and started his own lab supported by Wellcome Trust.

Variability statistics of motor cortical spiking activity revealed during resting state and motor behavior

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[4] Theoretical Systems Neurobiology, RWTH Aachen University, Aachen, GermanyAbstract

Abstract

Understanding the nature and origin of neuronal variability is essential for our understanding of information processing in cortical networks. To analyze variability in spiking activity we used 3 measures: (i) The coefficient of variation (CV) of inter-spike intervals (ISIs) measures the (ir)regularity of a sequence of spikes. Because it largely overestimates irregularity for firing rate changes, we use a local measure, the CV2 [1]. (ii) The Fano factor (FF), computed as the variance of spike counts divided by their mean, expresses the spike count variability across trials of a same experimental condition. (iii) We calculate the serial rank-order correlation (SRC) between neighboring ISIs as a measure of deviation from a renewal process [2]. We recorded simultaneously the spiking activity of 80 to 160 neurons using Utah arrays chronically implanted in motor cortex of 2 monkeys. We analyzed data recorded during a wakefulness resting-state condition (non-behavior) or a delayed reach-to-grasp task (behavior [3]). We found across all neurons a strong negative correlation between mean firing rate and mean CV2. However, if correlating for each neuron rate and CV2 in sliding windows, correlation is not significant in ~56% of the neurons, negative in ~34% and positive in ~10% of them. Furthermore, neurons with a significant SRC show a strong negative correlation between SRC and CV2. We found that SRC is mainly positive and significant in almost all neurons during non-behavior, whereas in only 20-30% of them during behavior. During behavior, FF is negatively correlated with firing rate and positively with CV2, and is lower in neurons with a negative than a positive SRC. When separating behavior in periods of wait and periods of movement, CV2 and firing rate are significantly lower and FF is significantly higher during wait than movement. We will discuss how these variability measures are related to behavior and the functional organization of motor cortical networks.

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Short Biography

I'm a Research Director at the CNRS in Marseille. By combining approaches from cognitive and theoretical neuroscience and recording massively parallel neuronal activity in monkey motor cortex, I study higher cognitive motor processes and investigate the temporal dynamics of cooperative, distributed cortical networks.

From vision to action: a comparative population study of hand grasping areas AIP, F5, and M1

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Abstract

Hand grasping requires the transformation of visual object information into corresponding hand actions. In the primate brain these processes are linked to area AIP (anterior intraparietal cortex), F5 (ventral premotor cortex) and M1 (primary motor cortex). Although these areas demonstrate selective responses when hand movements are planned or executed, it is up to now unclear how visual and motor information is encoded on the neuronal population level.

To address this question, we trained two macaques to grasp up to 50 different objects in a delayed reach-to-hold task. In this, we measured the kinematics of hand and arm together with spiking activity recorded from up to 300 single- and multi-units using microelectrode arrays. The high variation of visual stimuli and motor responses in this task allowed us separating visual attributes of objects from motor features of the hand. Canonical variant and hierarchical cluster analysis demonstrated a dominant visual role of AIP during both the planning and execution epoch. The neural population separated the objects primarily based on their shape and secondarily on their size. Furthermore, we found indicators for the processing of object affordances relevant for grasping. In contrast to AIP, we could identify in F5 a distinct motor representation that encoded the objects in motor terms. However, the highest correspondence to the recorded hand kinematics was observed in the M1 population activity that closely matched the multi-joint space of the hand and arm.

Together our results demonstrate distinct roles of AIP, F5, and M1 at the population level that are highly relevant for understanding how visumotor transformations are processed in the brain.

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Short Biography

I obtained my Diploma degree at the University of Applied Sciences Linz, Austria, where I decoded the spatial position of rats based on place cell activity. After my Master thesis I worked as in the research and software development department of Guger technoliges OEG, where I have developed neural interfaces. Since 2009, I am PhD student at the German Primate Center in Göttingen, where I have investigated visuo-motor transformations in macaque grasping areas AIP, F5 and M1.

COGNITIVE & CLINICAL NEUROSCIENCE

Third arm for surgeon: Embodiment study in virtual reality

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Abstract

Surgeons need assistance in almost every type of operation from open to laparoscopic and teleoperated surgery. The assistant should either work in parallel with the surgeon (e.g. holding the endoscope in laparoscopic surgery) or help him in performing a task that needs more than two hands (e.g. suturing, keeping tissue out of the way). The need of team work in these circumstances can be the source of error and efficiency decrease especially if the assistants are novice and/or unfamiliar with the surgeon [2]. In this study we investigate the possibility of having a third arm controlled by the surgeon to make him/her more independent, autonomous and dexterous [1]. Different experiments, proposed as games, are done in VR using the Kinect® camera for motion tracking. Three hands appear on the screen (two of which reproduce the user's two real hands and the third one controlled by the foot). The task is to manipulate three objects simultaneously. The learning time (time needed to totally succeed in realization of the task) is measured in each game. The subjects then fill a questionnaire. The aim is to study the mechanisms of embodiment of three independent hands as naturally as possible. About 10 subjects have already participated in the experiment. The current results show a tendency towards the ease of control three hands independently in this way. It is also reported that practice helps efficiently to enhance sense of ownership towards the third arm in dynamic experiments. Currently testing of this setup goes on with more people and with the development of the VR environment approaching realistic surgical situations. This opens up the possibility of new surgical techniques, frees space in the operating room and lowers risks and costs, as less assistive personnel and less communication will be needed during surgery.

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Short Biography

Elahe Abdi is a second year PhD assistant at EPFL. Her research lies in the joint domain of surgical robotics and neuroscience. Currently she works on the concept of having a third arm for the surgeon. She has completed her bachelor in Mechanical Engineering and master in BioMechanics at University of Tehran and Sharif University in Iran.

Perception of co-speech hand gestures in aphasic patients: Visual exploration during the observation of dyadic dialogues

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Abstract

Co-speech gestures can be referred to as hand movements that accompany spontaneous speech during conversation. Aphasia is an acquired language disorder which restricts verbal communication. Previous research in aphasic patients mainly focused on gesture production and neglected gesture perception. The few studies, which examined gesture perception in healthy subjects, used monologue stimuli (e. g. Gullberg & Holmqvist, 2006). The present study aimed to investigate the perceptive process of co-speech gestures during the observation of dyadic dialogues. It was expected that aphasia and the presence of co-speech gestures modulate visual exploration behavior.

Twenty-three aphasic patients and 23 age- and sex-matched healthy control subjects participated in the study. Visual exploration behavior was assessed by means of a contact-free infrared eye-tracker while subjects were watching videos depicting spontaneous dialogues. The factors co-speech gesture (present and absent), gaze direction (to the speaker and to the listener), and region of interest (ROI), including hands, face, and body, were analyzed separately for the depending variables cumulative fixation duration and mean fixation duration.

We found a co-speech gesture x gaze direction x ROI interaction, indicating that the presence of a co-speech gesture encouraged subjects to look at the speaker's hands. Further, there was a significant main effect of group and a significant. gaze direction x ROI x group interaction revealing that controls showed longer cumulative fixation duration on the speaker's face than aphasic patients.

Co-speech gestures seem to guide the observer's attention towards the speaker, the source of semantic input. This is a finding that could be of particular importance for aphasic patients who showed reduced cumulative fixation duration on the speaker.

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Short Biography

Basil Preisig obtained a Master's degree in Psychology with in-depth studies in neuropsychology and clinical psychology at the University of Bern in 2012. Subsequently, he started an interdisciplinary PhD in Neuroscience at the Medical Faculty. His research interests are nonverbal communication strategies such as gesture production and gesture perception in healthy and brain damaged populations.

Enumeration in children with developmental coordination disorder

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[2] Cognitive Neuroimaging Unit, INSERM, U992, CEA/SAC/DSV/DRM/NeuroSpin.

Abstract

Children with Developmental Coordination Disorder (DCD) are impaired in gross and fine motor functions and balance. DCD interferes with academic achievement and daily life. It is associated with persistent academic difficulties, in particular within mathematical learning. In the present study, we aimed to understand their impairments in numerical cognition using an approach that taps very basic numerical processes: 1) Subitizing, related to the object-tracking system, OTS, which allows to accurately and effortlessly perceive small numerosity; 2) estimation, related to the Approximate Number system, ANS, which allows to estimate objects and obeys Weber's law; and 3) counting abilities, an early cultural acquisition, which uses simple procedures and principles (e.g., cardinality). We employed two verbal tasks to assess visual enumeration in forty 7-10 years-old children with or without DCD. On both tasks, children enumerated the visual sets with numerosity within or beyond the classical subitizing range with a flashed or an untimed presentation. The flashed enumeration task showed the existence of a reduction of the OTS in children with DCD. Discrimination of larger numerosity showed a typical ratio effect but a greater imprecision in DCD –as revealed by the Weber fraction-, hence suggesting a greater imprecision of the ANS. The unlimited time enumeration task showed that DCD children like controls use a serial counting routine and understand basic principles necessary to perform counting. However, their counting procedure is very inefficient. Errors analysis showed that DCD children skipped or double counted objects. As gestures contribute to the development of counting skills, dysfunctional coordination seems to prevent children with DCD from keeping track of counted objects. Consequently, DCD children may fail to benefit from counting experience to refine their ANS. Those abilities and impairments in basic numerical processes in DCD children should be taken into account to develop future remediation tools.

