Society for the
Neural Control
of Movement
NCM

31st Annual Meeting

Dublin, Ireland
Clayton Hotel Burlington Road

SATELLITE MEETING
July 25, 2022

ANNUAL MEETING
July 26 – 29, 2022

www.ncm-society.org

@ncm-soc **#NCMDub22**

Program at a Glance

Schedule is subject to change

Time: 8:00 – 22:30 (15-minute intervals)

Sunday, 24-Jul
- Arrivals, Free Time (8:00 – 17:00)
- Satellite Registration (17:00 – 19:00)
- **Satellite Registration** (17:00 - 19:00)
- **Satellite Dinner (Optional extra fee)** (18:30 - 20:30)

Monday, 25-Jul
- Registration /Information Desk Open (8:00 – 18:15)
- **Satellite Meeting** (8:30 – 18:15)
- **Opening Reception**, *The Odeon Bar and Terrace* (19:30 - 21:30)

Tuesday, 26-Jul
- Registration / Information Desk Open; Posters on Display (Session 1); Exhibits on Display (8:00 – 18:00)
- ***Session 1 Panel I*** – Tsay *(08:00 - 10:00)*
- **Break** (10:00 - 10:30)
- ***Early Career*** – Emily Oby (10:30 - 11:15)
- ***Session 2 Perspective*** – Mirdamadi (11:15 - 12:30)
- **Lunch**
- ***Session 3*** **Poster 1** (13:00 - 15:00)
- ***Session 4 Individual I*** (15:00 - 17:00)
- ***Session 5 Blitz I*** (17:00 - 18:00)
- **NCM Board Meeting** (18:00 - 20:00)
- **Trainee Event and Social**

Wednesday, 27-Jul
- Registration / Information Desk Open; Posters on Display (Session 2); Exhibits on Display (8:00 – 17:30)
- ***Session 6 Panel II*** – Kilteni (8:00 - 10:00)
- **Break** (10:00 - 10:30)
- ***Session 7 Individual II*** (10:30 - 12:30)
- **Lunch**
- ***Session 8*** **Poster 2** (13:00 - 15:00)
- ***Session 9 Panel III*** – *Chib* (15:00 - 17:00)
- **Members' Meeting** (17:00 - 17:30)
- **Free Time**

Thursday, 28-Jul
- Registration / Information Desk Open; Posters on Display (Session 3); Exhibits on Display (8:00 – 14:00)
- ***Session 10 Individual III*** (08:00 - 10:00)
- **Break** (10:00 - 10:30)
- ***Session 11 Blitz II*** (10:30 - 11:30)
- **Lunch**
- ***Session 12*** **Poster 3** (12:00 - 14:00)
- **Free Time and/or Excursions**
- **Free Time**

Friday, 29-Jul
- Registration / Information Desk Open (8:00 – 18:00); Posters on Display (Session 4) (8:00 – 15:00)
- ***Session 13 Panel IV*** – Xing (08:00 - 10:00)
- **Break** (10:00 - 10:30)
- ***Session 14 Individual IV*** (10:30 - 12:30)
- **Lunch**
- ***Session 15*** **Poster 4** (13:00 - 15:00)
- ***Session 16 Panel V*** – Neumann (15:00 - 17:00)
- ***Session 17 Keynote Speaker*** – *Fay Horak* (17:00 - 18:00)
- **Closing Drinks Reception** (18:00 - 19:00)
- **Free Time**

Table of Contents

About NCM

The Society for the Neural Control of Movement (NCM) is an international community of scientists, clinician-investigators and students all engaged in research whose common goal is to understand how the brain controls movement.

NCM was conceived in 1990 by Barry Peterson. With an initial leadership team that also included Peter Strick and Marjorie Anderson, NCM was formally established to bring together scientists seeking to understand the neural mechanisms that guide meaningful activities of daily life, primarily through the brain's control of the eyes, head, trunk, and limbs. Early members consisted largely of systems neurophysiologists, behavioral, computational and theoretical neurobiologists, and clinician-investigators interested in disorders of motor function.

From the outset the goal of NCM was to provide a useful gathering of investigators in an informal and casual setting to present and discuss where we are in a diverse and complex field, where we should be going and how we might best proceed as a community with multiple perspectives and approaches. The meeting was to be unique in style, such that sessions were formulated and proposed by small groups of members, each and geared to inform the larger attending community through focused presentations and discussions integrated into themes reflecting the diversity of the membership. Sessions would change in content with each yearly meeting.

The inaugural NCM Conference took place in April 1991 on Marcos Island, Florida, with roughly 140 attendees. The success of the initial years promoted longevity and expansion of NCM and its conference, both in attendance (now over 250) and the breadth of scientific content. Sessions cover all levels of inquiry--from perception to genetic expression, and from whole organism to intracellular function, while also including computational and theoretical approaches. Sessions have expanded to include a variety of formats and durations to accommodate diverse needs and interests, while poster sessions have been augmented to yield highly popular, vibrant and flexible forums of scientific interchange. This highly regarded and robust conference continues to meet in desirable, family-friendly locations typically in late April/early May every year.

Letter from the President

WELCOME TO THE 31ST ANNUAL MEETING OF THE SOCIETY FOR THE NEURAL CONTROL OF MOVEMENT!

Baile Átha Cliath, an Irish name for the city of Dublin, refers to a spot on the River Liffey deemed advantageous for "fording hurdles." We did, indeed, face and ford numerous hurdles in bringing our first in-person NCM meeting in more than three years to within a few minutes of the Liffey. We find ourselves here thanks to the efforts of Marischal De Armond, Michelle Smith, and their Podium team, who worked with the NCM executives in an ever-changing pandemic landscape to identify and secure a suitable conference time and venue. In an effort to avoid creating even more hurdles during the meeting, we will require that masks be worn except when speaking from the platform, or when eating. See the website and other announcements for more detail. Let's work together to minimize transmission as much as possible!

Despite the meetings' unusual timing and lingering travel concerns, NCM members submitted many compelling proposals, registered in near-record numbers, and logged the highest-ever tally of NCM hotel reservations. VP and program chair Kathy Cullen, working with her designated successor, Adrian Haith, shaped an exciting program, including the popular "Blitz" talks that premiered in the 2021 virtual meeting. One Covid concession has been to separate the poster sessions from lunch, and to display each poster for only a single day so that we can spread them out a bit physically.

The main meeting will be preceded by a day-long satellite meeting, organized by Natela Shanidze and Neeraj Gandhi, which will focus attention on the neural control of eye and head movements, including a keynote address by Michael King. Keeping with our tradition, we will close the main meeting with a keynote address, this year from Fay Horak, winner of the NCM Distinguished Career Award, entitled "How to select the best balance and gait outcomes for clinical trials." Emily Oby will deliver the Early Career Award Keynote earlier in the week, speaking on, "Insights into motor control from brain-computer interfaces".

Brian Corneil will be stepping down as Development Officer at the end of the meeting, to be replaced by Kazuhiko Seki. In the past few years, the role of the Development Officer has evolved considerably and is now less about reaching out to potential sponsors, and more about creating opportunities for trainees. Events this year include a trainee social and a professional development session, both on Tuesday evening. We have 19 trainee award winners this year, appointed by virtue of having their work selected for a platform presentation. Of these, 11(!) have opted to contribute to the increasingly popular Meeting Highlights article, which again will be published in the Journal of Neurophysiology.

Finally, I'd like to welcome newly-elected members to the NCM board, which this year include Friedl de Groote, Sam McDougle, Hans Scherberger, and Aaron Wong. Megan Carey was reelected to a second term, and I wish to extend a special welcome to Susan Coltman, post-doctoral fellow at the University of Colorado, our new trainee member.

As we come and go across the River Liffey this week, let's celebrate the renewed opportunity to greet colleagues, in person, in Dublin. Enjoy the meeting!

Cordially,

Lee Miller
President

NCM Leadership

Elected members govern the Society for the Neural Control of Movement. These members comprise the Board of Directors who in turn elects Officers that comprise the Executive Committee. The Society's Bylaws govern how the Board manages the Society.

Officers and Board members are elected for three-year terms and may be re-elected to one additional contiguous term. The current Board comprises the following Officers and Directors:

OFFICERS

EXECUTIVE COMMITTEE

President &
Conference Chair
Lee Miller

Vice President &
Scientific Chair
Kathleen Cullen

Treasurer & Secretary
Rachael Seidler

Development Officer
Brian Corneil

BOARD MEMBERS

NAME	INSTITUTION	COUNTRY	TERM
Pieter Medendorp[2]	*Champalimaud Center of the Unknown*	Portugal	2019 - 2022
Claire Honeycutt[1]	*Arizona State University*	USA	2019 - 2022
Kazuhiko Seki[1]	*National Center of Neurology & Psychology*	Japan	2019 - 2022
Heather McGregor*	*University of Florida*	USA	2019 - 2022
Juan Alvaro Gallego[1]	*Imperial College London*	GBR	2020 - 2023
Andrea d'Avella[1]	*Universita degli Studi di Messina*	ITA	2020 - 2023
Joseph Galea[1]	*University of Birmingham*	GBR	2020 - 2023

Gelsy Torres[2]	*University of Pittsburgh*	USA	2020 - 2023
Neeraj Gandhi[1]	*University of Pittsburgh*	USA	2021 - 2024
Adrian Haith[2]	*Johns Hopkins University*	USA	2021 - 2024
Wilsaan Joiner[1]	*University of California Davis*	USA	2021 - 2024
Jennifer Semrau[1]	*University of Delaware*	USA	2021 - 2024

[1] Serving first 3 year term [2] Serving second 3 year term *Trainee Board Member

INCOMING BOARD MEMBERS

The following members will begin their term at the 2022 Annual Meeting:

NAME	INSTITUTION	COUNTRY	TERM
Megan Carey	*Champalimaud Center of the Unknown*	Portugal	2022 - 2025
Susan Coltman*	*University of Colorado, Denver*	USA	2022 - 2024
Freidl De Groote	*KU Leuven*	Belgium	2022 - 2024
Sam McDougle	*Yale University*	USA	2022 - 2025
Hans Scherberger	*German Primate Center*	Germany	2022 - 2025
Aaron Wong	*Moss Rehabilitation Research Institute*	USA	2022 - 2025

*Trainee Board Member

NCM ADMINISTRATION

Association Secretariat & Conference Management *management@ncm-society.org*

Podium Conference Services

- Michelle Smith
- Jude Ross
- Sondrine Marshall

BOARD SERVICE

Nominations for NCM Board service open in January. Nominations must come from members in good standing, and only members are invited to stand for election. To learn more about Board service or if you are interested in serving on the NCM Board, please discuss your interest with one of NCM's Board members or Officers, or send an email to *management@NCM-Society.org*.

MEMBERSHIP INFORMATION

NCM membership is open to all scientists, principal investigators and students from around the world, pursuing research whose goal is to understand how the brain controls movement. Memberships are valid September 1 through August 31 each year.

