Conference

Multisensory Integration in Action

Dates: December. 6 – 9, 2021

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Organizing Committee:

Prof. Roy Mukamel, Tel-Aviv University (chair)

Prof. Mukamel studies the neural mechanisms linking action and perception in the context of motor-skill learning and sensory predictions, and the neural representation of voluntary actions, intentions and goals. To this end he uses various neuroimaging techniques (including fMRI, EEG, and MEG), electrophysiological recordings in patients (spiking activity and intracranial EEG), and behavioral measures.

Contact: Sharet Building, Room 251, School of Psychological Sciences, Sagol School of Neuroscience, Tel-Aviv University, Tel-Aviv 69978, Israel, Tel: (972)-3-640-7246, Email: rmukamel@tau.ac.il

Dr. Firas Mawase, Technion – Israel Institute of Technology (co-chair)

Dr. Mawase studies the physiological and neural mechanisms that underlie motor behavior and motor recovery after brain injury. Dr. Mawase uses non-invasive brain stimulation tools and neuroimaging to discover the principles of sensorimotor control and to design rehabilitative devices and protocols.

Contact: Faculty of Biomedical Engineering, Technion. Neurorehabilitation & Sensorimotor Neuroscience Lab. Tel. +972-077-8871204. Email: mawasef@bm.technion.ac.il

Dr. Lior Shmuelof, Ben-Gurion University of the Negev

Dr. Shmuelof studies the cognitive and neural process that are involved in the acquisition of new motor abilities and in the reacquisition of lost abilities due to damage to the central nervous system. Dr. Shmuelof combines motor control behavioral experiments with functional and structural brain imaging experiments in healthy subjects and in subjects with movement disorders (such as CP, TBI and CVA).

Contact: Department of Brain and Cognitive Sciences, Ben-Gurion University of the Negev. P.O.B. 653 Beer-Sheva 8410501 Israel. Tel: 972-8-6428769. shmuelof@bgu.ac.il.

Prof. Yifat Prut, Hebrew University

Prof. Prut is studying the neural mechanisms by which the motor system translates converging inputs into appropriate motor commands for voluntary movements. This question is addressed by combining simultaneous recordings from multiple sites across the motor hierarchy with electrical and pharmacological perturbations of the system in non-human primates. Advanced techniques of data analysis are used to decipher the relations between neural networks, muscle synergies and motor behavior.

Contact: Dept. of Medical Neurobiology, The Hebrew University - Hadassah Medical School Jerusalem 91120. Tel: 972-2-6757912. Email: yifat.prut@ekmd.huji.ac.il.

Prof. Opher Donchin, Ben-Gurion University of the Negev
Prof. Donchin studies the process of motor adaptation from a behavioral, computational and physiological perspective. He uses behavioral, imaging and physiological techniques to test and expand a specific model of the process of motor adaptation and then to relate that model to the underlying physiology of motor control.
Contact: Department of Biomedical Engineering, Ben-Gurion University of the Negev, PO Box 653, Be'er Sheva, Israel. Tel: 08-647-9627. donchin@bgu.ac.il.

Prof. Ilana Nisky, Ben-Gurion University of the Negev
Prof. Nisky employs theories about the human sensorimotor control, perception, adaptation, learning, and skill acquisition in the development of human-operated medical and surgical robotic systems. She also uses robots, haptic devices, and other mechatronic devices together with computational models to understand the human sensorimotor system in real-life tasks like surgery, and in virtual tasks like virtual reality games or surgical simulation.
Contact: Building 64, Room 105, Department of Biomedical Engineering, the Markus Family Campus, Ben-Gurion University of the Negev. Tel: 972-86428936. email: nisky@bgu.ac.il

About the Seminar

We are proposing a program which will be delivered by leading scientists, from Israel and abroad, in the field of "Multisensory integration in action" as a Batsheva de Rothschild Seminar.