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Short Biography

Alice Gomez is a lecturer in Cognitive Psychology at the University Claude Bernard Lyon 1 and a member of Angela Sirigu's team in the Center for Cognitive Neuroscience (CNC). She completed a PhD in cognitive psychology in Grenoble (LPNC) on the interplay between spatial processing and episodic memory using behavioral and fMRI approach with a particular interest on developmental and acquired amnesia. Her interest in the neurocognitive mechanisms of developmental disorders led her to perform a postdoc in Stanislas Dehaene's lab. She studied cognitive and cerebral dysfunctions of children with Developmental Coordination Disorder with a particular interest on mathematics.

Standardization of american sign language trials for comparison of EMG and joint angles

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[2] Department of Biomedical Engineering, Northwestern University, Evanston IL, USA

Abstract

Simultaneous recordings of EMG and kinematics during complex hand movements are necessary for a broader understanding of how the intact hand is naturally controlled. Whereas in gait analysis, movement segments are often lined up using foot switches, in "open-loop" movements this method cannot be used. Objective determination of start- and endpoints of a movement has been proposed based on on multiple sources of information [1], for example hand posture, movement velocity, and time. In this study, we aimed to develop an objective method to align American Sign Language (ASL) movements in time, enabling comparison of these trials within and between subjects.

Intramuscular EMG data were recorded in seven subjects using bipolar wire electrodes. EMG signals were collected at 2000 Hz, filtered, and normalized to maximum voluntary contractions. Joint angles were measured using a Cyberglove. Subjects were instructed to closely follow a video of a hand gesturing an "L" or a "D" in ASL, starting and ending each posture with completely stretched fingers (Fig 1).

Specific start and endpoints of the captured hand movement were identified by solving for the maximum values of mathematical functions that weighted joint position and joint velocity of the MCP joint of the middle finger, and the time weighted either early (Eq. 1a) or late (Eq. 1b) in the trial.

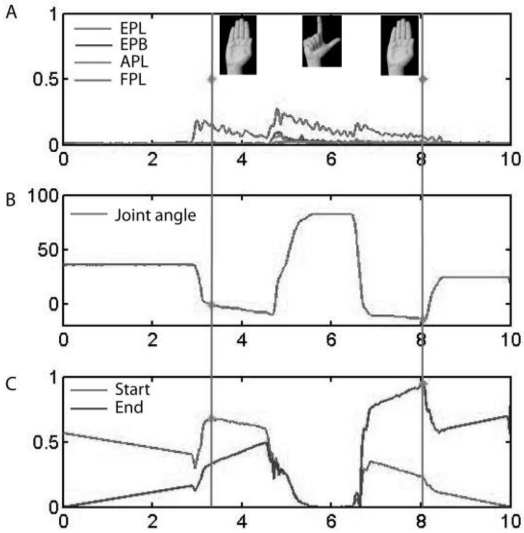

Figure 1. A. Normalized EMG activity of EPL, EPB, APL and FPL. Insets are the postures achieved during the trial. B. Joint angles of the MCP joint of the middle finger. C. Objective functions for both start- and endpoint, calculated based on joint angles and angular velocities of middle finger joints. Start- and endpoint of this trial determined using the mathematical function are plotted across all figures.

$$\text{Start} = \text{MAX}\left\{\left[1-\frac{i-1}{n}\right]\left[1-\frac{\theta_i^{MCP3}}{\theta_{\max}^{MCP3}}\right]\left[1-\frac{\dot{\theta}_i^{MCP3}}{\dot{\theta}_{\max}^{MCP3}}\right]\right\} \quad (1.a)$$

$$\text{End} = \text{MAX}\left\{\left[\frac{i-1}{n}\right]\left[1-\frac{\theta_i^{MCP3}}{\theta_{\max}^{MCP3}}\right]\left[1-\frac{\dot{\theta}_i^{MCP3}}{\dot{\theta}_{\max}^{MCP3}}\right]\right\} \quad (1.b)$$

We have successfully implemented this method to define a standardized motion cycle for analyzing complex hand movements using the repeatable, standardized neutral start and end position (Fig 1). We expect this method to enhance quality of data analysis and interpretation of data across different gestures and tasks as well as across different subjects.

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Short Biography

Marije finished her MSc in Human Movement Sciences at VU University, Amsterdam, and obtained her PhD at the Academic Medical Center in Amsterdam focusing on musculoskeletal adaptation in the spastic arm of cerebral palsy patients. She is currently appointed as a Post-doctoral Research Associate at the Sensory Motor Performance Program of RIC, focusing on hand biomechanics.

Cues in the execution of everyday sequential tasks: Support or interference?

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Abstract

The aim of the present study is to determine what role cues can play in the execution of everyday sequential actions. The influence of two main factors is taken into account – the impact of deficits presented after brain injury, the type of sequence that is being cued, and the level of cueing. Twenty-seven control participants and ten patients were assessed on their performance of tea-making in conditions involving either instructions given at goal level (e.g. make a cup of tea) or at the sub-goal level (e.g. add water to kettle). Two action sequences were tested in each participant (their familiar habitual tea & action sequence, and a non-familiar sequence). The results suggest that controls made more errors in the non-routine task; with cues at sub-goals enhancing performance. In contrast, in the task involving routine behaviours controls were less able to suppress an automatic sequence execution when cues were given at the sub-goal level, making more errors in this condition. Patients responded differently to cues depending on the exhibited type of impairment. Patients with sustained attention deficits struggled to adhere to cues when given at sub-goal level, in contrast patients with action disorganization deficits made most errors when cues were at the goal level. Results are discussed in view of developing intervention strategies for patients, as well as conclusions regarding mechanisms underlying sequential behaviours themselves.

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[2] Schwartz, M. F. (2006). The cognitive neuropsychology of everyday action and planning. Cognitive Neuropsychology, 23(1), 202-221.

Short Biography

Graduated in 2011 from the Warsaw School of Social Sciences and Humanities in Poland with a Master's Degree in Psychology. Graduated in 2014 from the University of Birmingham with a Master's Degree in Brain Injury Rehabilitation. Currently employed at the University of Birmingham as a research associate on the CogWatch project, aiming at cognitive rehabilitation of apraxia and action disorganization syndrome.

The cognitive and neural correlates of apraxia

R. Evans[1]*, W.-L. Bickerton[1], G. Humphreys[1], J. K. Lau[1], A. Worthington[1], P. Rotshtein[1]

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Abstract

The aim of this study is to understand the neural and cognitive systems underlying apraxia using function-lesion mapping of gesture tasks. Data from 293 sub-acute stroke survivors included: a comprehensive neuropsychological battery (Birmingham Cognitive Screen, BCoS) to test the cognitive domains of praxis, memory, attention, language and number; the Barthel Index and brain images to assess the integrity of grey matter. Apraxia was assessed using three gesture tasks imitation, production and recognition. Our first analysis aimed to explore relations between the praxis gesture tasks and the other cognitive-behavioural measures. We found significant relationships between apraxia and language, calculation and spatial attention (neglect). Barthel as a measure of functional independence correlated with language, attention, memory and mood, however the largest correlations were with the praxis tasks especially gesture production and imitation. The three gesture praxis also highly correlated. Therefore to be able to tease apart the underlying processes we conducted principal component analysis. This revealed three components: a shared component across all three gesture tasks; a semantic component; and visual-verbal component. A follow up voxel-based morphometry analysis showed that the shared component was linked with lesions to bilateral middle temporal lobes and the left inferior parietal lobe. Impairment in semantic component correlated with lesions to the posterior cingulate gyrus and right inferior parietal lobe. In contrast, impaired non-semantic processing (imitation) was associated with lesions in the left anterior cingulate gyrus, left hippocampus and left inferior parietal lobe. Poor performances on tasks relying on processing of verbal inputs were related to lesions in the middle temporal gyrus, anterior cingulate gyrus and thalamus; whereas deficits with processing of visual inputs were correlated with lesions in the cerebellum, right occipital pole, right precuneus and bilateral cuneus regions. Overall the data support existing cognitive models for apraxia, demonstrating that apraxia is a hetrogneous syndrome that can arise from lesion to multiple dissociated networks. However there is also a strong shared component that was associated with lesions to left inferior parietal and bilateral temporal lobes.