BENEFITS

NCM membership includes the following benefits:

- Opportunity to submit proposals and abstracts for sessions at the Annual Conference
- Opportunity to submit proposals for satellite meetings
- Opportunity to register for Annual NCM Conferences at reduced registration rates
- Access to the member resource database and other members' web services
- Professional development and networking
- Access and ability to respond directly to job opportunity postings
- Ability to post job opportunities
- Access to online NCM resources and Annual Conference proceedings
- Access to scholarships (Grad Students and Post Docs)
- Opportunity to vote in Annual Elections of NCM Board members
- Opportunity to stand for election to, and serve on, the NCM Board of Directors
- Regular email updates and notices

To become an NCM Member please visit us at the registration desk today

NCM HISTORY

Since 1991 NCM's annual conferences have provided a forum for leading edge research, scholarly debate, the interchange of ideas, and a platform for many exceptional established and emerging researchers in the field of Neural Science. We are proud that this has all been accomplished in some of the nicest destinations in the world. Our history is strong and our future is bright.

CONFERENCE	DATES	CITY	COUNTRY	HOTEL
30th Annual Meeting	April 20 – 22, 2021	Virtual		
29th Annual Meeting*	April 23 – 27, 2019	Toyama	Japan	Toyama International Conference Center
28th Annual Meeting*	April 30 – May 4, 2018	Santa Fe	USA	Hilton Buffalo Thunder
27th Annual Meeting*	May 1 – 5, 2017	Dublin	Ireland	The Clayton Hotel Burlington Road
26th Annual Meeting	April 24 – 29, 2016	Montego Bay	Jamaica	Hilton Rose Hall Resort
25th Annual Meeting*	April 20 – 24, 2015	Charleston, SC	USA	Francis Marion Hotel
24th Annual Meeting*	April 21 – 25, 2014	Amsterdam	Netherlands	Grand Hotel Krasnapolsky
23rd Annual Meeting*	April 16 – 20, 2013	San Juan, Puerto Rico	USA	El San Juan Hotel & Casino
22nd Annual Meeting*	April 23 – 28, 2012	Venice	Italy	Hilton Molino Stucky
21st Annual Meeting*	April 26 – 30, 2011	San Juan, Puerto Rico	USA	El San Juan Hotel & Casino

20th Annual Meeting*	April 20 – 25, 2010	Naples, Florida	USA	Naples Beach Hotel & Golf Club
19th Annual Meeting*	April 28 – May 3, 2009	Waikoloa, Hawaii	USA	Waikoloa Beach Marriott Resort & Spa
18th Annual Meeting	April 29 – May 4, 2008	Naples, FLA	USA	Naples Beach Hotel & Golf Club
17th Annual Meeting*	March 25 – April 1, 2007	Seville	Spain	Melia Sevilla
16th Annual Meeting*	April 30 – May 7, 2006	Key Biscayne, FLA	USA	Sonesta Beach Resort
15th Annual Meeting	April 12 – 17, 2005	Key Biscayne, FLA	USA	Sonesta Beach Resort
14th Annual Meeting*	March 25 – April 3, 2004	Sitges	Spain	Melia Sitges
13th Annual Meeting	April 22 – 27, 2003	Santa Barbara, CA	USA	Fess Parker's Doubletree Resort
12th Annual Meeting*	April 14 – 21, 2002	Naples, FLA	USA	Naples Beach Hotel & Golf Club
11th Annual Meeting	March 25 – 30, 2001	Seville	Spain	Melia Sevilla
10th Annual Meeting	April 9 – 17, 2000	Key West, FLA	USA	Wyndham Casa Marina Resort
9th Annual Meeting*	April 11 – 19, 1999	Kauai, Hawaii	USA	Princeville Resort
8th Annual Meeting	April 14 – 22, 1998	Key West, FLA	USA	Marriott Casa Marina Resort
7th Annual Meeting*	April 8 – 16, 1997	Cozumel	Mexico	Presidente Intercontinental
6th Annual Meeting	Apri 16 – 21, 1996	Marco Island, FLA	USA	Radisson Suite Beach Resort
5th Annual Meeting	April 18 – 25, 1995	Key West, FLA	USA	Marriott Casa Marina Resort
4th Annual Meeting*	April 13 – 22, 1994	Maui, Hawaii	USA	Maui Marriott Resort (Lahaina)
3rd Annual Meeting	April 13 – 18, 1993	Marco Island, FLA	USA	Radisson Suite Beach Resort
2nd Annual Meeting	April 21 – 26, 1992	Marco Island, FLA	USA	Radisson Suite Beach Resort
1st Annual Meeting	April 6 – 11, 1991	Marco Island, FLA	USA	Radisson Suite Beach Resort

*indicates a Satellite Meeting was held in conjunction with the Annual Conference

The **Medical Rehabilitation Research Resource Network (MR3)** is a consortium of six centers nationwide providing expertise, technology, and resources to support clinical and translational research in medical rehabilitation across a wide range of disciplines and disease focus areas.

NCMRR.org

Center for Smart Use of Technologies to Assess Real-World Outcomes (C-STAR)

Focus: Technology-Related Rehabilitation

Northwestern University | Shirley Ryan AbilityLab

Restore Center

Focus: Mobile Technology

Stanford University

National Center of Neuromodulation for Rehabilitation (NM4R)

Focus: Neuromodulation for Rehabilitation

Medical University of South Carolina

Learning Health Systems Rehabilitation Research Network

Focus: Inplementation Science, Learning Health Systems

Brown University | University of Pittsburgh | Boston University

C-PROGRESS

Focus: Pediatric Rehabilitation

Virginia Tech | The Ohio State University

The American Academy for Cerebral Palsy and Developmental Medicine (AACPDM)

Alliance for Regenerative Rehabilitation Research & Training (AR3T)

Focus: Regenerative Rehabilitation

University of Pittsburgh | Mayo Clinic

University of Texas at Austin | Stanford University

Visit us online at **NCMRR.org** to learn more about opportunities in medical rehabilitation research, including:

- Fellowships / Sabbaticals
- Visiting Scholar Opportunities
- Advanced Training Workshops
- Online Presentations / Webinars
- Pilot Study Programs
- Consultation Services
- Research Cores / Databases
- Rehabilitation News

The MUSC National Center of NM4R is proud to serve as home of the MR3 Network Coordinating Center (NIH Grant P2C HD086844)
The MR3 Network is supported by the National Institutes of Health *Eunice Kennedy Shriver* National Institute for Child and Human Development (NICHD), in partnership with the NCMRR, the NCCIH, the NIDCD, the NINR, the NINDS, and the NIBIB. Together, these resources enhance and strengthen the medical rehabilitation research landscape nationwide.

General Conference Information

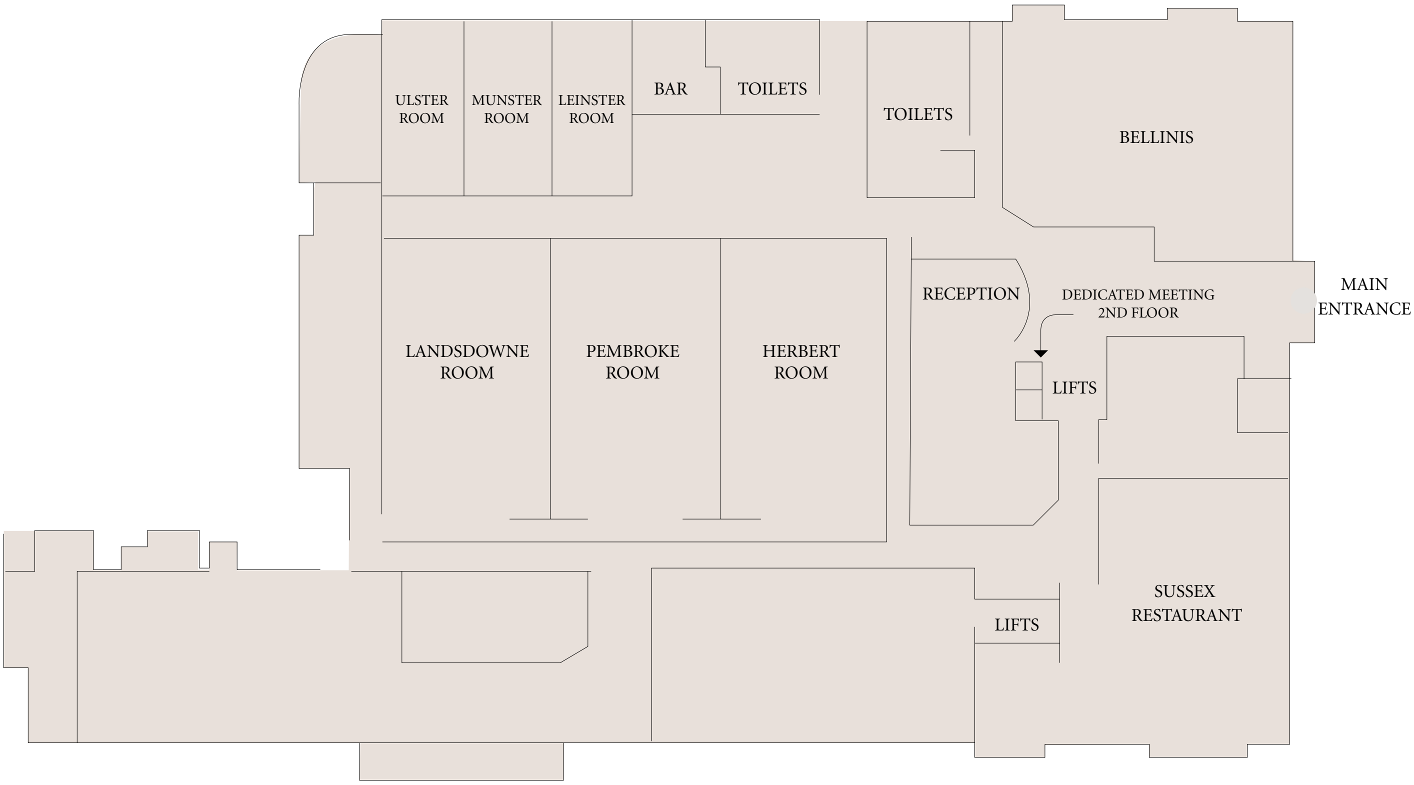
CONFERENCE VENUE

Clayton Hotel Burlington Road

Upper Leeson Street
Dublin, 4 D04 A318
Ireland

All conference sessions will take place in this location. The Opening Reception will be off-site at the Odeon Bar and Restaurant, a short 15 minute walk from the host hotel.

FLOOR PLANS



REGISTRATION

SATELLITE MEETING

Satellite Meeting registration fees include access to the full day meeting with refreshment breaks and a buffet lunch on Monday July 25th. An optional dinner can be added to meeting registration for satellite attendees. The dinner is scheduled for Sunday July 24th.