The ultimate manifestation of behavior is through movement, and execution of goal-directed actions. Not only complex behaviors such as locomotion, feeding, communication, or emotional expressions but also apparently simple movements like flicking the hand to shoo a fly, are the consequence of cognitive mechanisms which require formulating a desired consequence, planning, and motor control which requires constant evaluation and error correction. Consequently, understanding the principles underlying our ability to perceive, understand, plan and generate goal directed movements is a fundamental research question in Cognitive Neuroscience.

While a roadmap of the neural mechanisms underlying perception exists (from on/off cells, orientation columns, motion/color/and object selective regions in the visual pathway from the retina to temporal/parietal regions), an equivalent roadmap in the motor domain is still rudimentary. At the same time the interaction between communities studying neural mechanisms of human perception, and those studying motor control is limited, with largely separate dedicated meetings (e.g. VSS and NCM). Case in point, researchers in the motor control community mostly use sensory signals (auditory/visual) as a means (cue) to trigger movement (which is their primary measure of interest) while researchers in the perception community mostly use motor output (e.g. key press) simply as a means for reporting perception (which is their primary measure of interest). **Thus, although the interaction between perception and action is fundamental to behavior, the underlying neural mechanisms remain largely unknown.**

Accumulating evidence over the past two decades suggests system-wide interactions between basic motor and high cognitive functions. For example, evidence points to overlapping neural representations of action generation and perception. Perception of actions evokes neural activity in regions predominantly characterized by their motor properties, and conversely, more recent evidence suggests that performance of voluntary actions modulates neural activity in regions predominantly characterized by their sensory properties. Recent methodological and analytical advances allow addressing the ongoing fundamental gap in knowledge regarding how the motor and sensory systems interact. As an example, a key issue both in action control and action recognition is the question which features and dimensions underlie the organization of actions during their control and recognition. Similar questions have been examined in the field of Object Recognition, which received a massive boost from recent developments in the field of deep neural networks and their application to Cognitive Neuroscience. Therefore, strengthening the flow of ideas between the relevant research communities is timely.

The proposed seminar will cover a number of topics at the forefront of research into how action and the motor system interact with perception to produce goal-directed behavior. By bringing together the perspectives of leading experts in multidisciplinary research approaches: neuroimaging, non-invasive brain stimulation, behavioral analyses and physiology, our aim is that the seminar provide a basis for bridging across distinct domains of research. We believe that the proposed program will be relevant to scientists and experts from diverse research and practice disciplines: neuroscience, psychology, education, biophysics, social sciences, physical therapy, occupational therapy and medicine. Beyond the inherent value of providing a much needed forum for addressing topics at the forefront of cognitive science from wide yet converging perspectives, we see great importance in bringing top international scientists, primarily from Europe and North America, to the proposed venue in Israel. The benefits here are two-fold: first, the proposed Batsheva Seminar will contribute to boosting and enriching current local research, and second, it will expose the international scientific community to the new research work undertaken at Israeli research institutions. Both aspects will contribute to the initiation of new international collaborative research projects as well as strengthen existing ones.

Scientific impact & innovative aspects of the symposium: The proposed Bat-Sheva seminar addresses a fundamental question in Cognitive Neuroscience, namely, the principles underlying our ability to successfully interact with our environment. Despite decades of research on goal-directed actions in humans, our understanding of the corresponding systems neuroscience perspective is still lacking behind the knowledge in other domains, e.g. object perception. By bringing together researchers from a wide range of disciplines with a focus on goal-directed actions we hope to narrow the gap. A key aim of the symposium is to foster existing and initiate new collaborations between senior and junior researchers from Israel and their international colleagues working on goal-directed actions. By providing an intimate setting for specialists in the field to interact, we believe that the Bat-Sheva seminar is an ideal mechanism to facilitate future collaborations. The scientific impact of the meeting will also be enhanced by recording the talks and publishing them online in order to provide the entire community with the opportunity to watch

them. Another explicit aim of the symposium is to expose advanced Ph.D. / early postdoc trainees to leading scientists in the field and to allow them to gain experience in organizing scientific meetings. Thus, a small group of dedicated early career researchers will be in charge of (i) organization of panel discussions aiming to address key questions in the field of multisensory integration in action (see day 3 round tables) (ii) writing an editorial piece describing the results of the panel discussions and (iii) increasing the visibility of the meeting through social media networks. The small venue of the Bat-Sheva seminar will allow personal interactions that may help students to find potential labs for the next stage of their career.