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Short Biography

Rachel Evans has a background in investment and finance and moved into psychological research in 2003. She is currently employed by the University of Birmingham and facilitates Stroke research within the NHS.

Illusory ownership and agency induced by passive and active pinching

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Abstract

Bodily self-consciousness involves the feeling that our body belongs to us, termed “body ownership”, as well as the feeling that we control and generate the actions of our body, termed “agency” [1] and is believed to originate from the integration of congruent multisensory signals. By means of conflicting multisensory information, bodily self-consciousness has been experimentally manipulated to induce a feeling of ownership for an external object such as a rubber hand [2] or a virtual avatar [3][4]. Most studies investigating illusory ownership for external objects employed visuo-tactile stimuli, not involving any overt motion by the participant.

In this study, we developed a novel paradigm combining robotics and virtual reality to investigate illusory effects induced by visuo-proprioceptive and visuo-motor conflicts. Subjects either actively moved a robotic finger interface with their right index finger in a pinching movement against the opposing thumb, or were passively moved by the robotic device. The displayed virtual avatar performed a pinching action either synchronous or asynchronous with the real hand, and with either the same hand (right) or the other hand (left) (2x2 design). Following each active/passive exploration period, subjects were asked to rate their feeling of ownership over the virtual hand and of agency for the pinching movement. In data collected from 27 subjects, we found that the feeling of ownership for the virtual hand is maximized when the movements of the real and virtual hand are synchronized ($p_{passive}<0.0001$, $p_{active}=0.001$) and performed with the same hand ($p_{passive}=0.0006$, $p_{active}<0.0001$). Furthermore, a group of participants reported a new type of illusory effect, not reported before in the literature: the feeling of illusory agency during passive pinching ($p_{synchrony}<0.0001$, $p_{congruency}=0.009$). The results show further evidence that the feelings of ownership and agency are generated and can be manipulated by congruent sensory-motors signals.

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Short Biography

Michel Akselrod obtained a BSc (2010) and a MSc (2012) in Life Sciences from the Ecole Polytechnique Fédérale de Lausanne (EPFL). During his masters, he specialized in neurosciences and conducted his master thesis at the University of Houston, Texas USA, under the supervision of professor Haluk Ogmen (UofH, USA) and professor Michael Herzog (EPFL, CH), studying the visual system using fMRI. In September 2012, he started his PhD in a joint program between the laboratory of Cognitive Neuroscience at EPFL, directed by professor Olaf Blanke, and the rehabilitation engineering laboratory at ETHZ, directed by professor Roger Gassert. He is interested in studying how the representation of the body in the brain can be mapped and modulated with tools such as robotics, virtual reality and real-time fMRI neurofeedback.

Neuromodulation averts phantom pain and reinstates the deprived cortex to the sensorimotor system

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[2] Oxford Centre for Enablement, Nuffield Orthopaedic Centre

Abstract

Following arm amputation individuals frequently report experiencing vivid sensations of the missing limb. These 'phantom' sensations are often experienced as painful, manifested in an intractable, and highly debilitating, chronic neuropathic pain syndrome (phantom limb pain, PLP). Neurorehabilitation approaches, designed to reinstate the representation of the missing hand into the deprived cortex, are ineffective. We recently showed that the magnitude of chronic PLP positively scales with maintained representation of the missing hand during voluntary performance of phantom movements, as well as functional isolation of the deprived cortex. The current study was aimed at modulating PLP using non-invasive brain stimulation (neuromodulation), in a double blind, counterbalanced and sham-controlled design.

Twelve unilateral upper-limb amputees suffering from chronic phantom pain underwent twenty minutes of excitatory (anodal, 1mA) or sham brain stimulation (transcranial direct current stimulation, tDCS) to deprived sensorimotor cortex while performing a PLP-inducing task. Task-based and resting-state functional magnetic resonance imaging scans, as well as subjective pain ratings, were obtained prior to and post neuromodulation. Whereas PLP was increased in the sham condition, excitatory stimulation of the deprived sensorimotor cortex averted this pain increase. Phantom pain induction was seen in conjunction with functional isolation of the phantom hand area from the sensorimotor cortex, and decreased functional connectivity between the intact and phantom hand sensorimotor cortices. The prevention of PLP increase following excitatory neuromodulation was related to a functional reintegration of the phantom hand cortex into the sensorimotor system, as reflected in increased fMRI activation in sensorimotor areas during phantom hand movements.

Our results reveal tDCS as a promising potential tool for the management of phantom limb pain and highlight the tight coupling between PLP and the sensorimotor system. These results should be taken into consideration when designing novel therapies to relieve PLP.

Short Biography

I am a DPhil student at the neuroimaging center (FMRIB) of the University of Oxford. In my research I use neuroimaging techniques and non-invasive brain stimulation to study brain plasticity following the loss of sensory in- and outputs (i.e., amputation). My DPhil is funded by the Medical Sciences Graduate School Studentship and supervised by Dr Tamar Makin and Prof. Heidi Johansen-Berg. I am also collaborating with Prof. Christian Beckmann, located at the Donders Institute in the Netherlands.

NEUROPROSTHETICS

Action Reading Machine: A proposal for generalising Fadiga's (1995) method of TMS-induced motor-evoked potentials

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Abstract

We propose the further development of Fadiga's MEP method [1], where Transcranial Magnetic Stimulation (TMS) over M1 is used to induce Motor Evoked Potentials (MEPs) in the related arm muscles as a 'read-out' of movement-selective motor cortical states. Fadiga et al. [1] first demonstrated that MEPs recorded during action observation were strongest in those muscles that are involved in executing the observed action. Whereas initially these action-selective MEPs were believed to primarily reflect upstream activity in premotor 'mirror' regions, over the last 20 years evidence has been accumulating for the presence of mirror-like activity in M1. Recently, Vigneswaran et al. [2] additionally showed that the discharge of 'facilitation-type' neurons was remarkably lower during observation than during execution, and that 'suppression-type' neurons actually increased firing during execution. Whilst these findings certainly caution against simply equating cortical motor states during action observation and execution, we still believe that Fadiga's MEP method can provide a rich source of information about motor cortical states in human experiments.

First, whereas in previous studies only a small number of muscles was recorded, we suggest recording from as many hand-, arm- and shoulder muscles as technically feasible (using a 32 channel EEG system). Second, the most appropriate stimulation intensity, coil shape and size for such a 'shotgun' stimulation approach will need to be identified. Third, suitable stimulation sequences will need to be piloted for estimating the time course of activation during, e.g., action observation and execution. And fourth, we propose that pattern classification techniques are used to identify 'fingerprints' of a wide range of individual motor actions. As a result, such an Action Reading Machine (ARM) could provide researchers with time series of 'activation strength' of multiple action representations that might be concurrently prepared or simulated (e.g., Vogt et al. [3]).

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Short Biography

Stefan Vogt is an experimental psychologist and neuroscientist and has widely published on action observation, imitation learning and automatic imitation. He gained a diploma in Psychology at Münster University and received his PhD at Bremen University in 1988. He then worked as a Senior Researcher at the Max-Planck-Institute for Psychological Research in Munich, before joining the Psychology Department at Lancaster University in 1995. His research is focussed on relationships between perception, motor imagery, and action, and he uses a range of behavioural and neuroscience methods, kinematic data, reaction times, and functional magnetic resonance imaging (fMRI).

Unsupervised segmentation of natural movement for smart prosthetic control

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Abstract

While the mechanical structure of human limbs is well understood, their control, and its computational implementation are unclear. The window into this problem may lie within the vast amounts of data we are able to collect from human behaviour. Yet, analysing very big data sets is a challenge in itself and state of the art Bayesian approaches can easily become computationally intractable, or reduce to models so simple that they fail to capture the underlying structure. Here, we present a computationally simple method for segmenting data into basic actions and exploit this simplified structure to develop a smarter control algorithm for prosthetic devices based on observing the movement of intact limbs. Our method combines a series of powerful, yet inexpensive algorithms to achieve segmentation and clustering of the time series: PCA, approximate Bayesian segmentation and temporal correlation. We validate our approach on a synthetic data set for which the ground truth is known and show that the proposed method is extremely robust to noise and parameter variation. Computational complexity scales linearly with the number of data points. We then apply the method to a large dataset of natural hand movements recorded from healthy subjects, allowing us to extract subject-independent movement descriptors. We simulate amputees by removing multiple dimensions of movement information and show that we can effectively reconstruct this missing data based on the movement descriptors found with complete data. We achieve significantly better predictions than would be possible by directly correlating observed and missing data. This work emphasises tight relationship between our limbs during everyday activities and opens a new pathway for the control of prosthetic limbs.