ANNUAL CONFERENCE

Annual Conference registration fees include access to all sessions including panel, individual, and poster sessions. Registration also includes daily refreshment breaks, buffet lunches, the Opening Reception at the Odeon Bar and Restaurant, the trainee reception for trainee delegates and the Closing Drinks Reception.

ADDITIONAL TICKETS

Tickets can be purchased separately for your guests and/or children for the Opening Reception, Closing Drinks Reception and Buffet Lunches and excursions. These additional tickets can be purchased from the staff at NCM's Registration Desk.

NAME BADGES

Your name badge is your admission ticket to the conference sessions, coffee breaks, meals, and receptions. Please wear it at all times. At the end of the Conference we ask that you recycle your name badge in one of the name badge recycling stations that will be set out or leave it at the Registration Desk.

To help identify and mentor our future investigators, student delegates have blue edged badges. All other delegates have clear badges. NCM Officers and Board Members, Exhibitors and Staff will be identified by appropriate ribbons. The scholarship winners and the Early Career Award winner will be identified by award winner ribbons.

DRESS CODE

Dress is casual for all NCM meetings and social events.

REGISTRATION AND INFORMATION DESK HOURS

The NCM Registration and Information Desk, located in the foyer/lobby outside the Herbert/Pembroke Rooms, will be open during the following dates and times:

Sunday, July 24	17:00 – 19:00 *in the hotel lobby*
Monday, July 25	07:30 – 18:30
Tuesday, July 26	07:30 – 18:00
Wednesday, July 27	07:30 – 17:30
Thursday, July 28	07:30 – 14:00
Friday, July 29	07:30 – 18:00

If you need assistance during the conference, please visit the Registration Desk.

POSTER INFORMATION

ANNUAL MEETING

There are four Poster Sessions during the Meeting and posters have been allocated to either one of the sessions based on poster themes. Poster presenters must set-up and remove their posters during the following times.

POSTER SESSION 1

Set-up:
Tuesday July 26, between 07:30 and 10:00

Remove:
Tuesday July 26, no later than 18:00

POSTER SESSION 2

Set-up:
Wednesday July 27, between 07:30 and 10:00

Remove:
Wednesday July 27, no later than 17:30

POSTER SESSION 3

Set-up:
Thursday July 28, between 07:30 and 10:00

Remove:
Thursday July 28, no later than 14:00

POSTER SESSION 4

Set-up:
Friday July 29, between 07:30 and 10:00

Remove:
Friday July 29, immediately after the poster session completion at 15:00

Any posters that are not taken down by the removal deadline will be held at the registration desk until the end of the Meeting. Any posters that remain unclaimed by the end of the Meeting will be disposed of.

Information on Poster Authors (Lead), Poster Numbers and Poster Titles begins on page 51
For a complete copy of all the poster abstracts, a digital abstract booklet can be downloaded from the Member Only section of the NCM Website.

STAFF

NCM staff from Podium Conference Specialists can be identified by orange ribbons on their name badges. Feel free to ask anyone of our staff for assistance. For immediate assistance please visit us at the Registration Desk.

INTERNET SERVICES

Wireless Internet is available to Annual Meeting delegates for no charge. Simply choose the **Clayton Hotel WiFi network** and agree to the terms and conditions. No password is required. Kindly note, the WiFi strength is ideal for checking emails and websites but is not strong enough for streaming videos or heavy social media use.

If you are active on social media, make sure to hashtag *#NCMDub22 @ncm_soc* when referring to the meeting. We ask all NCM delegates to respect no live tweeting of presentations without prior approval from the speakers/authors and no photography in the poster hall. We encourage social tweets about the conference and look forward to growing our online community.

If you require assistance, please visit the registration desk and we will endeavour to assist you.

NO SMOKING POLICY

The Clayton Hotel Burling Road is a completely non-smoking facility. Smoking areas are located outside the front entrance to the hotel.

Special Meetings & Events

GENERAL INFO

Sunday, July 24 19:00 – 21:00

SATELLITE OPTIONAL DINNER

(Satellite Meeting Registrants)

Location:
Sussex Restaurant in the Clayton Hotel Burlington Road

Monday, July 25 19:30 – 21:30

OPENING RECEPTION

Location:
Odeon Restaurant and Bar

Wednesday, July 27 17:00 – 17:30

NCM MEMBERS MEETING

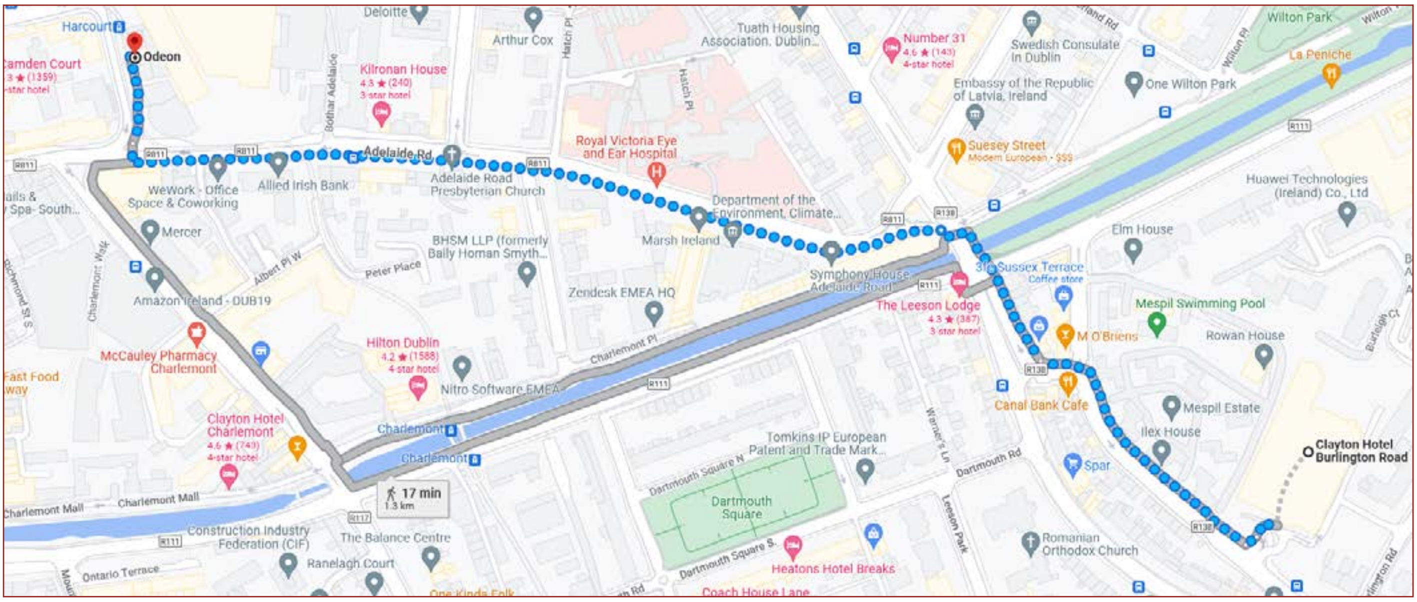
Location:
Fitzwilliam Hall

Friday, July 29 18:00 – 19:00

CLOSING DRINKS RECEPTION

Location:
BBar

ODEON RESTAURANT WALKING MAP



Odeon Restaurant

Join us at the Odeon Restaurant, 57 Harcourt Street, Saint Kevin's, Dublin 2 for the Opening Reception.

With an outdoor patio, indoor space and ample room to spread out, we welcome delegates to get reacquainted with colleagues and meet new delegates. Join us for appetizers, a BBQ, and cocktails.

Directions:

Exit the hotel and **turn right** onto Sussex Rd/R138

Turn right onto Leeson Street Upper/R138 and continue to follow R138

Turn left onto Adelaide Rd/R811

Turn right onto Harcourt St/R114/R811

CONFERENCE EXCURSIONS

Additional tickets for the excursions can be purchased at the NCM Registration Desk until tours are sold out. **Please note, advance purchase is required.**

HISTORIC WALKING TOUR

14:45 – 16:45
Maximum of 25 participants
Price: $20 USD

In just over 2 hours, this Fáilte Ireland-approved, award-winning and entertaining walking tour, conducted by history graduates of Trinity College Dublin and the National University of Ireland, explores the main features of Irish history – Dublin's development, the influence of the American and French Revolutions, the Potato Famine, the Great War and the 1916 Rising, the War of Independence, the Northern conflict and Ireland today.

This tour will meet at the Grattan statue, College Green, opposite the Trinity College front gate.

ULYSSES ONE HUNDRED

Following the footsteps of Joyce and his Revolutionary Generation in Dublin Walking Tour
14:45 – 16:45
Maximum of 25 participants
Price: $20 USD

James Joyce was the same age as Eamon de Valera, a towering figure in 20th century Irish history, but as a teenager had visited the home of Hannah Sheehy-Skeffington, one of Ireland's foremost feminists and the older sister of his schoolmates. This centenary year of the publication of his landmark literary masterpiece Ulysses is an opportunity to reflect on Joyce from a historical perspective, and to locate him within a generation redefining Irish cultural identity and pursuing Ireland's sovereignty. On our rambles we will reflect on Joyce's vivid portrayal of Dublin on the eve of political turmoil and Revolution.

This tour will meet at the Grattan statue, College Green, opposite the Trinity College front gate.

Satellite Meeting

NCM SATELLITE MEETING, DUBLIN, IRELAND

JULY 24 & 25, 2022

All sessions will be held at the Clayton Hotel Burlington Road

The vestibular and oculomotor systems are inextricably linked in their design. Without proper eye movement control (motor), vestibular function is disrupted, and without vestibular signal (sensory), appropriate eye movement control is not possible in a moving organism. Although this interdependence has complex effects on visual stability, balance, and posture; the two systems can often seem simple in their basic architecture. For example, the vestibular apparatus is an engineering marvel for understanding signal processing and developing neural prostheses. Insults to the vestibular and oculomotor control streams produce profound effects on both behavior and perception (visual and vestibular) yet can also exhibit a resilient ability to recover. A deeper understanding of these systems, both intact and damaged, requires studies that bridge cellular and systems neurosciences and also incorporate behavioral, computational, and clinical efforts.

The satellite meeting will consider this range of topics through sessions focused on oculomotor control and vestibular processing in periphery and in the central nervous system, particularly in terms of their impact on action and perception.