In order to further boost the scope, breadth and appeal of the seminar, we intend to schedule it in temporal proximity (but separate venue) to the annual Karniel Computational Motor Control Workshop (KCMCW; https://in.bgu.ac.il/en/engn/biomed/CMCW/Pages/default.aspx; currently scheduled for March 14 – 16, 2021). The KCMCW is a 3-day workshop that runs annually at BGU from its founding in June, 2005, and attracts international speakers of high caliber in the field of computational motor control – from mathematics, engineering, biology, medicine and the cognitive sciences (~8 international speakers and ~100 attendees a year). By scheduling the proposed Bat-Sheva seminar in temporal proximity to the KCMCW, we will provide a unique opportunity for local and international speakers to attend both events and broaden the scope of their research. This will provide needed synergy between cognitive neuroscientists (proposed Bat-Sheva Seminar) and researchers with stronger computational/engineering/robotics/modelling orientation (KCMCW) which do not always interact. Invited speakers from abroad will be encouraged to attend both the Bat-Sheva seminar and the KCMC workshop, and invited speakers to the KCMC will be encouraged to attend the Bat-Sheva seminar. We believe that by combining efforts, the whole will be much greater than the sum of its parts, with great potential for novel interactions and collaborations.

We aim at a versified list of speakers. Due to the current circumstances with the COVID-19 pandemic, and uncertainty surrounding international travel, we felt it was premature to approach potential speakers from the list at this stage and soliciting their confirmation to attend. We note that some of the speakers on the list have expressed their enthusiasm in the past to attend such a seminar and confirmed their attendance on previous rounds of applications that were eventually not funded. Therefore, we believe that, given favorable travel conditions around the scheduled seminar date, many speakers from the list will be happy to attend – even more so with the planned conjugate KCMCW.

Below is the list of international and Israeli participants and their respective domains of expertise, followed by a detailed schedule of the seminar.

List of invited international speakers and their topics of expertise:

1. Dr. Clare Press, Dept of Psychological Sciences, Birbeck University, UK: Dr. Press investigates how people control their own actions and imitate and process others' actions. She also investigates the online influence of action on perception. She addresses these questions both in typical development and in individuals with autism spectrum conditions.

2. Prof. Jody Culham, The Brain and Mind Institute, University of Western Ontario, London, Ontario Canada: Prof. Culham studies the neural basis of the human prehension system. She uses cognitive neuroscience approaches to investigate how the human brain uses sensory information to perceive the world and guide hand actions such as reaching, grasping and tool use.
3. Prof. Jason Gallivan, Department of Psychology, Queen's University, Ontario, Canada: Prof. Gallivan studies the brain mechanisms by which mental events are transformed into goal-directed actions. To this end he uses a combination of techniques including behavioural measurements, functional brain imaging (fMRI) and neuromodulation techniques to explore the cognitive and neural bases of a variety of processes—decision-making, perception, memory and learning—that govern the control of action.
4. Prof. Emily Cross, Institute of Neuroscience and Psychology, University of Glasgow, UK: Prof. Cross explores experience-dependent plasticity in the human brain and behaviour using neuroimaging, neurostimulation and behavioural techniques. She is particularly interested in complex action learning and perception, and often makes use of action experts and training paradigms from highly skilled motor domains, such as dance, music, gymnastics, contortion, and acrobatics. Her primary research tools are functional magnetic resonance imaging (fMRI), transcranial magnetic imaging (TMS), transcranial direct current stimulation (tDCS), reaction time measures, behavioural training paradigms and robots.
5. Angelika Lingnau, Institute of Psychology, University of Regensburg, Germany: Prof. Lingnau studies the neural representation of action planning, action observation, action execution, and imagery in humans. To this aim, she uses a variety of methods, in particular multivariate pattern (MVP) analysis of fMRI and MEG data, TMS, and eye tracking.
6. Prof. David Ostry, Department of Psychology, McGill University, Montreal Quebec, Canada: Prof. Ostry's research focuses on understanding the biological mechanisms of voluntary movement and deals equally with speech production and human arm motion. He uses mathematical models, robots and behavioral and physiological techniques to assess motor function and the characteristics of motor learning.
7. Prof. Paul Gribble, Department of Psychology, University of Western Ontario, London Ontario, Canada: Prof. Gribble studies basic scientific questions about human sensory and motor systems, how the brain controls voluntary movement, and how plasticity in sensory and motor brain areas support motor learning.
8. Julien Doyon, University of Montreal, Quebec, Canada: Prof. Doyon is the head of the neuroimaging unit at the University of Montreal. He is a leading expert in the research bridging between motor learning processes and their link to sleep and memory. Prof. Doyon is a world expert in functional neuroimaging of cognitive and motor function.
9. Prof. Angelo Maravitta, Department of Psychology, Milan Center for Neuroscience, University of Milan-Bicocca, Milan, Italy: Prof. Maravita studies body representation, body awareness, multisensory integration of bodily and extrapersonal signals in healthy subjects and patients with chronic pain.