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Short Biography

Andreas Thomik received his B.Sc. in Microengineering from EPFL in 2010, followed by a M.Sc. in Biomedical Engineering from Imperial College London in 2011 where he stayed to pursue a Ph.D. in the field of Neurotechnology at the Brain & Behaviour Lab. His research interests range from the neuroscience of sensorimotor control to applications in prosthetics and assistive devices. The main focus of his PhD thesis is the hierarchical structure and grammar of human behaviour, for which he has developed computational methods and experimental paradigms.

Neural mechanisms of non-invasive brain-machine interfaces control

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Abstract

Advances in neuroscience and engineering have led to the development of technologies allowing the control of external devices through real-time decoding of brain activity, using invasive and non-invasive brain-machine interfaces (BMI).

Non-invasive BMIs based on surface EEG sample from large brain regions but have not the spatial resolution to describe the mechanisms throughout the brain involved in BMI control.

Here we developed an EEG-BMI-fMRI protocol that allowed us to accomplish real-time, motor imagery-based, non-invasive BMI based on surface EEG recordings while recording brain activity using fMRI.

Sixteen healthy subjects participated in the study. BMI was obtained using a 64 channel MR-compatible EEG, while BOLD signal was acquired using a 3T scanner. A previously used BMI algorithm based on the real time analysis of the mu-rhythm was adapted for on-line classification.

Participants were instructed to perform lateralized motor imagery with visual feedback: following a directional cue, they had to control the movement of a cursor by imagining clasping their left or right hand. Additionally, in half of the trials, the visual feedback was experimentally manipulated by inverting the direction of the cursor (deviated trials) to investigate the effects related to such visuo-neural conflicts.

In the left and right motor imagery conditions, fMRI results revealed activations in premotor cortex, posterior parietal cortex, supplementary motor area, but also in anterior insula and occipital cortex, with stronger activation in contralateral premotor cortex. Furthermore, contrasting the non-deviated with the deviated condition revealed activation in the basal ganglia. Our results extend previous EEG-BMI-fMRI data and present a novel approach that allows to generate BMI control based on EEG signals recorded during 3T fMRI.

We conclude that when controlling a non-invasive BMI, human subjects rely on a distributed and bilateral network including the fronto-parietal, visual and insular cortices, and basal ganglia.

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Short Biography

Silvia Marchesotti obtained a BSc (2008) in Biomedical Engineering and a MSc (2010) in NeuroEngineering from the University of Genoa. During her master thesis conducted at the Laboratory of Psychophysics (EPFL), she focused on the technical aspects of the combined use of EEG and TMS. In 2011, she started her PhD in a joint collaboration between the laboratory of Cognitive Neuroscience (prof.Olaf Blanke) and the Laboratory of Robotic Systems (prof. Hannes Bleuler) at EPFL. The main topic of her thesis concerns the investigation of bodily self-consciousness mechanisms related to Brain Computer Interfaces (BCI) mediated action, as well as to executed movements.

Novel Electrocorticographic Brain-Computer Interface Framework for Dexterous Control of a Robotic Hand

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Abstract

An implanted chronic brain-computer interface (BCI) could improve the quality-of-life for individuals with severe neuromuscular deficits by providing a system to enact intuitive, volitional control of assistive devices. Electrocorticography (ECoG)-based control systems for dexterous upper-body robotic prostheses have shown promise to fulfill this role. However, current methods for analyzing and modeling ECoG data are still relatively limited, relying primarily on linearly translating power in single high-frequency bands (70-200Hz) to the movement of a cursor. To be effective in the long term, a BCI system for hand prosthetics must be developed such that it can replicate natural human control by taking advantage of motor primitives, as represented in ECoG data, as well as exploit the brain's natural abilities, including its remarkable plasticity, to accomplish fine manipulation tasks. Here we demonstrate preliminary techniques for dimensionality reduction of ECoG motor and sensory field potential recordings into synergistic motor primitives and present a framework to control a highly dexterous and adaptable robotic hand. Utilizing ECoG data recorded at different resolutions (macro, mini, and micro grid formats) we are able to test a variety of strategies for robotic control as well as better understand the neural dynamics of innate human hand control. Leveraging recordings from 10 subjects, implanted with clinical (10mm spacing), medium (5mm spacing), and high-resolution (3mm spacing) platinum subdural ECoG grids (implanted as per separate epileptic clinical considerations), suggests the presence of synergistic movements of individual digit joints during coordinated grasping further establishing this type of dimensionality reduction as a robust set of targets for control of the robotic systems. Through this system, we hope to provide a platform by which to significantly advance our understanding of the computational basis of human manipulation capabilities and enhance the utility of ECoG for practical brain-computer interfaces for hand prosthetics.

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Short Biography

Devapratim Sarma is a PhD Candidate in the Department of Bioengineering at the University of Washington. His current research under the guidance of Dr. Rajesh Rao and Dr. Jeffrey Ojemann focuses on the computational analysis of electrocorticographic data during dexterous hand manipulations to better understand the neural circuits and encoding mechanisms related to motor control. He is also heavily involved with the NSF Center of Sensorimotor Neural Engineering. Prior to his time in Seattle, Dev received a B.S. in Bioengineering (2008) and a B.S. in Animal Physiology and Neuroscience (2009) from the University of California, San Diego.

HAPTICS & DEXTERITY

Broad-band tactile noise is most effective in improving motor performance and is most pleasant

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Abstract

Modern attempts to improve human performance focus on stochastic resonance (SR). SR is a phenomenon in non-linear systems characterized by a response increase of the system induced by a particular level of input noise, and which is consistent with higher local and long range synchrony. Recently, we reported that an optimum level of 0–15 Hz mechanical noise applied to the human index finger improved static isometric force compensation. A possible explanation was a better sensorimotor integration caused by increase in sensitivity of peripheral receptors. The present study in 10 human subjects compares SR effects in the performance of the same motor task and on pleasantness, by applying three mechanical Gaussian-noises on the fingertip receptors (0–15 Hz mostly for Merkel's receptors, 250–300 Hz for Pacini's corpuscles and 0–300 Hz for all). We document that only the 0–300 Hz noise induced SR effect during the transitory phase of the task. In contrast, the performance was improved during the stationary phase for all three noise frequency bandwidths. This improvement was stronger for 0–300 Hz and 250–300 Hz than for 0–15 Hz noise. Further, we found higher degree of pleasantness for 0–300 Hz and 250–300 Hz noise bandwidths than for 0–15 Hz. Moreover, in recent experiments in cats we confirmed that spinal neurons activated by Pacini's corpuscles exhibited a stronger SR effect for optimal tactile noise than those spinal neurons activated by Merkel's receptors. Thus, we show that the most appropriate noise that could be used in haptic gloves is the 0–300 Hz, as it improved motor performance during both stationary and transitory phases. In addition, this noise had the highest degree of pleasantness and thus reveals that the glabrous skin can also forward pleasant sensations.

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Short Biography

Elias Manjarrez received the B.Sc. degree in physics, the M.Sc. degree in physiology, and the Ph.D. degree in neuroscience from the Center for Research and Advanced Studies of the National Polytechnic Institute CINVESTAV-IPN, Mexico. Since 2001, he has been head of laboratory at the Institute of Physiology in Puebla, Mexico. Prof. Manjarrez and colleagues published the first demonstration of these phenomena: internal stochastic resonance (SR) in the central nervous system, the SR in the motor system and the multisensory SR.

Upper limb movement deficits in cerebral palsy

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Abstract

Three-dimensional movement analysis (3DMA) is being increasingly used to evaluate upper limb movements, though the interpretation of the multiplicity of data remains complex. Here, we introduce a summary index, the "Arm Profile Score" (APS), to quantify upper limb movement deficits in children with unilateral cerebral palsy (UCP).

Twenty children with UCP (10.9ys±2.9ys) and 20 individually age-matched typically developing children (TDC) were assessed using a standardized, reliable protocol for upper limb 3DMA, including reach, reach-to-grasp and gross motor tasks [1]. Marker tracking was done with the Vicon MX-system (Oxford Metrics Group, UK) and kinematics were calculated following ISB-recommendations [2] using customized data analysis tools [3]. In children with UCP, the House-score (functional hand use) and clinical measures of muscle tone and strength were also assessed.

The APS is calculated as the RMS difference between kinematic data of the individual child with movement deficits and the average data from TDC and can be decomposed into 13 Arm Variable Scores (AVS), representing individual joint angles. Significant correlations were found between House-scores and APS (ρ -0.63 to -0.80), i.e. children with lower House-scores had more deviating arm kinematics. Increased wrist tone, and decreased forearm and grip strength were also significantly correlated with higher APS-scores, especially for the reach and reach-to-grasp tasks (ρ_{tone} 0.64 to 0.81; $\rho_{strength}$ -0.54 to -0.73). This study provided a sound base to use the APS to evaluate upper limb movement deficits in children with unilateral CP. Current results suggest that treatment aimed at distal tone reduction or strength training might influence upper limb kinematic deficits. Further study using bimanual tasks and the quantitative assessment of mirror movements will deepen our understanding of the impact of the underlying brain lesion in the motor control of each hand.