The satellite is organized by **Natela Shanidze**, *The Smith-Kettlewell Eye Research Institute and* **Neeraj Gandhi**, *University of Pittsburgh*

Sponsored by:

EYESEETEC

SUNDAY JULY 24

17:00 – 19:00 **SATELLITE REGISTRATION**

19:00 – 21:00 **OPTIONAL SATELLITE DINNER**

Sussex Restaurant in the Clayton Hotel Burlington Road

MONDAY JULY 25

08:00 - 08:30 **REGISTRATION**

08:30 - 08:40 **WELCOME/INTRODUCTION**

from Natela Shanidze and Raj Gandhi

08:40 – 10:10 **SESSION 1:**
Peripheral vestibular processing

Discussion Leader: **Neeraj Gandhi**, *University of Pittsburgh*

Title TBC
Kathleen Cullen, *John Hopkins University*

Discharge properties of neurons in the 8th nerve, vestibular nucleus and abducens nucleus may explain suboptimal VOR characteristics in response to neuroprosthetic stimulation
James Phillips, *University of Washington*

Neural basis of VEMP Testing: Canal and Otolith afferent responses to clicks and tone bursts
Hong Zhu, *University of Mississippi Medical Center*

Calcium transients in vestibular hair cells and supporting cells
Holly Holman, *University of Utah*

10:10 – 10:20 **COFFEE BREAK**

10:20 – 12:10 **SESSION 2:**
Central vestibular signals & integration I (eye-head coordination, VOR, reafference, compensation)

Discussion Leader: **Hans van der Steen**, *Erasmus University Medical Center*

Organization of the gravity-sensing system in zebrafish
Martha Bagnall, *Washington University*

Are the eyes yoked or independent? Evidence from neuroanatomical studies
Paul May, *University of Mississippi Medical Center*

Oculomotor plant hypothesis (OPH) 2.0: Abducens neuron behaviors during combined eye-head gaze shifts, disjunctive smooth pursuit and sleep in monkeys
Wu Zhou, *University of Mississippi Medical Center*

Neural circuits suppressing brain omnipause-neuron activity and triggering saccadic eye movements
Mayu Takahashi, *Tokyo Medical and Dental University*

Coding strategies for representing natural self-motion across ascending vestibular pathways
Jerome Carriot, *McGill University*

12:10 – 14:10 **LUNCH AND SATELLITE MEETING POSTER SESSION**

14:10 – 16:00 **SESSION 3:**
Central vestibular signals & integration II (motor learning, eye-hand coordination, self-motion/navigation, central balance control, ascending vestibular signals for navigation and heading)

Discussion Leader: **Lawrence Snyder**, *Washington University*

Eye movements for active sensing and memory during visually-guided navigation
Dora Angelaki, *New York University*

Reference frames for encoding spatial motion in the cerebellum
Andrea Green, *University of Montreal*

Characterization of head orientation and heading during everyday activity in humans: implications for modeling perceptual biases
Paul MacNeilage, *University of Nevada, Reno*

Explaining inter-individual variations in central spatial-orientation processing
Faisal Karmali, *Massachusetts Eye and Ear*

Probing some links among aging, vestibular function, and balance
Dan Merfeld, *Ohio State University*

16:00 – 16:10 **COFFEE BREAK**

16:10 – 17:40 **SESSION 4:**
Dysfunctional vestibular signals

Discussion Leader: **Steve Lisberger**, *Duke University*

The effects of noise exposure of vestibular function
Courtney Stewart, *LTC Charles S Kettles VA Medical Center, Ann Arbor &*
Natela Shanidze, *The Smith-Kettlewell Eye Research Institute*

Integration of magnetic and gravity cues for avian navigation
David Dickman, *Baylor University*

Imbalance and dizziness caused by vestibular schwannomas correlate with vestibulo-ocular reflex precision & bias
Susan King, *Massachusetts Eye and Ear*

Effect of head tilt and stimulus tilt on saccade direction biases
Jorge Otero-Millan, *University of California Berkeley*

17:40 – 17:55 **KEYNOTE INTRODUCTION BY CRAIG EVINGER**

17:55 – 18:40 **SATELLITE KEYNOTE**

The striking persistence of oscillopsia in patients with bilateral vestibular hypofunction
Michael King, *University of Michigan, Ann Arbor*

19:30 – 21:30 **OPENING RECEPTION FOR ANNUAL MEETING**

Please Note: If you registered to attend the Satellite Meeting ONLY and want to attend the dinner, tickets can be purchased at the registration desk.

Annual Conference Schedule

DAY 1 MONDAY JULY 25, 2022

19:30 – 21:30 **OPENING RECEPTION**
Off Site at the Odeon Restaurant

DAY 2 TUESDAY JULY 26, 2022

08:00 - 10:00 **SESSION 1, PANEL I**
Beyond a visuo-centric view: The crucial role of proprioception in sensorimotor learning

Jonathan Tsay[1], Cristina Rossi[2], Hannah Block[3], Chris Miall[4]

[1]University of California Berkeley, [2]Johns Hopkins University, [3]Indiana University Bloomington, [4]University of Birmingham

10:00 – 10:30 **BREAK**

10:30 – 11:15 **EARLY CAREER AWARD PRESENTATION**

Insights into motor control from brain-computer interfaces
Emily Oby, *University of Pittsburgh*

11:15 - 12:30 **SESSION 2, PERSPECTIVE I**

Cortical control of human balance and mobility
Jasmine Mirdamadi[1], Sue Peters[2], Sam Stuart[3]

[1]Emory University, [2]Western University, [3]Northumbria University

12:30 – 13:00 **LUNCH**

13:00 – 15:00 **SESSION 3, POSTER 1 AND EXHIBITORS**

15:00 – 17:00 **SESSION 4, INDIVIDUAL I**

Manual force encoding in the motor cortex of macaques and humans
Elizaveta Okorokova[1], Anton Sobinov[1], John Downey[1], Ashley van Driesche[1], Qinpu He[1], Charles Greenspon[1], Nicholas Hatsopoulos[1], Sliman Bensmaia[1]

[1]University of Chicago

Motor cortex isolates skill-specific dynamics to implement context-specific feedback control
Eric Trautmann[1], Najja Marshall[1], Hannah Chen[1], Francisco Sacadura[1], Elom Amematsro[1], Elijah Aliyari[1], Daniel Wolpert[1], Michael Shadlen[1], Mark Churchland[1]

[1]Columbia University

Nonlinear manifolds underlie neural population activity during behaviour
Catia Fortunato[1], Jorge Bennasar-Vázquez[1], Junchol Park[2], Lee Miller[3], Joshua Dudman[2], Matthew Perich[4], Juan Gallego[5]

[1]Bioengineering Department, [2]Janelia Research Campus, [3]Feinberg School of Medicine Northwestern, [4]Icahn School of Medicine at Mount Sinai, [5]Imperial College London

Effector-specific sensorimotor transformations in dorsolateral prefrontal cortex during a head-unrestrained reach task

Veronica Nacher[1], Parisa Abedi-Khoozani[1], Vishal Bharmauria[1], Harbandhan Arora[1], Xiaogang Yan[1], Saihong Sun[1], Hongying Wang[1], John Crawford[1]
[1]*York University*

Reformatting of the representation of action from neocortex to striatum

Junchol Park[1], Catia Fortunato[2], Juan Gallego[2]
[1]*Howard Hughes Medical Institute,* [2]*Imperial College London*

Somatosensory and motor cortex both causally contribute to speech motor learning

Matthias Franken[1], Timothy Manning[1], Alexandra Williams[1], David Ostry[1]
[1]*McGill University*

17:00 – 18:00 SESSION 5, BLITZ I

Where is the target of our movement?

Jeroen Smeets[1], Cristina de la Malla[2], Eli Brenner[1]
[1]*Vrije Universiteit Amsterdam,* [2]*Universitat de Barcelona*

Predicting full-body proprioceptive cortical anatomy and neural coding with topographic autoencoders

Max Grogan[1], Kyle Blum[2], Lee Miller[2], Aldo Faisal[1]
[1]*Imperial College London,* [2]*Northwestern University*

Biomimetic stimuli from a vestibular prosthesis improve postural control in a nonhuman primate

Olivia Leavitt[1], Kathleen Cullen[1]
[1]*Johns Hopkins University*

Characterization of head orientation and heading during everyday activity: Implications for modeling.

Christian Sinnott[1], Peter Hausamann[2], Paul MacNeilage[1]
[1]*University of Nevada - Reno,* [2]*KINEXON*

Ocular eccentricity affects subjective visual vertical perception in health and disease

Catherine Agathos[1], Anca Velisar[1], Natela Shanidze[1]
[1]*Smith-Kettlewell Eye Research Institute*

Perception of time-varying envelopes begins at the single-neuron level in central vestibular pathways: implications for perception and motor control

Isabelle Mackrous[1], Jerôme Carriot[1], Kathleen Cullen[2], Maurice Chacron[1]
[1]*McGill University,* [2]*Johns Hopkins University*

Humans optimize energy and time for point-to-point walking movements

Elizabeth Carlisle[1], Arthur Kuo[1]
[1]*University of Calgary*

Deep brain stimulation frequency affects evoked potential delay, amplitude, and frequency components

Jessica Vidmark[1], Estefania Hernandez-Martin[2], Terence Sanger[1]

[1]University of California, Irvine, [2]University of La Laguna

18:00 – 19:00 TRAINEE EVENT AND SOCIAL

Join us to hear from industry leaders about jobs outside of academia. Following a panel discussion, a drinks reception for all the trainees in attendance with the industry leaders.

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DAY 3 WEDNESDAY JULY 27, 2022

08:00 - 10:00 SESSION 6, PANEL II

Cancelation of self-generated sensations: neural mechanisms and functional advantages across species and sensory modalities

Konstantina Kilteni[1], David Schneider[2], Avner Wallach[3], Kathleen Cullen[4]

[1]Karolinska Institutet, [2]New York University, [3]Columbia University, [4]John Hopkins University

10:00 – 10:30 BREAK

10:30 - 12:30 SESSION 7, INDIVIDUAL II

Predictability as control priority in a functional task: computational research with clinical applications

Rashida Nayeem[1], Salah Bazzi[1], Mohsen Sadeghi[1], Reza Sharif Razavian[1], Dagmar Sternad[1]

[1]Northeastern University

A distributed circuit for regulating feedback control policy

Jonathan Michaels[1], Mehrdad Kashefi[1], Olivier Codol[1], Rhonda Kersten[1], J. Andrew Pruszynski[1]

[1]Western University

Behaviorally relevant, but not any salient events, inhibit rapid hand movements

Clara Kuper[1], Martin Rolfs[2]

[1]Humboldt Universität zu Berlin, Berlin School of Mind and Brain, [2]Humboldt Universität zu Berlin, Berlin School of Mind and Brain, Bernstein Center for Computational

Emergence of habitual control in a novel motor skill over multiple days of practice

Christopher Yang[1], Noah Cowan[1], Adrian Haith[1]

[1]Johns Hopkins University

A sensory race between oculomotor control areas for coordinating motor timing

Antimo Buonocore[1], Ziad Hafed[1]

[1]*University of Tuebingen*

Express reaching responses are preserved in Parkinsons Disease and insensitive to levodopa treatment

Rebecca Kozak[1], Maggie Prenger[1], Madeline Gilchrist[1], Kathryne Van Hedger[1], Mimma Anello[1], Penny MacDonald[1], Brian Corneil[1]

[1]*Western University*

12:30 – 13:00 **LUNCH**

13:00 – 15:00 **SESSION 8, POSTER 2 AND EXHIBITORS**

15:00 - 17:00 **SESSION 9, PANEL III**

Motivational influences on motor performance

Vikram Chib[1], Court Hull[2], Amanda Therrien[3], Mati Joshua[4]

[1]*Johns Hopkins University,* [2]*Duke University,* [3]*Moss Rehabilitation Research Institute,* [4]*The Hebrew University of Jerusalem*

17:00 – 17:30 **NCM MEMBERS MEETING**

All members of the Society for the Neural Control of Movement are invited to attend

17:30 – 18:30 **CORTEXPLORE WORKSHOP AND DEMONSTRATION**

Join us to hear exciting new things from the Cortexplore team. Beverages will be provided for those in attendance. *Meeting Room 6*

DAY 4 THURSDAY JULY 28, 2022

8:00 – 10:00 **SESSION 10, INDIVIDUAL III**

Beyond remapping: how is cortical information content altered following hand loss?