10. Jorn Diedrichsen, University of Western Ontario, Canada: Prof. Diedrichsen studies how the human motor systems learn to produce skilled movements using custom-built robotic devices that measure and apply specific force perturbations during the movement. Prof. Diedrichsen combines computational modeling, transcranial direct current stimulation (TDCS), high-resolution functional magnetic resonance imaging (fMRI) and patient-based work to understand the learning processes and underlying neural substrates in detail.
11. Richard Carson, Trinity College Dublin, Dublin, Ireland: Prof. Carson's research focuses on the development of novel approaches to the amelioration of age-related cognitive and behavioural dysfunction. In this context, a pivotal role is ascribed to methods and applications that optimise the utilisation of adaptive brain plasticity. His clinical and pre-clinical research has a specific emphasis upon the neuro-rehabilitation of stroke survivors through the development and clinical evaluation of a number of novel, targeted non-pharmacological rehabilitation interventions. Additionally, he investigates the scientific basis of interventions that may be used to harness brain plasticity during periods of limb immobilisation, with the aim of maintaining functional capacity in older persons who have sustained injuries as a result of a fall.
12. Prof. David Schneider, New York University, USA: Prof. Schneider focuses on understanding how sensory, motor, and learning systems within the brain converge to store memories about the past and make predictions about the future. Using the mouse as a model organism, Schneider's research uses electrical, optical, and pharmacological techniques to monitor and manipulate the activity of networks, neurons and synapses in behaving mice.
13. Prof. Lee Miller, Northwestern University, USA: Prof. Miller studies the representation of action in the brain, the mechanisms that underlie the production and the transformations of these signals as they propagate throughout these networks. Furthermore, he develops applications of these basic principles that could be of therapeutic value to human patients. Prof. Miller is the president of the Neural Control of Movement society.
14. Prof. Jonathan Wolpaw, Director of the National Center for Adaptive Neurotechnologies, New York State, USA: Prof. Wolpaw is a pioneer in the field of brain-computer interfaces to restore communication and control to people who are severely paralyzed by amyotrophic lateral sclerosis (ALS), strokes, or other devastating neuromuscular disorders and currently leads several clinical studies using this technology in human patients.
15. Prof. Marc Schieber, University of Rochester, USA: Prof. Schieber lab investigates how the brain controls movements of the body, and translates these findings to advance brain-machine interface technology for restoration and repair of lost or damaged neurological function. Prof. Schieber specifically focus on the control of fine finger movements, like those used in delicate surgery, and on the combination of reaching, grasping, and manipulating.