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Short Biography

I graduated as an MSc in Rehabilitation Sciences and Physiotherapy in 2005 at the KU Leuven (Belgium), where I continued working and obtained my PhD in Biomedical Sciences in 2011. My research has resulted in the development of a standardized, reliable protocol for upper limb three-dimensional movement analysis, including an open-source data analysis tool. In October 2012, I started at the Neural Control of Movement Lab (ETH Zurich, Switzerland), where I now focus on the sensorimotor system and how changes in brain networks relate to upper limb deficits in children with cerebral palsy.

Single finger object manipulation

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Abstract

When grasping an object between two digits, the load and the grip force are adjusted to the friction between the skin and the object to anticipate slips and ensure the continuation of the task [1]. Yet, during object manipulation the digits' action is alternated and the balance of forces between them is redistributed. Little is known regarding the sensory inputs or the behavioural consequences of a fingertip on different contact surfaces when dragging an object (elbow in neutral position). Here, in one participant, the applied normal (FN) forces by a single digit (digit 2) were investigated when comparing dragging six times backwards (BK) and forwards (FW) a servoed-controled object having inertial, viscous and friction properties, with different contact surfaces: sand paper (SP), suede (SU) and silk (SI). Either the object was dragged with the digit in a constant flexed (FLEX), or extended position (EXT), or dynamically flexing and extending the digit (DYN). When performing the BK and the FW drags, a main trial effect (BK and FW: $p<0.001$), a trial x position (BK and FW: $p<0.001$) and a trial x surface interactions (BK and FW: $p<0.001$) were found. Post-hoc tests revealed that the peak of FN developed throughout trials significantly differed between all positions in BK (all pairwise: $p<0.001$) and FW (all pairwise: $p<0.01$). Regardless of the surface, when comparing the averaged FN developed before and after each backwards dragging, it increased of 95% (±40%) after the DYN ($p<0.001$), slightly decreased after the EXT of -9% (±15%; $p<0.001$) but remained steady after the FLEX position ($p=0.215$). Our preliminary results suggest a posture-dependant specific control of the digit, likely attributable to the biomechanics of the metacarpophalangeal joint. More data will be collected to confirm these results. Also, we will compare the control of the digit 2 when dragging a servoed-controled object with different mechanical properties.

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Short Biography

Aude-Clémence Doix received a Ph.D. in Health Science from the Norwegian University of Science and Technology (Trondheim, Norway) and a Ph.D. in Human Movement Science from the University of Nice - Sophia Antipolis (Nice, France) in 2013. Aude-Clémence Doix currently holds a postdoctoral position at the Department of Integrative Medical Biology at the University of Umeå where her research focuses on the neuromuscular mechanisms of the sensorimotor control and muscle performance in humans.

Can sensory feedback modulate cross education?

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Abstract

Cross education is the process whereby training of one limb gives rise to enhancements in the performance of the opposite, untrained limb. The effect of providing mirrored visual feedback of the moving limb (during unilateral training), on the cross education of the opposite (untrained) limb, was investigated in the context of a task that required maximal motor output. In Experiment 1 thirty-six participants trained under one of three different visual feedback conditions: mirrored visual feedback of the training (left) limb (n=12); no visual feedback of either limb (n=12); and visual feedback of the inactive (right) limb (n=12). Training consisted of 300 discrete, ballistic wrist flexion movements executed as fast as possible. The participant was instructed to maximise the peak acceleration of the flexion movement. Auditory feedback indicated whether performance improved or did not improve on each successive effort. Performance of the right limb on the same task was assessed prior to, at the mid-point and following the period of left limb training. The transfer of performance to the untrained limb (expressed as a percentage of the improvement of the trained limb) was markedly greater for the mirrored visual feedback group (136%) than for the no visual feedback group (70%) (W=92, p=0.007, r=0.45). The group that received visual feedback of the inactive limb did not differ from the group that received no visual feedback group in terms of the level of transfer. Experiment 2 was a replication of Experiment 1 with only two groups: Mirror (n=33) and No-Mirror (n=48). In this case, visual feedback was found to have no effect upon transfer. The outcomes are discussed in terms of theoretical models that have been proposed to account for the phenomenon of cross education. The possibility for added benefit from adjunctive vibrotactile feedback is also considered.

Short Biography

I graduated from Queen's University, Belfast in 2010 with a first class honours Bachelor of Science degree in Psychology, and then progressed to PhD level under the supervision of Professor Richard Carson. For the final two years of my PhD, I conducted neuroimaging research at Trinity College Institute of Neuroscience, Dublin, using a combination of resting-state functional magnetic resonance imaging (rs-fMRI), task-based fMRI, Diffusion Tensor Imaging (DTI) and Transcranial Magnetic Stimulation to investigate upper limb function. In January 2014 I commenced post-doctoral research at ETH Zurich in the Neural Control of Movement laboratory under the supervision of Professor Nicole Wenderoth.

Comparison of bimanual control manifolds in daily tasks

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[3] MRC Clinical Sciences Centre, Imperial College London

Abstract

Humans continuously interact with their physical environment, mostly by using one or both hands. Yet, it is not understood how the brain achieves this coordination, and in particular whether the hands make use of a unified control strategy, which they adapt to the task, or if there are task-dependent control strategies, which are shared across humans, possibly as result of evolution. Constrained laboratory settings, however, will only provide reduced insight into these questions and the variety of natural bimanual movements.

We overcome the limitations of laboratory experiments by recording the hand movements from ten right-handed subjects performing tasks from daily living (e.g. folding a blanket) using two data gloves. Using Principal Component Analysis, we compute the task-dependent eigenspace of the left, right, and combined hands, thus informing us about the different control manifolds subjects use to achieve a given task, as well as enabling us to quantify the differences between and within the control manifolds of individual subjects. Interestingly, in tasks requiring only one hand for active manipulation of the object, while the other acts as a stabiliser, (e.g. opening/closing a bottle), characteristic features of individual hand movement allow us to identify the subject performing them. However as soon as tasks become bimanual, the inter subject distinction diminishes. Our findings provide insight into coordination of hand movements in natural settings and thus contribute to a better understanding of the development of the human motor system. Furthermore, these results suggest a novel method to measure the degree of bimanual involvement in specific tasks, and have the potential to inform us about how movement in the dominant hand influences motion in the other hand.

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Short Biography

Andreas Thomik received his B.Sc. in Microengineering from EPFL in 2010, followed by a M.Sc. in Biomedical Engineering from Imperial College London in 2011 where he stayed to pursue a Ph.D. in the field of Neurotechnology at the Brain & Behaviour Lab. His research interests range from the neuroscience of sensorimotor control to applications in prosthetics and assistive devices. The main focus of his PhD thesis is the hierarchical structure and grammar of human behaviour, for which he has developed computational and experimental techniques.

Human grasping in unstructured environments

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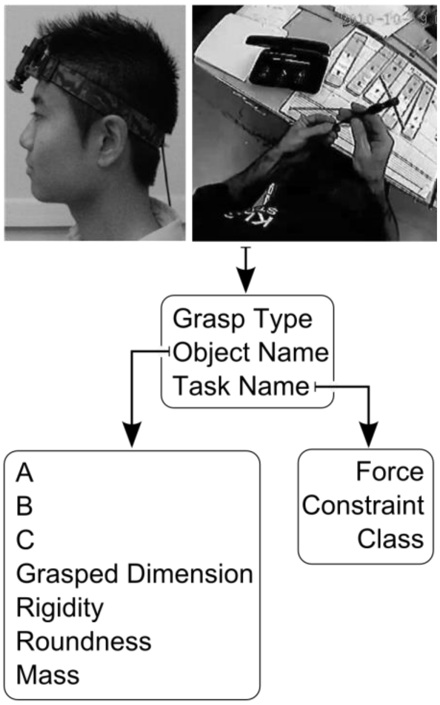
Abstract

We present an analysis of human grasping behavior in unstructured environments. A head-mounted camera recorded two housekeepers and two machinists during their regular work. The full dataset contains 27.7 hours of tagged video and represents a wide range of manipulative behaviors.

Concerning the frequency of grasps, we found that a relatively small set of grasps were used the majority of the time. For 80 % of the study duration, only 5 (housekeeper) or 10 (machinist) grasp types were used. Regarding the properties of the, we found that most of them were well within a graspable range. That has direct implications for artificial hand design - in order to grasp 90 % of the objects in our dataset, a hand should be able to grasps objects 7 cm wide with a mass of 700 g. Finally, we found that 46 % of tasks are constrained, where the manipulated object is not allowed to move in a full six degrees of freedom.