Dollyane Muret[1], Maria Kromm[1], Arabella Bouzigues[1], Vijay Kolli[2], Tamar Makin[1]

[1]*UCL,* [2]*Queen Mary's Hospital*

The effect of tactile augmentation on force field adaptation

Chen Avraham[1], Ilana Nisky[1]

[1]*Ben-Gurion University of the Negev*

Effects of task-irrelevant visual feedback on motor adaptation in a bimanual redundant motor task

Toshiki Kobayashi[1], Daichi Nozaki[1]

[1]*The University of Tokyo*

Distinct functional architectures for implicit and explicit motor learning from reinforcement signals

Andrew Byun[1], Maurice Smith[1]

[1]*Harvard John A. Paulson School of Engineering and Applied Sciences*

Blocking cerebellar signals increases internal noise and impairs motor adaptation

Yifat Prut[1], Sharon Israeli[1], Firas Mawase[2], Jonathan Kadmon[1]

[1]The Hebrew University, [2]The Technion - Israel Institute of Technology

Probing the foundations of motor learning for physical Human-AI collaboration

Ali Shafti[1], William Dudley[1], Aldo Faisal[2]

[1]Imperial College London, [2]Imperial College London & University of Bayreuth

10:00 – 10:30 **BREAK**

10:30 – 11:30 **SESSION 11, BLITZ II**

High-performance kinematic decoding and neural-state estimation that leverages general properties of motor-cortex population geometry

Sean Perkins[1], Karen Schroeder[1], John Cunningham[1], Qi Wang[1], Mark Churchland[1]

[1]Columbia University

Influence of implicit and explicit feedback response to a visual error on visuomotor learning response

Yuto Makino[1], Keisyu Inoue[1], Toshiki Kobayashi[1], Daichi Nozaki[1]

[1]The University of Tokyo

Anticipatory force control for skilled manipulation of objects at variable contact points depend on visual feedback at grasp contact

Joshua Bland[1], Marco Davare[2], Michelle Marneweck[1]

[1]University of Oregon, [2]King's College London

Express visuomotor responses in hip abductor muscles: Evidence for an intricate relationship between fast stepping and postural control

Lucas Billen[1], Brian Corneil[2], Vivian Weerdesteyn[1]

[1]Donders Institute, Radboud University Medical Center, [2]Western University

Sensory tuning in neuronal movement commands

Ziad Hafed[1], Amarender Bogadhi[2], Matthias Baumann[1], Anna Denninger[1]

[1]Centre for Integrative Neuroscience, [2]Boehringer Ingelheim Pharma GmbH & Co. KG

Nociception impedes grasping recovery in the spinal cord injured rat

John Walker[1], Taegyo Kim[1], Simon Giszter[1], Megan Detloff[1]

[1]Drexel University College of Medicine

An intention-based strategy for grasping prosthesis

Andres Agudelo-Toro[1], Jonathan Michaels[2], Wei-An Sheng[3], Hansjörg Scherberger[4]

[1]German Primate Center, [2]Western University, [3]Institut des Sciences Cognitives Marc Jeannerod, [4]University of Göttingen

Hasty sensorimotor decisions rely on an overlap of broad and selective changes in motor activity

Gerard Derosiere[1], David Thura[2], Paul Cisek[3], Julie Duque[1]

[1]Catholic University of Louvain, [2]Lyon Neuroscience Research Center, [3]University of Montreal

Cerebellar function for recalibrating visual space, motor space and internal movement predictions

Jana Masselink[1], Alexis Cheviet[2], Denis Pélisson[2], Markus Lappe[1]

[1]University of Muenster, [2]University Claude Bernard Lyon

11:30 – 12:00 **LUNCH**

12:00 – 14:00 **SESSION 12, POSTER 3 AND EXHIBITORS**

14:00 – onwards **FREE TIME AND TICKETED EXCURSIONS**

DAY 5 FRIDAY JULY 29, 2022

08:00 – 10:00 **SESSION 13, PANEL IV**

Interrogating the neural control of movement during free behavior

David Xing[1], Ilka Diester[2], Ann Kennedy[1], Jesse Marshall[3]

[1]Northwestern University, [2]University of Freiburg, [3]Harvard University

10:00 – 10:30 **BREAK**

10:30 – 12:30 **SESSION 14, INDIVIDUAL IV**

Postural and volitional signals occupy separate neural dimensions in motor cortex

Patrick Marino[1], Lindsay Bahureksa[2], Carmen Fisac[2], Emily Oby[1], Asma Motiwala[2], Erinn Grigsby[1], Adam Smoulder[2], Alan Degenhart[3], Wilsaan Joiner[4], Steven Chase[5], Byron Yu[2], Aaron Batista[1]

[1]University of Pittsburgh, [2]Carnegie Mellon University, [3]Starfish Neuroscience, [4]University of California, Davis, [5]Carnegie Mellon Univeristy

Vestibular reflexes in neck muscles contribute to stabilizing the head across the range of dynamic motion experienced during everyday life

Robyn Mildren[1], Omid Zobeiri[1], Kathleen Cullen[1]

[1]Johns Hopkins University

Resting-state functional connectivity predicts postural deficits following spaceflight

Heather McGregor[1], Nichole Beltran[2], Yiri De Dios[2], Jacob Bloomberg[3], Scott Wood[4], Ajitkumar Mulavara[2], Roy Riascos[5], Patricia Reuter-Lorenz[6], Rachael Seidler[1]

[1]University of Florida, [2]KBR, [3]NASA Johnson Space Center, retired, [4]NASA Johnson Space Center, [5]University of Texas Health Science Center at Houston, [6]University of Michigan

Basal ganglia-spinal cord pathway that commands locomotor asymmetries

Jared Cregg[1], Simrandeep Kaur Sidhu[1], Ilary Allodi[1], Roberto Leiras[1], Ole Kiehn[1]

[1]University of Copenhagen

Data-driven gait signatures reveal individual-specific differences in gait dynamics post-stroke

Taniel Winner[1], Trisha Kesar[2], Lena Ting[1], Gordon Berman[3]

[1]Georgia Institute of Technology and Emory University, [2]Department of Rehabilitation Medicine, Division of Physical Therapy, Emory University, [3]Department of Biology, Emory University

Movement is governed by rotational dynamics in spinal motor networks

Rune Berg[1]

[1]*University of Copenhagen*

12:30 – 13:00 LUNCH

13:00 – 15:00 SESSION 15, POSTER 4

15:00 - 17:00 SESSION 16, PANEL VI

Basal ganglia circuit communication for movement execution and motor learning: The vigorous tutor revisited

Andreea Bostan[2], David Robbe[3], Roxanne Lofredi[1], Wolf-Julian Neumann[1], Robert Turner[2]

[1]*Charité - Universitätsmedizin Berlin,* [2]*University of Pittsburgh,* [3]*Inserm Aix-Marseille University*

17:00 – 18:00 SESSION 17, DISTINGUISHED CAREER AWARD TALK

How to select the best balance and gait outcomes for clinical trials

Fay Horak, *Oregon Health and Science University*

18:00 – 19:00 CLOSING DRINKS RECEPTION

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Team & Individual Oral Abstracts

TUESDAY JULY 26, 2022

08:00 – 10:00 SESSION 1, PANEL I

Beyond a visuo-centric view: The crucial role of proprioception in sensorimotor learning

Jonathan Tsay[1], Cristina Rossi[2], Hannah Block[3], Chris Miall[4]

[1]University of California Berkeley, [2]Johns Hopkins University, [3]Indiana University Bloomington, [4]University of Birmingham

A visuo-centric perspective on motor learning is appealing. Not only does it fit with a zeitgeist which holds vision as a "dominant" sense, but it also matches our intuition of how we view task success: In day-to-day life, we frequently interact with visual objects, whether it be picking up a glass of water or moving the computer mouse over a desired icon. When a perturbation is introduced, we try to re-establish conditions such that the visual feedback is once again reinforcing. However, this visuo-centric perspective neglects evidence regarding the role of proprioception in motor control and learning: For instance, deafferented individuals struggle to generate specific patterns of muscle contractions in a feedforward manner. Moreover, neurologically healthy and congenitally blind individuals can adapt to a force-field perturbation without the aid of vision, presumably relying solely on proprioceptive input. This panel will present an alternative to the visuo-centric framework, arguing that proprioception may play an indispensable role in motor learning. We will show behavioral, theoretical/computational, neurophysiological and case-study results addressing both basic and clinical questions related to proprioception: Jonathan Tsay will present a new mechanistic understanding of implicit adaptation, a process that is elicited to minimize a proprioceptive error, the distance between the perceived hand position and its intended goal. He will use this proprioceptive re-alignment model (PReMo) to re-examine many phenomena that have previously been interpreted in terms of learning from visual errors, as well as offer novel accounts for unexplained phenomena. Cristina Rossi will present new findings that characterize the multiple learning mechanisms involved in locomotor adaptation, and their relationship to perceptual changes. A common mechanism may result in motor aftereffects and perceptual aftereffects, whereas another mechanism allows the locomotor system to flexible scale its adaptive response to different task demands (i.e., speed ratios on a split belt treadmill). Hannah Block will present new results that strengthen the behavioral and neural link between visuo-proprioceptive recalibration and motor planning. She will also show how these perceptual changes are not only difficult for people to consciously detect but are also robustly retained even after participants are permitted to view their actual hand. Chris Miall will present data from deafferented participants, showing how intact proprioception is critical to allowing an implicit representation of actions, and how without it, actions are governed explicitly, with consequent loss of adaptive sensorimotor responses. We will conclude with a 20-min discussion about the role of proprioception in sensorimotor learning. Prof. Denise Henriques will join the panel to help catalyze a stimulating discussion.