List of Isareli speakers and their topics of expertise:

1. Ehud Zohary, Hebrew University. Area of expertise: *Action observation, visual perception, plasticity*. Webpage: https://elsc.huji.ac.il/faculty-staff/ehud-zohary

2. Ehud Ahissar, Weizmann Institute of Science. Area of expertise: *neural representation of vision and touch in rodents and humans and construction of robotic and hybrid agents (brain-machine interface).* Webpage: https://www.weizmann.ac.il/neurobiology/labs/ahissar/home
3. Tamar Flash, Weizmann Institute of Science. Area of expertise: *computational modeling of movement.* Webpage: http://www.weizmann.ac.il/math/tamar/home
4. Avi Karni, University of Haifa. Area of expertise: *motor learning and plasticity, the role of sleep, developmental learning disabilities.* Website: http://neuro-etho.haifa.ac.il/LFBI-LR/research_interests.htm
5. Lior Shmuelof, Ben-Gurion University of the Negev. Area of expertise: *motor learning and motor control using behavioral experiments, computational modeling, and advanced functional Magnetic Resonance Imaging (fMRI) techniques*. Webpage: https://in.bgu.ac.il/en/humsos/bal/Pages/default.aspx
6. Roy Mukamel, Tel-Aviv University. Area of expertise: *neural representations of sensorimotor integration, skill learning and predictive coding.* Webpage: https://socsci3.tau.ac.il/rmukamel/
7. Yaniv Assaf, Tel Aviv University. Area of expertise: *the anatomical characteristics of brain tissue as well as structural aspects of neuro-plasticity and behavioral correlates using MRI.* Webpage: http://neuroimaging.tau.ac.il/
8. Nitzan Censor, Tel-Aviv University. Area of expertise: *perceptual and motor learning using TMS, fMRI and behavior*. Website: http://www.censorlab.tau.ac.il/
9. Ido Tavor, Tel-Aviv University. Area of expertise: *the connection between structure, function, and human behavior using magnetic resonance imaging.* Webpage: https://www.tau.ac.il/~idotavor/
10. Jason Friedman, Tel-Aviv University. Area of expertise: *Understanding the strategies used by the brain to control movement, in healthy people and individuals with motor disorders, with a focus on modeling movements and forces of the hand and fingers.* Webpage: http://www.movementscienceslab.com/
11. Firas Mawase, Technion. Area of expertise: *computational neuroscience and functional imaging of the brain linking state-of-the-art advances in basic science and biomedical engineering to a patient-based rehabilitation.* Webpage: https://www.mawase-lab.com/
12. Opher Donchin, Ben-Gurion University. Area of expertise: *physiological and behavioral aspects of motor control and motor learning, adaptation and perturbation during reaching movement. Physiology of the cerebellum, the relationship of long term and short term motor learning, and the role of conscious awareness in motor control*. Webpage: https://ml-lab.weebly.com/
13. Yifat Prut, Hebrew University. Area of expertise: *operation of the motor system during physiological and pathological states. descending mechanism(s) through which group of muscles are rapidly recruited for performing motor tasks, and how **ascending** sensory information shapes motor actions by dictating the timing of these events.* Webpage: https://elsc.huji.ac.il/faculty-staff/yifat-prut

14. Hagai Bergman, Hebrew University. Area of expertise: *physiological (multiple electrode) recordings to explore the computation physiology of the basal ganglia, its disorders and therapy*. Webpage: https://elsc.huji.ac.il/faculty-staff/hagai-bergman
15. Ilana Nisky, Ben-Gurion University. Area of expertise: *human motor control, haptics, robotics, human and machine learning, teleoperation, and robot-assisted surgery*. Webpage: http://bioroblab.weebly.com/ilana-nisky.html

Participants:

The seminar will be published in relevant media (academic mailing lists, website, social media etc.) and is open to all researchers interested in the field. In order to anticipate the number of attendees in advance, free registration will be required.