Using the object and task properties we were able to predict the grasp type used with 47 % accuracy. The strongest predictors of the grasp type are object size, task constraints, and object mass. We also found that large and heavy objects are usually grasped by a power grasp, but small and lightweight objects are not necessarily grasped with a precision grasp.



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Short Biography

Aaron M. Dollar is the John J. Lee Associate Professor of Mechanical Engineering and Materials Science at Yale. He earned a B.S. in Mechanical Engineering at the University of Massachusetts at Amherst, S.M. and Ph.D. degrees in Engineering Sciences at Harvard, and conducted two years of Postdoctoral research at the MIT Media Lab. His research topics include human and robotic grasping and dexterous manipulation, mechanisms and machine design, and assistive and rehabilitation devices. He is the recipient of the 2013 DARPA Young Faculty Award, 2011 AFOSR Young Investigator Award, and the 2010 NSF CAREER Award.

Classifying dexterous manipulation in human and robotic systems

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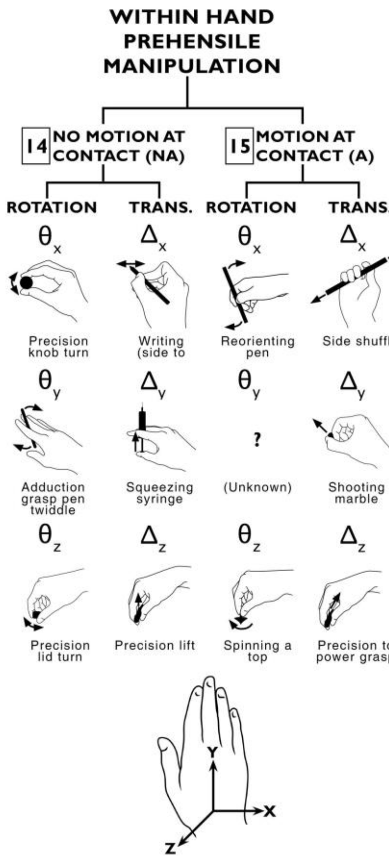
Abstract

Understanding and comparing human and robotic dexterous manipulation requires precise terminology and a classification scheme designed for that purpose. Our work includes a hand-centric and motion-centric manipulation classification and examples of how to apply it in various ways. It is first discussed how the taxonomy can be used to identify a manipulation strategy. Then, applications for robot hand analysis and engineering design are explained. Finally, the classification is applied to three activities of daily living (ADLs) to distinguish the patterns of dexterous manipulation involved in each task. The same analysis method could be used to predict problem ADLs for various impairments or to produce a representative benchmark set of ADL tasks. Overall, the classification scheme proposed creates a descriptive framework that can be used to effectively describe hand movements during manipulation in a variety of contexts and might be combined with existing object-centric or other taxonomies to provide a complete description of a specific manipulation task.



Dexterous sub-classification of human or robotic manipulation

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Short Biography

Ian M. Bullock is a PhD candidate studying human grasping and dexterous manipulation at Yale University. He earned a B.S. in Engineering from Harvey Mudd College (Claremont, CA) and an M.S. and M.Phil. from Yale University. His research looks at the capabilities of the human hand from the perspective of trying to improve robotic hand design, haptic interfaces, and rehabilitation efforts.

NEURO-REHABILITATION

Reduction of enhanced physiological tremor via stochastic noise

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Abstract

Enhanced physiological tremor is a disabling condition which could impose a strong limitation to perform fine movements. Under the light of the hypothesis that "boosting the strength of the peripheral input pushes the tremor-related spinal and cortical systems closer to anti-phase firing and hence reduces tremor" [1], the present study aims at investigating whether Gaussian stochastic noise enables reduction of enhanced physiological tremor accompanied with performance improvement during a visuomotor task. Specifically, eight subjects with enhanced physiological tremor performed a visuomotor task requiring to compensate isometrically with the right index finger a static force generated by a manipulandum on which Gaussian noise (3-35 Hz) was applied. The finger position was displayed on-line on a monitor as a small white dot which the subjects had to maintain in the center of a green circle defined as the reference (for methodological details see [2]). EMG from the active hand muscles and finger position were recorded. The performance was measured by the mean absolute deviation of the white dot from the zero position. The tremor was identified by the acceleration in the frequency range 7-12 Hz. Two different conditions were compared: with and without optimum noise. We found that application of optimum noise reduces tremor (accelerometric amplitude and EMG activity) and improved the behavioral performance as reflected by the improved mean absolute deviation from zero. Thus, we provide the first evidence of a significant reduction of enhanced physiological tremor in the human sensorimotor system due to application of external stochastic noise.

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Short Biography

Carlos Trenado received his BSc and MSc degrees in mathematics from the National Autonomous University of Mexico (UNAM) and New Mexico State University, respectively. He obtained a PhD degree in neurotechnology at the faculty of medicine of Saarland University, Germany. Currently, he is a postdoctoral fellow at the Cortical Motor Control Laboratory of the Freiburg University Hospital (Head Prof. Dr. Dr. Rumyana Kristeva). His current research interests include improved performance via stochastic resonance for rehabilitation applications and modeling.

Soft robotic hand orthosis for assistance and therapy in activities of daily living

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Abstract

Robotics technology has recently been adapted for the rehabilitation of hand function following neurological injury, in order to provide physical therapy, quantitative assessments of recovery, as well as support for activities of daily living (ADL) at home. While various developments have been proposed, it remains challenging to provide reasonably compact, lightweight, robust and affordable robotic devices that can cope with the complexity and versatility of the human hand. Hand exoskeleton devices typically involve a serially connected mechanical chain to transmit motion to the distal joints, and are thus inherently bulky, heavy and complex. To tackle this problem, we developed a soft finger mechanism that consists of three parallel spring blades at each joint. These allow aligning the remote rotation center of the mechanism with that of the finger joint, while providing a compact and lightweight implementation. The developed exoskeleton prototype consists of five finger modules that are actuated by a linear motor. The device is capable of assisting grasping motion in both flexion and extension, with a maximum of 10 N flexion/extension force output. The prototype is controlled by an EMG sensor attached to the user's forearm. The total mass of the hand exoskeleton is 202 g including the linear motor. A single finger module is 4.7 mm in thickness and 5 mm in width, for a mass of only 7 g. The control unit can be attached on the user's waist (200 g) including a battery that lasts approximately one day. The key novelty of the developed device is that the spring mechanism is inherently compliant, allowing for a natural adaptation of the finger position during the grasping of complexly-shaped objects or exploration. In addition, the compliance is beneficial for the safety of user. The device is currently being clinically evaluated with stroke patients.

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Short Biography

Jumpei Arata received a PhD in mechanical engineering from the University of Tokyo, Japan, in 2004. During 1998 and 2001, he spent two years at the Swiss Federal Institute of Technology, Lausanne, Switzerland, on a grant from an international exchange program and a Swiss Federal Scholarship. He is currently an associate professor at the Center for Advanced Medical Innovation, Kyushu University, Japan. His current research interests include flexible mechanisms, haptic devices, and medical robots.

Rhythmic auditory stimulation for robot-assisted hand function training in stroke therapy

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Abstract

Robot-assisted hand-function-training (RT) complements conventional treatment effectively [1]. “Rhythmic auditory stimulation” (RAS), an effective therapeutic technique for gait- and arm-training in post-stroke-treatment [2], was never applied nor evaluated for RT. Four specified RAS-designs for RT are suggested (metronome, spearcon-beat [3], waltz-music, multisensorical-beat). Four pilot-experiments (E1-4) investigated effects of RAS-designs on function and motivation. In E1-3 effects during performance of the Nine-Hole-Peg-Test were evaluated with healthy-subjects (n=20), in E4 during the Box-and-Block-Test with stroke-patients (n=9). Results showed, function and motivation were better with rhythmic-stimulation than without, and motivation was best with waltz-music. Strongest effects on function were seen with metronome in E2,3, in E1, 4 with waltz-music. As results indicate RAS improves function and motivation, waltz-music, and/or metronome are proposed for observations in RT.

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Short Biography

In her PhD, Florina Speth researches on effects of sound in robot-assisted hand function training for stroke patients. In 2011 she gained her M.A. in Cognitive Musicology, Neurolinguistics and Music Therapy at the University Cologne. In her Magister thesis she developed a multimodal stimulating prototype for post-stroke hand rehabilitation-training. 2010-2012 she was working as research-assistant at a neurological rehabilitation clinic within a study for the development of a test-battery grading spasticity in paretic upper limbs of stroke patients. At the same time she was working as neurological music therapist. 1995-2001 she studied Violoncello at the University Mozarteum Salzburg as young-student.