10:30 – 11:15 EARLY CAREER AWARD WINNER TALK

Insights into motor control from brain-computer interfaces

Emily Oby, *University of Pittsburgh*

We are capable of a nearly endless repertoire of movements: we can walk, run, skip, reach, grab, kick, throw, dance, and more. The ease with which most of us perform these movements conceals the fact that motor control is one of the most complex tasks the brain performs. How can we make sense of this vast complexity? To do so, scientists always seek simpler systems as a starting point toward full understanding. A brain-computer interface offers one such simplification. A brain-computer interface, or BCI, directly connects the brain to the external world, bypassing damaged biological pathways. It replaces the impaired parts of the nervous system with hardware and software that translates a user's internal motor commands into action. A BCI can provide new insights into the natural processes of motor planning, control, and learning. In turn, the better we understand natural motor control, the better BCI systems will be. My research addresses both sides of this relationship. First, I use BCIs to address basic science questions about how we execute movements and learn new motor skills. How does the brain learn to make skilled movements? How do neural dynamics drive skilled movements? Then, I apply what we have learned about the brain to develop BCI algorithms to improve clinical BCIs. How can BCIs generalize between diverse skilled movements?

11:15 – 12:30 SESSION 2, PERSPECTIVE I

Cortical control of human balance and mobility

Jasmine Mirdamadi[1], Sue Peters[2], Sam Stuart[3]
[1]Emory University, [2]Western University, [3]Northumbria University

Postural control involves hierarchical coordination of sensorimotor circuits mediated through automatic, subcortical mechanisms and top-down cortical mechanisms. Cortical involvement in balance and gait has traditionally been inferred indirectly, through degradation in performance during a cognitive task. Direct measures of brain activity during balance and mobility using electroencephalography (EEG) and functional near infrared spectroscopy (fNIRS) offer mechanistic insight into declines in function that are needed to predict fall risk, detect declines in function before a fall, and develop targeted interventions. Greater cortical activity may compensate for declines in automatic postural control. However, whether greater brain activity is compensatory or dysfunctional remains unclear due to a large emphasis on a single brain region (e.g., prefrontal cortex), the same task difficulty, or same environmental context. We will discuss recent advancements in brain activity during balance and mobility, highlighting individual, group, and task-dependent changes and their associations with function in health, aging, and neurological impairment. Jasmine Mirdamadi will discuss EEG activity evoked by standing balance perturbations as a function of task difficulty and an individual's balance ability. She will then translate this work to whole-body motion perception to provide a mechanistic framework for how cortical sensory integration needed for perception may contribute to balance function. Sue Peters will discuss cortical activity involved in planning of limb coordination for step initiation and walking and how cortical activity changes with attention and rehabilitation interventions in people with and without stroke. Sam Stuart will discuss the use of mobile brain/body imaging, through separate and combined fNIRS and EEG devices, to monitor brain activity response to cueing interventions (i.e., visual, auditory, tactile cues) for walking impairment in Parkinson's disease (PD). He will also describe brain activity changes with pharmaceutical intervention and complex mobility tasks (i.e., turning). Lessons from the field will be provided on using combined mobile imaging and inertial sensor technology in clinical populations. Main discussion points include: which aspects of cortical activity distinguish individual differences in balance and mobility function? Is altered cortical activity compensatory or dysfunctional? How can cortical activity inform mechanisms of interventions or guide precision medicine? Are we ready for a multimodal neuroimaging approach?

15:00 – 17:00 SESSION 4, INDIVIDUAL I

Manual force encoding in the motor cortex of macaques and humans

Elizaveta Okorokova[1], Anton Sobinov[1], John Downey[1], Ashley van Driesche[1], Qinpu He[1], Charles Greenspon[1], Nicholas Hatsopoulos[1], Sliman Bensmaia[1]
[1]*University of Chicago*

From prehension to pianism, object interactions require precise control of both the movement of the hand and of the forces it exerts on objects. Recent work shows that time-varying posture of the hand is encoded in the activity of populations of neurons in primary motor cortex (M1). Less is known about how manual forces are encoded in M1 because simultaneously tracking hand postures and exerted forces has proven challenging. To fill this gap, we developed an experimental apparatus that allows us to monitor both hand movements and manual forces. We then recorded the neural activity in M1 as monkeys grasped sensorized objects, identified a population of neurons whose activity tracks manual forces, and characterized the force signal in this population. Next, we applied the insights gleaned from able-bodied macaques to develop manual force decoders in a person with tetraplegia. We instructed the participant to grasp a set of objects, in a virtual environment, with varying amounts of force while we monitored the M1 activity via chronically implanted electrode arrays. We then built decoders that harness force signals in M1 to allow the participant to exert forces with his virtual hand. The participant then performed a variety of tasks in VR that required the manual exertion of graded forces on objects. We show that non-linear decoders of force with temporal dependence (e.g. LSTM) significantly outperform standard linear methods. These results pave the way for brain-controlled bionic hands that allow the user not only to precisely shape the hand but also to apply well-controlled forces with it.

Motor cortex isolates skill-specific dynamics to implement context-specific feedback control

Eric Trautmann[1], Najja Marshall[1], Hannah Chen[1], Francisco Sacadura[1], Elom Amematsro[1], Elijah Aliyari[1], Daniel Wolpert[1], Michael Shadlen[1], Mark Churchland[1]
[1]*Columbia University*

Performing two skills, such as swinging a tennis racquet or ax, requires both differences in typical motor output and different feedback-driven adjustments. The motor cortex (M1) is involved in specifying motor output, but its role in performing computations underlying skill-specific feedback control is not well understood. Neural activity in M1 reflects the underlying dynamics necessary to create motor outputs (muscle activity) and reflects the output during context-dependent feedback-driven corrections. The major features of M1 activity don't reflect outputs per se, but instead may be structured to not only create the typical output, but to enable rapid sensory-guided adjustments. This extension makes a strong prediction: M1 activity should be very different when two skills require different feedback-driven responses, even if outputs are matched. We assume a central component of skilled performance is learning a feedback control policy; i.e., a mapping from errors conveyed by the sensory inputs to corrective motor outputs. It is typically challenging to discern which aspects of neural activity reflect motor outputs and which reflect skill-specific feedback control. Here, we employed a 1D force production task with two contexts that required the same typical motor output, but opposite responses to sensory feedback, comprising different skills. We trained a monkey to match the vertical position of a cursor to a variety of scrolling dot paths. Pushing forward on a handle determined cursor height. In the positive-gain context force moved the cursor upwards, while in the negative-gain context, force moved the cursor downwards. Mirrored paths were presented across contexts so that forces were nearly identical. Using 45 mm primate Neuropixels, we recorded thousands of neurons in the M1 and basal ganglia (GPi). Most neurons in M1 had complex patterns of activity that were strongly context (gain) dependent and did

not directly reflect force or muscle activity, and GPi activity was strongly context-specific. Unexpectedly, identical motor outputs under the two gain conditions were driven by very different internal patterns of neural activity in M1. We then introduced cursor jump perturbations on some trials, and using demixed PCA (dPCA), we found a high-variance dimension attributable to context, and lower-variance dimensions for visual perturbation and force output. This empirical data suggest that context-dependent neural trajectories may allow each context to leverage different dynamics to flexibly transform the same sensory feedback into opposing outputs. Collectively, these results suggest that skills are produced by skill-specific (not output-specific) neural trajectories that allow for flexible input-output relationships produced by dynamics close to that trajectory. A prediction of this hypothesis is that motor cortex activity may leverage the vast volume of a high-dimensional neural space to store the repertoire of distinct motor skills.

Nonlinear manifolds underlie neural population activity during behaviour

Catia Fortunato[1], Jorge Bennasar-Vázquez[1], Junchol Park[2], Lee Miller[3], Joshua Dudman[2], Matthew Perich[4], Juan Gallego[5]

[1]Bioengineering Department, [2]Janelia Research Campus, [3]Feinberg School of Medicine Northwestern, [4]Icahn School of Medicine at Mount Sinai, [5]Imperial College London

The activity of neural populations during behaviour can be well-described by relatively few population-wide activity patterns spanning a "neural manifold". This observation, which holds true across many brain regions and species, is largely based on studies analysing linear flat neural manifolds spanning the neural population activity. We hypothesised that since neurons have nonlinear responses and make thousands of recurrent connections that may enhance this nonlinearity, nonlinear manifolds should capture the neural population activity better than flat manifolds. Analysis of a centre-out reaching task in monkeys confirmed that, even during a relatively simple behaviour, motor cortical population activity is best captured by a nonlinear manifold: nonlinear manifolds identified with Isomap needed fewer dimensions to explain the neural population variance than linear manifolds identified with PCA. Moreover, these nonlinear manifolds preserved the structure of the data better than their flat counterparts. To investigate if manifold nonlinearity arises due to the dense connectivity patterns of brain circuits, we trained RNNs with varying degrees of recurrent connectivity to perform a similar task. As predicted, neural manifolds only became nonlinear if networks had many connections. Intriguingly, for the same amount of connectivity, more heterogeneous connectivity patterns led to greater nonlinearities, suggesting that cytoarchitecturally distinct regions may present different degrees of manifold nonlinearity. To test in vivo this presumed influence of circuit connectivity, we compared neural manifolds from two anatomically distinct motor regions - motor cortex and striatum - using simultaneous recordings from mice performing a grasping and pulling task. Manifold nonlinearity was indeed strongly region-dependent: striatal manifolds were consistently more nonlinear than cortical manifolds. In addition to circuit connectivity, we also expected task complexity to shape manifold nonlinearity: if manifolds are nonlinear, more varied tasks requiring a richer set of neural activity patterns should reveal greater nonlinearities, as this activity would explore a larger portion of the manifold. We confirmed this using neural population recordings from human motor cortex during attempted handwriting. Drawing lines of varying length across 16 directions and writing all letters in the English alphabet had more nonlinear manifolds than the simpler tasks of drawing lines in a single direction or writing a handful of similar letters, respectively. Thus, linear dimensionality reduction methods that identify flat manifolds find linear approximations to an intrinsically nonlinear manifold. This nonlinearity is influenced by the underlying circuit architecture and becomes more evident during more complex behaviours. Accounting for these-region specific nonlinearities may be crucial as the field moves toward the study of more complex and naturalistic behaviours.