Seminar program:

Day 1: Action perception and sensorimotor loops	
08:30 – 09:00	Registration and Reception
09:00 – 09:15	Welcome remarks
09:15 – 09:45	Clare Press, Birkbeck University of London, UK.
09:45 – 10:15	Udi Zohary, Hebrew University, Israel
10:15 – 10:45	Jody Culham, Western University, Canada
10:45 – 11:15	Coffee Break
11:15 – 11:45	Ehud Ahissar, Weizamnn Institute of Science, Israel
11:45 - 12:15	Jason Gallivan, Queen's University, Canada
12:15 – 13:30	Lunch
13:30 – 14:00	Avi Karni, Haifa University, Israel
14:00 – 14:30	Emily Cross, University of Glasgow, UK.
14:30 – 15:00	Ilana Nisky, Ben-Gurion University, Israel
15:00 – 15:30	Coffee Break
15:30 – 16:00	Angelika Lingnau, University of Regensburg, Germany
16:00 – 16:30	Roy Mukamel, Tel-Aviv University, Israel
19:00 -	Festive dinner

Day 2: Plasticity, learning and body representations	
08:00 – 09:00	Breakfast
09:00 – 09:30	David Ostry, McGill University, Canada

09:30 - 10:00	Yaniv Assaf, Tel-Aviv University, Israel
10:00 – 10:30	Paul Gribble, University of Western Ontario, Canada
10:30 – 11:00	Coffee Break
11:00 – 11:30	Nitzan Censor, Tel-Aviv University, Israel
11:30 – 12:00	Julien Doyon, McGill University, Canada
12:00 – 13:30	Lunch Break
13:30 – 14:00	Ido Tavor, Tel-Aviv University, Israel
14:00 – 14:30	Angelo Maravita, University of Milano-Bicocca, Italy
14:30 – 15:00	Jason Friedman, Tel-Aviv University, Israel
15:00 – 15:30	Coffee Break
15:30 – 16:00	Tamar Flash, Weizmann Institute of Science, Israel
16:00 – 16:30	Firas Mawase, Technion, Israel
19:00 -	Festive dinner

Day 3: Networking and round tables

09:00 – 12:00	Morning activity (tour + authentic lunch at local restaurant)
12:00 – 15:00	Free time
15:00 - 17:30	Round tables and discussion panels on key open questions in the field of multisensory integration in action, led by early-career researchers
20:00 –	Dinner

Day 4: Cortical and sub-Cortical motor control networks

08:00 – 09:00	Breakfast
09:00 – 09:30	Jorn Diedrichsen, Western University, Canada
09:30 -10:00	Opher Donchin, Ben-Gurion University, Israel
10:00 – 10:30	Lior Shmuelof, Ben-Gurion University, Israel
10:30 – 11:00	Coffee Break
11:00 – 11:30	Yifat Prut, Hebrew University, Israel
11:30 – 12:00	David Schneider, NYU, USA
12:00 – 13:30	Lunch Break
13:30 – 14:00	Hagai Bergman, Hebrew University, Israel
14:00 – 14:30	Lee Miller, Northwestern University, USA

14:30 – 15:00	Jonathan Wolpaw, Wadsworth Center, USA
15:00 – 15:30	Coffee Break
15:30 – 16:00	Marc Schieber, University of Rochester, USA
16:00 – 16:30	Richard Carson, Trinity College Dublin, Ireland
19:00 -	Festive dinner

Cost Estimates:

The following budget foresees approx. 30 speakers (~15 Israeli, ~15 international), plus junior scientists (PhD students, postdocs) from Israel and abroad, for a total of approx. 60 participants. The budget will be managed at TAU by Roy Mukamel and at Technion by Firas Mawase. Additional funding (beyond those offered by the Bat-Sheva fund) will be raised from TAU, Technion, BGU, and ISF.

Description	**Further details**	**Estimated Cost (in USD)**
Accommodation for invited speakers + Venue	5 nights	$15,000
Travel (flights, trains) for invited speakers	~15 international speakers	$15,000
Catering (coffee & lunch breaks)	6 coffee breaks + 3 lunch breaks for 60 people across 3 days of talks	$10,000
Social dinner/events	3 social dinners/receptions (on days 1, 2 and 4)	$9,000
Social event (day 3)	Tour	$1,000
Conference programs, logos, rollup banners, website		$2,000
total		**$52,000**