Adaptive, robot assisted training for wrist motion recovery in a young sub-acute stroke subject

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Abstract

Several studies support the hypothesis that robot assisted therapy for adult stroke subjects can be beneficial in promoting the recovery process when conveyed in conjunction to conventional rehabilitation. Robotic therapy has been mainly applied to adults subjects and, little is known about children or youth. This study presents preliminary results of a robot-assisted rehabilitation training protocol applied to a 14 years old subject suffering from sub-acute stroke. Robotic therapy was applied to the distal portion of her left, affected upper limb in order to reduce the degree of motor impairment. The left wrist of the subject was attached to a fully backdrivable exoskeleton that allows full range of motion over the three degrees of freedom of the joint. The training protocol consisted of 3 months of therapy sessions. The subject was asked to perform goal-directed, planar reaching movements, aiming at a target located at the limit of the workspace. To complete the task, the patient had to move the end-effector of the robot while playing a simple but engaging video-game. Target position's and the robot's configuration were chosen to constrain the movement to flexion/extension and radial/ulnar deviation over the subject's entire supported active range of motion (ROM), evaluated at the beginning of training sessions by measuring the amplitude of the voluntary movements in the two aforementioned directions. The robot provided a variable assistance to complete the movements, modulated according to the patient's motor abilities detected by monitoring when the speed of the robot end-effector exceeds a certain threshold. In order to assess subject's improvements we measured the time the subject took to complete the task, the amount of the assistance needed from the robot, the accuracy of the matching position, and the smoothness of the trajectories. The results show that robot-assisted training of reaching movements successfully improved arm movement ability and promoted upper extremity functional recovery. Moreover they highlight the effectiveness of robotic therapy for both dynamic and kinematic changes at the beginning and end of the experiment.

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Short Biography

Francesca Marini graduated in Biomedical Engineering at the University of Rome "La Sapienza" in 2013, with a master thesis in biomechanics concerning the validation of an innovative procedure for sensor to segment calibration in gait analysis. She did an internship at the mechanical and thermal measurements lab (Mechanical and Aerospace engineering division) of "La Sapienza" and at the Movement Analysis and Robotics LABoratory (MARLAB) at the Children's hospital Bambino Gesù, of Palidoro (Rome). In April 2013 she was recruited as research fellow at the Italian Institute of Technology (IIT). Since January 2014, under the supervision of Prof. Pietro Morasso and Prof. Lorenzo Masia, she has been following a PhD program in Cognitive Robotics, Interaction and Rehabilitation Technologies at IIT. Her PhD project is mainly focused on robotic rehabilitation in children with neurological injuries.

Upper limb measurement tools for children with neuromotor disorders: A systematic review

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Abstract

To investigate the effectiveness of upper limb rehabilitation, reliable and responsive measures of upper limb function, capacity and performance are needed. Lately, some reviews have addressed psychometrics of upper limb outcome measures for children. Yet, most of them focused on a specific patient and/or age group and it remains unclear whether results can be generalized to children with broader diagnoses or age ranges, as seen normally in pediatric neurorehabilitation settings.

This systematic review aimed to depict the evidence concerning reliability and responsiveness of upper limb measurement tools used in pediatric neurorehabilitation.

A two-tiered search was conducted between December 2012 and June 2013. The first search identified upper limb outcome measures for 1-18 years old children with neuromotor disorders. The second examined the psychometric properties of the tools included. Two independent reviewers rated the methodological quality of the included papers with the COSMIN checklist[1]. A „best evidence synthesis“[2] was performed to assemble information about each measurement tool.

The first search delivered 1566 hits. Of these, 84 papers were included. The screening of the retrieved papers revealed 39 upper limb assessment tools. In 51 papers, data about reliability was reported. Responsiveness was outlined in 7 studies whereas 10 studies provided information about the measurement error. In total, 17 studies were of poor, 32 of fair, and 6 of good or excellent methodological quality.

Very few tools with at least a moderate positive level of evidence are available for children with cerebral palsy and very few psychometric studies involved children with other diagnoses than cerebral palsy. To date no study of at least fair methodological quality about responsiveness of upper extremity outcome tools for children with neuromotor disorders exists.

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Short Biography

Corinna Gerber studied Human Movement Sciences at the ETH in Zurich. Since 2012 she is a PhD student in Health Sciences and Technology and works in the Pediatric Rehab Research Group (PRRG) in Affoltern am Albis, Switzerland.

MyHand: Assistive hand orthosis to overcome stroke impairments

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Abstract

Many stroke patients suffer from impaired motor control, synergies and overactive flexor muscles in the arm and hand [1]. The peak aperture of the hand is often greatly reduced, preventing the patient from effectively grasping and manipulating objects and hindering them during Activities of Daily Life (ADL). The MyHand project aims to improve the functional hand use of stroke patients during ADL at home. For this goal, we are developing an active hand orthosis that can be worn throughout the day and will assist hand movements through active compensation of the neural impairments. This "therapy at home" should help to prevent contractures and learned disuse.

After stroke, the affected hand tends to become the supporting hand and the non-affected hand the dominant hand during bimanual activities. The MyHand orthosis will help achieve cylindrical and lateral grasps, which are the most frequently used supporting hand movements. To achieve this, an advanced detection system is needed that will be able to make a distinction between desired movements and undesired muscle activation caused by abnormal muscle control (spasticity, synergies, etc.). The orthosis then needs to compensate for the undesired muscle activation, while allowing the user to perform voluntary movements. Furthermore, the orthosis needs to be wearable all day long. This puts high demands on the mobility, wearability, usability, aesthetics and safety of the device. Key design aspects in user acceptance have been determined through user interviews. These are easy donning and doffing, high comfort, low weight, compact size and easy cleaning of the orthosis.

In the current concept, only extension of the fingers is actively controlled through a single actuator with flexible connections to each finger. Thumb abduction will be actuated too, but the wrist is passively supported using an elastic palmar cuff. Muscle activity is measured of the extensor and flexor muscles in the forearm and the deltoids of the shoulder.

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Short Biography

Johannes van Wijngaarden has a BSc in Technical Medicine and is working towards his MSc in Biomedical Technology. Laura Smulders has a BSc in Industrial Design Engineering and is working towards a double MSc in Industrial Design Engineering and Biomedical Technology. Both are in the MSc Design Honors program at the University of Twente. Arno Stienen is an Assistant Professor at the University of Twente and specializes in upper extremity motor learning and rehabilitation. MyHand is supported by Fonds NutsOhra (NL, #558695).

Disorganization of motor unit control in paretic hand muscle post-stroke

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Abstract

The potential mechanisms underlying paresis for voluntary motion following a cerebral stroke are varied in nature.

Possibilities include reduced central drive, disuse atrophy, motoneuron loss, reinnervation subsequent to MN loss, muscle contracture and inefficient activation of muscle. To date, studies directed at understanding the role of inefficient motor unit(MU) activation have been conducted primarily using intramuscular recordings, which are often time consuming with low unitary yields. Recently, a novel EMG system(dEMG) from Delsys Inc., provides the user with automated MU decomposition of the surface EMG signal recorded from a surface sensor array electrode. In addition to information regarding MU recruitment threshold and mean firing rates(MFR), the surface recordings provide information regarding individual motor unit action potential(MUAP) structural parameters, such as MUAP amplitude and duration.

The objective of this study was to examine the possible contribution of disordered control of motor unit (MU) recruitment and firing patterns to muscle weakness post-stroke. The dEMG system was used to record sEMG signals and extract MU parameters from the first dorsal interosseous muscle (FDI) of both sides of three hemiparetic stroke survivors. An estimate of the MUAP amplitude was derived using spike-triggered averaging of the sEMG signal. The relationship between p-p MUAP amplitude and MU threshold (reflecting the size principle) as well as between MU MFR and MU threshold (reflecting onion skinning) was compared between the two sides of each stroke subject. Our preliminary results suggest a disrupted orderly recruitment based on MUAP size, a compressed recruitment range, and a lack of the 'onion skin' pattern due to saturated MU firing rates on the paretic side. In contrast, MU organization was similar bilaterally for the subject with minor impairment. These results suggest that MU organizational changes with respect to recruitment and rate modulation can contribute to muscle weakness post-stroke.

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Short Biography

Nina Suresh has a Bachelor of Science degree in Computer Science and Mathematics and a Ph.D. degree in Biomedical Engineering from the University of Illinois, Chicago. She is currently a Research Scientist with the Rehabilitation Institute of Chicago(RIC). Nina's overall research interests include understanding the neural mechanisms underlying paresis and spasticity in stroke survivors as well as the characterization of task dependent differences in muscle activation in multifunctional muscle.