Effector-specific sensorimotor transformations in dorsolateral prefrontal cortex during a head-unrestrained reach task

Veronica Nacher[1], Parisa Abedi-Khoozani[1], Vishal Bharmauria[1], Harbandhan Arora[1], Xiaogang Yan[1], Saihong Sun[1], Hongying Wang[1], John Crawford[1]
[1]*York University*

Dorsolateral prefrontal cortex (DLPFC) is associated with executive control and response selection, but the extent to which it is involved in effector-specific transformations is unclear. We addressed this question by recording 711 single neurons from DLPFC while two trained monkeys performed a head-unrestrained reaching paradigm. Animals touched one of three central LEDs at waist level while maintaining gaze on a central fixation dot and were rewarded if they touched a target appearing at one of 15 locations in a 40° x 20° (visual angle) array. Animals typically shifted gaze first, followed by sustained head movement and a reach (Arora et al. J. Neurophys. 2019). Analysis of 499 neurons in two monkeys showed an assortment of target/stimulus, gaze, pre-reach, and reach-timed responses in DLPFC. Most neurons could be described as falling into three main groups: 'Early" (increased firing rate during the target presentation / gaze onset), "Early-late" (sustained activity from target presentation through reach), and "Late" (peaking during reaches). Importantly, early gaze-related activity only occurred when followed by a reach (compared to 172 neurons also tested in no-reach controls). We then tested the spatially tuned neurons using a model-fitting procedure to determine their spatial codes (Keith et al. J. Neurosci. Meth. 2009). Early responses were often gain modulated by initial hand position (41%), gaze position (19 %), or initial head position (5 %), with some overlap between these modulations. Individual neurons showed a variety of preferred spatial codes (target, gaze, head, hand) but at the overall population level, early responses showed a preferential coding for head movement, whereas later responses showed a preference for coding hand movement. Overall, these data suggest a specific role for DLPFC in eye-head-hand coordination where gaze signals appear to trigger posture-dependent head and hand control signal, and a more general role for this structure in cognitive-motor integration.

Reformatting of the representation of action from neocortex to striatum

Junchol Park[1], Catia Fortunato[2], Juan Gallego[2]
[1]*Howard Hughes Medical Institute,* [2]*Imperial College London*

The interplay between two major forebrain structures - motor cortex and dorsal striatum - is critical for voluntary, goal-directed movements. Canonical accounts have proposed a division of labor in which the motor cortex represents critical signals for the planning and online execution movement, with subcortical striatum playing a more circumscribed role in behavior control. For example, it has been proposed that striatum may be critical for representing action identity, selection and/or initiation, or effort cost and/or movement vigor. Alternatively, a few groups have focused more on the striatum as a critical component of the specification of movement execution. This latter alternative has led to proposals that striatum may be critical for specifying, via reinforcement learning, many continuous parameters for motor control. These alternative predictions - an abstracted representation of action versus a rich representation of movement parameters - can potentially be distinguished by comparison of representations observed in motor cortical and striatal activity across movements that vary in their kinematics and kinetics, putative parameters underlying descending forebrain control of movement. However, to date it has been difficult to distinguish amongst these models because many lab tasks have been designed to exhibit little variance in any movement parameter or to vary primarily along a single parameter or without large scale cortical and subcortical recordings. To address these questions we developed a novel task in which a variable-torque joystick could be robotically positioned in front of a head-fixed mouse. Mice reached to pull the joystick at two locations and with two independent force requirements to elicit a water reward. We combined this task with simultaneous, high density electrophysiological recordings from primary

motor cortex, a premotor frontal cortical area, and dorsal striatum. Mice exhibited readily distinguishable, but variable, reaching trajectories and forces to each joystick position while successfully completing 80% of trials across locations and torque requirements. Multiple analyses led to the conclusion that activity in striatum does not represent an abstracted subset of action parameters, but rather encodes the full dimensionality of movement representations observed in primary and premotor cortical recordings. For example, the performance of a continuous decoder of movement and classifier of trial type using striatal activity was equivalent to or greater than the performance from premotor or motor cortical activity. However, there was a notable difference - examination of individual subcortical and cortical units contributions to decoding revealed a greater spatiotemporal separation in striatum. This suggests a 'reformatting' of cortical representations in the dorsal striatum to support action parameter-specific credit assignment; a key problem for reinforcement learning.

Somatosensory and motor cortex both causally contribute to speech motor learning

Matthias Franken[1], Timothy Manning[1], Alexandra Williams[1], David Ostry[1]
[1]*McGill University*

Speakers readily adapt their articulation to various sensory perturbations, such as formant alterations, pitch shifts, or loudness modulations. It is thought that this sensorimotor adaptation, much like in non-speech motor learning, relies on comparing predicted sensory feedback with observed sensory feedback. However, the neural mechanisms that support this learning are poorly understood. Interestingly, there is accumulating evidence that the somatosensory system plays an active role in motor learning. For example, somatosensory stimulation such as facial skin deformation may alter subsequent speech motor learning. In the present study, we investigated whether the primary somatosensory cortex and the primary motor cortex are causally involved in speech motor learning. The hypothesis is that if a brain area participates in speech motor learning, then disruption of its activity using magnetic brain stimulation prior to learning will either reduce learning or eliminate it altogether. Fifty participants performed a speech motor learning task, in which they produced the words 'shame' (/ʃeɪm/) and 'shake' (/ʃeɪk/) while receiving auditory feedback through headphones. After thirty baseline productions, the frequency spectrum of the initial fricative sound was shifted in real-time by 3 semitones, resulting in a shift from /ʃ/ towards /s/, and held at this value for the remaining 150 speech productions. Such altered auditory feedback typically leads to adaptation, in which speakers compensate for the altered auditory feedback by shifting their vocal output in the opposite direction. Participants performed the speech adaptation task after continuous theta-burst stimulation, which was used to disrupt activity during learning in the lip area of either primary motor cortex or primary somatosensory cortex, in a between-participants design. The findings to date show that whereas participants show speech motor adaptation in a control condition, adaptation is blocked by disrupting either primary motor cortex or primary somatosensory cortex. Motor-evoked potentials measured at the lips before and after theta-burst stimulation in the somatosensory condition confirm that blocking adaptation in this condition was not caused by indirect effects of somatosensory stimulation on primary motor cortex. These results show that the primary somatosensory cortex is causally involved in speech motor learning, in line with recent studies suggesting that motor learning is driven, at least in part, by the somatosensory system. In addition, this is the first study showing that both primary motor and primary somatosensory cortex causally contribute to motor learning. The current results show that even in altered auditory feedback, the somatosensory system may be crucial for updating the memory of the adaptive motor commands and their associated somatosensory representations.

WEDNESDAY JULY 27, 2022

08:00 – 10:00 SESSION 6, PANEL II

Cancelation of self-generated sensations: neural mechanisms and functional advantages across species and sensory modalities

Konstantina Kilteni[1], David Schneider[2], Avner Wallach[3], Kathleen Cullen[4]

[1]Karolinska Institutet, [2]New York University, [3]Columbia University, [4]John Hopkins University

Distinguishing the sensations that are produced by our own movements (reafference) from those produced by external causes (exafference) is a fundamental problem for our nervous system and a prerequisite for our survival. Compare how dramatically different our responses are (a) to the footsteps we hear, when these are not due to our walking (auditory reafference) but due to a stranger following us (auditory exafference); (b) to our vestibular input, when this is not generated by our head motion (vestibular reafference) but because we accidentally fall on the floor (vestibular exafference); and (c) to the touch we feel on our cheek, when this is not due to our hand (somatosensory reafference) but due to an insect crawling on our face (somatosensory exafference). To solve this problem and guide our behavior appropriately, the nervous system uses information about the organisms' own movements to predict the reafferent sensory signals. The prediction can then be canceled from the incoming sensations, thus amplifying the difference between self-generated and external sensations. This panel will raise questions on the similarities and differences in this cancelation mechanism across four different species (mice, electric fish, monkeys, humans) and four different modalities (auditory, electrosensory, vestibular, somatosensory), as well as its functional advantages in motor control. In mice, David Schneider will show that auditory responses to self-generated sounds are suppressed relative to sounds that are unexpectedly shifted in frequency. He will argue that this frequency-specific suppression in the auditory cortex arises from a stable, learned, and specific movement-based prediction that is implemented over short time scales with within-movement temporal specificity. Avner Wallach will show that the responses of the electrosensory lobe output neurons in freely swimming electric fish selectively encode external stimuli. He will argue that the cerebellum-like circuitry of the electrosensory lobe learns and stores multiple motor-based predictions specific to different sensory contexts. Kathleen Cullen will show how vestibular reafference is canceled in primates by a cerebellum-based mechanism, when there is a precise match between the actual and expected proprioceptive feedback. She will argue that this cerebellum-based mechanism displays rapid updating whenever a new sensorimotor relationship is established. Konstantina Kilteni will show that the responses of the human somatosensory cortices to self-generated touch are attenuated compared to externally generated touch, or self-generated touch that is shifted in time, and that the functional corticocerebellar connectivity is related to this attenuated perceived intensity of the somatosensory reafference. She will argue that somatosensory attenuation depends on an internal model between the specific action and its temporally precise feedback.

10:30 – 12:30 SESSION 7, INDIVIDUAL II

Predictability as control priority in a functional task: computational research with clinical applications

Rashida Nayeem[1], Salah Bazzi[1], Mohsen Sadeghi[1], Reza Sharif Razavian[1], Dagmar Sternad[1]

[1]Northeastern University

Humans physically interact with complex objects every day. An example is picking up a cup of coffee: the hand applies forces not only to the cup, but also to the sloshing liquid, which creates complex forces back onto the hand. Challenges of complex interactions become evident in individuals with motor impairments, where small disturbances can lead to failure, e.g., spilling the coffee. Dynamic behavior can evolve rapidly, making it difficult to correct errors given the latencies in the neuromotor system. How do humans manage these complex dynamics? Our previous work showed humans seek to make interactions predictable, to avoid error corrections. In two follow-up studies we investigated how humans prepare a virtual 'cup of coffee' to make subsequent interactions more predictable. A third study used a real-life version of the task to assess how our theoretically derived metrics may quantify impairment severity after stroke. When transporting a complex object from rest, the transient dynamics can display unpredictable behavior, which depends on the initial conditions. A first study examined whether humans prepared a complex object and exploited initial conditions to increase predictability of the interaction. Participants transported a 'cup of coffee', a virtual cup with a ball rolling inside. A model of the cup-and-ball was rendered in a virtual environment, subjects moved the cup via a robotic manipulandum that haptically transmitted the ball forces. Participants were encouraged to explore the object dynamics to find preferred initial conditions (i.e., ball position and velocity) prior to a continuous 15s movement. Results showed that subjects converged to initial conditions that reduced duration of transients and increased overall predictability of interaction forces. Dynamic simulations confirmed that these initial conditions increased predictability towards theoretically optimal values. The second study investigated the role of haptic and visual feedback in achieving predictability. In the absence of visual feedback subjects were able to converge to predictable interactions, albeit suboptimally. In the absence of haptic feedback, subjects were unable to converge to initial conditions and moved the cup slowly to neutralize ball dynamics. Surprisingly, this strategy increased predictability of interactions, yet to a lesser degree than the haptic feedback condition. A third study investigated if predictability could serve as a measure of functional impairment after stroke. In a custom-developed real-life version of the task, individuals after stroke transported a cup with a rolling ball inside, to targets on a table. Neurotypical and mildly affected subjects prioritized predictability between cup and ball dynamics. Moderately and severely affected individuals showed similarly reduced predictability. This indicates that functionally inspired tasks with novel metrics are sensitive to quantify the ability to complete activities of daily living.