Initial clinical trial of the Exo-Glove, a soft wearable robot for the hand: the case of tetraplegia (C4)

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Abstract

We will present the Exo-Glove, a tendon-driven soft wearable robot for the hand, and its initial clinical trial to a person with tetraplegia. The Exo-Glove is driven by the tendons attached to the glove with a special design and fabrication methods, which enable the wearable robot to be lightweight and compact, but allow the person with hand disability to grasp various different shaped objects with simple control. Grasping of various-shaped objects with the Exo-Glove was attempted by a healthy subject and a subject with SCI(C4). The subject had been injured 6 months ago, and cannot flex and extend the fingers and the thumb at all but can move the elbow and the shoulder. Fig. 1 shows the grasping by the disabled subject using Exo-Glove. Both subjects grasped all the target objects. Because of the soft structure, the Exo-Glove has different properties compared with rigid wearable robots. It's not just lightweight and compact, but the unconstrained d.o.f. of the Exo-Glove and the different finger properties could generate different trajectory from person to person depending on the finger properties. More tendons can be attached to generate pull forces on specific points. Understanding how these characteristics could affect the person with disability neurologically would be valuable to further develop the Exo-Glove to be used for rehabilitation.

Fig. 1. Various grasping motions with Exo-Glove performed by subject with paralysis in the hand.

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Short Biography

Kyu-Jin Cho received the B.S and M.S. degrees from Seoul National University, Seoul, Korea, in 1998 and 2000, respectively, and the Ph.D. degree in mechanical engineering from the Massachusetts Institute of Technology, Cambridge, in 2007. He was a Postdoctoral Fellow at the Harvard Microrobotics Laboratory until 2008. He is currently an Associate Professor of Mechanical and Aerospace Engineering and the Director of the Biorobotics Laboratory, at SNU, Seoul, Korea. His research interests include soft biologically inspired robotics, and rehabilitation/ assistive robotics. He has received the PaikAm Award from Korean Society of Precision Engineering in 2013 and the Early Career Award from IEEE Robotics and Automation Socoety in 2014.

The use of ecological sounds in facilitation of tool use in apraxia

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Abstract

The CogWatch project aims to create an intelligent assistance system to improve activities of daily living (ADL) in stroke survivors, who suffer from impaired ability to use everyday tools (apraxia). The core of this symptom lies in the compromised ability to access the appropriate motor program relevant to the task goal. Patients demonstrate difficulties during the execution of single and multiple tool use and during the pantomime of the same movement [1]. There is lack of evidence whether sensory cueing can facilitate tool use in those patients if presented prospectively to a patient. This study explores the use of cues, based on ecological sound linked to the action goal, in the facilitation of pantomime and actual tool use. Eco-acoustics define environmental sound as an audible product of physical event, caused by interaction of the materials. Recent research suggests that motor networks associated with mirror neurons respond to the action-related sounds [2]. In this study, three ADL tasks were introduced: hammering, sawing, and tooth brushing. Ten patients with left brain damage and five patients with right brain damage following first cerebrovascular accident were tested. In addition, twenty age-matched controls were tested, in the same experimental paradigm, ten in the non-dominant hand performance. The study comprised of four different cueing modes (prior to task execution): no cues, auditory instruction, pictorial instruction, and ecological sounds. Comparison of performance across these conditions incorporated a video-based error assessment, overall performance scoring, along with the analysis of kinematic outcome measures and movement variability. Environmental sound display prior to task execution produced multi-dimensional facilitation of the movement in selected patients in both tool use and pantomime mode. The findings from this study will support the development of Cogwatch system that aims to provide automatized guidance for the patients during home- based ADL after dismissal from the hospital.

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Short Biography

My principal research interest lies in the field of motor control and neuropsychology of perception and action. I have joined Department of Sport and Health Science, TUM in July 2012 to work as a Post-doctoral Fellow in the Cogwatch project www.cogwatch.eu. My current line of work is dedicated to understanding how external sensory information can guide performance in clinical populations with motor and cognitive disorders.

Neurocognitive robot-assisted rehabilitation of hand function

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Abstract

Over the past decades, robotic devices have been tested for their beneficial effect on the recovery process following stroke. The present work investigated unexploited potential in upper limb robot-assisted rehabilitation by adopting a therapy concept focused on hand function and incorporating the training of haptic perception. Neurocognitive therapy – a concept requiring patients to solve cognitive problems based on expected and perceived somatosensation – was implemented on the ReHapticKnob, a rehabilitation robot to train hand function. Several exercises focusing on the interaction with virtual objects rendered by the robot (e.g. grasping a virtual sponge) and the identification of haptic stimuli (e.g. amplitude of passive finger displacement) were implemented on the robot and evaluated in a clinical study.

Eighteen subacute stroke patients participated in a four-week randomized controlled trial. The intervention group (N=8) received robotic therapy during four 45-minute sessions per week over four weeks. A dose-matched control group (N=10) received conventional neurocognitive therapy without the robot. In parallel, both groups attended their daily rehabilitation program at the clinic. Motor, sensory, cognitive and robotic assessments were conducted before the start and after the completion of the robot-assisted therapy, as well as in a follow-up session.

Patients from both groups showed reduced motor impairment (Fugl-Meyer Assessment of the Upper Extremity (FMA-UE)) and significant functional improvements in dexterity (Box and Block Test). A non-significant trend of improved sensory perception was also observed in both groups. Neurocognitive robot-assisted rehabilitation was shown to be clinically well accepted, and equally beneficial as conventional neurocognitive therapy in terms of upper limb motor impairment reduction. The ReHapticKnob further has the potential to objectively assess and monitor patients throughout therapy progression using accurate and reliable sensor measurements.

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Short Biography

Olivier Lambercy received the MSc degree in microengineering from the Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, in 2005, and the PhD degree in mechanical engineering from the National University of Singapore, Singapore in 2009. He is currently Senior Research Associate at the Rehabilitation Engineering Lab at ETH Zurich, Switzerland. His main contributions are in the field of robot-assisted rehabilitation of hand function after stroke, and his research interests include medical and rehabilitation robotics, motor control and human-machine interaction.

Robotic assessment of finger proprioception

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Abstract

Sensory function, and proprioception in particular, plays a crucial role in the learning and execution of motor actions. Neurological injuries, such as stroke, can lead to severe sensory deficits affecting quality of life, especially when they occur at the level of the hand. Moreover, reduced sensory function has been linked to poor prognosis of functional recovery after stroke. Nevertheless, sensory deficits are rarely addressed in current clinical settings and clinicians lack proper assessment tools for the assessment of proprioceptive deficits.

We propose a robotic assessment tool for the qualitative, automated evaluation of proprioception in the hand by measuring the joint angle position difference threshold (DL) in the metacarpophalangeal joint of the index finger. The experimental evaluation of an adaptive algorithm called Parameter Estimation by Sequential Testing (PEST) is presented by comparing it with the frequently used but limited method of constant stimuli (MOCS), both in combination with a two-interval two-alternative forced choice (2AFC) paradigm. The results of a pilot study with 13 healthy young subjects showed DLs in a similar range for PEST (1.73°±0.78°) and MOCS (2.15°±0.77°). However, no significant correlation between the two methods was found. Nevertheless, the number of trials could be reduced by approximately 50% using PEST, resulting in an assessment time of less than 15 minutes.

The test-retest reliability of this new assessment method using PEST and 2AFC is currently being evaluated in a study at the Kliniken Schmieder Allensbach, Germany, with stroke patients and age-matched healthy elderly subjects. Robotic assessment outcomes will be correlated with clinical scales in order to assess the validity of the proposed method. We expect that this new assessment approach not only has the potential to allow clinicians to monitor recovery, but might also help in designing adequate therapies that target the recovery of sensory function.

References

[1] Rinderknecht MD, Popp W, Lambercy O, Gassert R. (2014). Experimental Validation of a Rapid, Adaptive Robotic Assessment of the MCP Joint Angle Difference Threshold. Eurohaptics.

Short Biography

Mike Domenik Rinderknecht began his Ph.D. studies on robotic sensory assessment and therapy of hand function after stroke at the Rehabilitation Engineering Lab (RELab) at ETH Zurich in June 2013. He received his B.Sc. and M.Sc. in Microengineering in 2010 and 2012, respectively, both from Ecole Polytechnique Fédérale de Lausanne (EPFL), with a focus on robotics and autonomous systems. He further obtained a minor in Biomedical Technologies. As a visiting research student at the Collaborative Haptics and Robotics in Medicine Laboratory (CHARM Lab) at Stanford University he investigated learning and transfer in isometric and dynamic reaching for stroke rehabilitation. His research interests range from rehabilitation and medical robotics, assistive devices and prosthetics, virtual reality and haptics to sensory-motor learning and neuroscience.

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