A distributed circuit for regulating feedback control policy

Jonathan Michaels[1], Mehrdad Kashefi[1], Olivier Codol[1], Rhonda Kersten[1], J. Andrew Pruszynski[1]
[1]*Western University*

Although many studies have examined the role of cortical activity preceding voluntary movements, far fewer have examined the neural dynamics underlying rapid responses to unexpected sensory input. Similarly, recent theories of motor cortex describe how neural activity evolves during the initiation of voluntary movements, but generally do not consider the sensory feedback that arises following unexpected perturbations or during continuous control. To address this gap, we trained a macaque monkey to perform a delayed reaching task in which one of two targets must be reached after an unexpected mechanical perturbation pushed the arm either into or out of each target. During behavior we recorded from PMd, M1, and S1 using high-density Neuropixels probes (>1700 single neurons across sessions) and from populations of motor units in relevant arm muscles using novel high-density injectable arrays (>70 single motor units across sessions). Neural population activity prior to the perturbation represented the goal target most strongly in PMd, less in M1, and least in S1. High-density recordings (>100 neurons simultaneously) allowed us to ask how well the trial-to-trial changes in neural state before the perturbation could predict rapid changes in kinematics following the perturbation. Pre-perturbation activity in motor unit populations very strongly predicted kinematics beginning ~30ms after the perturbation on single trials, while activity in PMd and M1 well predicted kinematics beginning ~70ms after the perturbation, implicating trial-to-trial variability in these areas in rapid feedback responses. Expanding on dynamical systems-based models of motor control, we developed neural network models that were trained to control a realistic biomechanical model of the arm including muscle dynamics and delayed sensory feedback, which well recapitulated measured behavioral and neural dynamics. We propose that the distributed neural state observed prior to a perturbation is optimized to align incoming proprioceptive information with ongoing activity such that it drives the correct output to muscles through a combination of continuous delayed feedback and local recurrent dynamics. One prediction of this proposal is that during continuous movement, perturbations not detrimentally affecting the movement goal do not cause large excursions in the neural state, while perturbations that detrimentally affect movement goal rapidly modulate ongoing muscle output through recurrent connectivity. A second prediction is that during continuous movement control delayed sensory feedback is the primary driver of ongoing activity. These simulations provide the basis of a biologically plausible implementation of the principles of optimal feedback control, and ongoing experiments are leveraging our high-density neural and motor unit recording technology in a continuous reaching task with random targets and perturbations to provide the ideal dataset to further test these proposals.

Behaviorally relevant, but not any salient events, inhibit rapid hand movements

Clara Kuper[1], Martin Rolfs[2]

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To rapidly adapt our movements to changes in the environment, we need to readily process new information. While a signal indicating that the environment changed might quickly be available, updating movement plans contingent on the behavioral relevance of the change will take longer. How should a motor system behave while a salient change is being processed? Saccadic eye movements pause even after irrelevant salient changes - a phenomenon known as saccadic inhibition (Reingold & Stampe, 1999; Rolfs et al., 2008). But similar observations about hand movements are not as prevalent. Here, we show that only behaviorally relevant changes in the environment have overt consequences for the execution of hand movements. In our study, participants collected an irregular array of six dots on their smartphone or tablet, by tapping on them in a swift, horizontal sequence of movements. On 50% of the trials, the background of the screen flashed white for 33ms, which constituted a salient, but behaviorally irrelevant change. On another, independently chosen 50% of the trials, all dots suddenly changed their position, resulting in a salient, and behaviorally relevant change. If the flash and position changes occurred on the same trial (25% of all trials), they did so at the same time. Participants were instructed to adapt their responses to the new positions of the dots on the screen. An analysis of participants' errors between the touch position and the dot position revealed that participants adjusted their responses to the new information within about 400 ms after change onset, confirming that behaviorally relevant information was indeed incorporated into movement plans. We computed movement rates - the number of movements per second as a function of time - aligned to the onset of changes. Indeed, we found clear signatures of hand movement inhibition: In trials with behaviorally relevant changes, movement rate decreased by 30% within about 400ms after the change. We did not observe a dip for behaviorally irrelevant changes, nor did a simultaneous behaviorally irrelevant change alter the pattern of response adjustment or inhibition that accompanied a behaviorally relevant change. Pausing a movement can only possibly benefit the accuracy of its execution when the pause shifts the movement to a time window when the motor plan has integrated the new information. In our data, the time window during which participants adjusted their responses to a baseline level of error coincides with the time window of hand movement inhibition. This suggests that the hand movement system achieves accurate responses by delaying the onset of a movement until new, behaviorally relevant information is integrated into the motor plan. Our results suggest that hand movement inhibition is a consequence of adjusting the motor plan to behaviorally relevant information in the environment, but - contrary to saccadic inhibition - is not a general signature of processing novel information.

Emergence of habitual control in a novel motor skill over multiple days of practice

Christopher Yang[1], Noah Cowan[1], Adrian Haith[1]
[1]*Johns Hopkins University*

When humans learn new motor skills, their behavior can become habitual, or inflexible to changes in the goals/structure of a task. Neuroscientists and psychologists have long debated the nature of habits and their relationship with motor skills, but these debates have been hampered by a dearth of empirical work examining how habits form during motor skill acquisition. Although habit formation has been studied to a limited extent in tasks where one must select between a few discrete choices (e.g., arbitrary visuomotor associations), the extent to which these findings generalize to real-world tasks with a continuum (i.e., infinity) of possible states and actions is unclear. To better understand the nature of habit formation in continuous skills, we performed a multi-day learning experiment to examine the emergence of habitual behavior as participants learned a novel motor skill. Participants learned to control an on-screen cursor using a bimanual mapping where moving the left hand vertically moved the cursor horizontally while moving the right hand horizontally moved the cursor vertically. After practicing this mapping for two, five, or ten days, we altered the mapping by flipping the direction of cursor movement in the horizontal axis. We assessed, using both a point-to-point movement task and a continuous tracking task, whether participants would be able to update their control of the cursor in accordance with the new flipped mapping, or whether they would habitually continue to use the mapping they had originally practiced. We found that, in both tasks, participants became more skillful in using the bimanual mapping with up to five days of practice. However, participants use of this mapping became habitual after only two days of practice. Furthermore, the habit that participants had formed did not become stronger or more resistant to extinction with more practice. These data demonstrate a dissociation between the emergence of skill and habit during learning; motor behaviors can continue to become more skillful with practice even after they have become habitual. Thus, our results suggest that habitual behaviors, despite being defined as inflexible to change, maintain some level of flexibility during learning.

A sensory race between oculomotor control areas for coordinating motor timing

Antimo Buonocore[1], Ziad Hafed[1]
[1]*University of Tuebingen*

Successful interaction with the environment requires a fine balance between following internal goals, like planning a movement, and maintaining sensitivity to external events. Because external events necessarily come asynchronously to current internal brain state, a so-called “race condition” can frequently occur in sensorimotor behavior: on the one hand, there is an internal motor plan in progress; on the other, a new competing orienting response is jumpstarted by the external event. Handling such a race condition requires both rapid sensing of the outside world as well rapid inhibition of motor plans. We, therefore, hypothesized that omnipause neurons (OPN’s) in the nucleus raphe interpositus (rip), constituting the very final gateway for allowing or preventing saccades, should exhibit classic hallmarks of early sensory areas: these neurons can rapidly regularize the race condition by momentarily interrupting an ongoing movement plan in favor of processing an orienting response to the external event. This would require that OPN's exhibit ultra-rapid, sophisticated visual pattern analysis capabilities. We first confirmed that OPN's had sustained tonic activity during fixation and paused for saccades of any size and direction. We then presented visual patterns during fixation. We used gratings of different spatial frequency, contrast, orientation, and motion speed/direction. Despite their high tonic rates (e.g. 100 spikes/s), OPN's exhibited highly robust short-latency phasic activity increases <50 ms after image onset. Critically, such visual responses were feature-tuned, with preferred stimuli causing an almost doubling of tonic rate. Consistent with another motor structure, superior colliculus (SC), OPN's preferred low spatial frequencies and had clear contrast sensitivity. They also exhibited offset responses, like early visual areas. Despite not having clear spatially-confined receptive fields, OPN's preferred foveal and, sometimes, lower visual field locations. Most intriguingly, OPN visual response latencies were even earlier than in the SC with the same images. What is the functional role of such early OPN visual pattern analysis capability? It allows OPN's to race with the SC for controlling motor timing, as we confirmed with electrical stimulation. We injected short stimulation pulse trains to "simulate" brief phasic visual responses in either OPN's, SC, or V1. In OPN's, visual "bursts" momentarily inhibited spontaneous saccades. Contrarily, SC visual "bursts" increased spontaneous saccade likelihood, and V1 visual "bursts" were consistent with sensing phosphenes. Therefore, OPN's can quickly sense exogenous events and reset oculomotor activity, effectively regularizing the race condition that can otherwise take place between an existing motor plan and a newly initiated one, say, via the SC. Our results provide a highly mechanistic description of why even simple visually-guided saccades can exhibit surprisingly large timing variability.

Express reaching responses are preserved in Parkinsons Disease and insensitive to levodopa treatment

Rebecca Kozak[1], Maggie Prenger[1], Madeline Gilchrist[1], Kathryne Van Hedger[1], Mimma Anello[1], Penny MacDonald[1], Brian Corneil[1]

[1]*Western University*

Parkinson's Disease (PD) is a common movement disorder characterized by slow and stiff voluntary movements, due to dopamine depletion of the dorsal striatum. A growing body of evidence suggests PD patients retain the ability to generate reflexive and/or stimulus-driven movements of the eyes and upper limbs. However, the mechanism of action for such spared responses remains largely unknown. Recent work has suggested that Express Reaching Responses arise from the tecto-reticulospinal tract, which lies in parallel to the corticospinal tract. Express reaching responses are the first phase of stimulus-driven muscle recruitment, appearing ~100 ms after stimulus onset, well before movement onset. The presence and magnitude of express reaching responses are correlated with rapid RTs during visually-guided reaching. Our objective was to test the hypothesis that the tecto-reticulospinal tract is spared in PD by examining express reaching responses. Furthermore, we sought to examine the impact of dopaminergic medication (DA), commonly used to treat motor symptoms in PD. Toward this end, we recorded reach kinematics and electromyographic activity (EMG) from pectoralis major, a muscle involved in cross body reaching, in 16 PD and 18 age-matched healthy-control (HC) participants, as they performed visually-guided reaches in a Kinarm robot, both off and on DA, with session order counterbalanced across participants. Participants reached towards targets in an emerging target paradigm, which has been shown to robustly elicit express reaching responses, and short latency RTs. We found that PD and HC participants differed on two key phases of reaching movements; either volitional movement, or movement initiation. Consistent with a movement disorder, PD patients exhibited lower peak velocities ($p = 0.01$), longer movement durations ($p = 0.001$), and lower peak EMG amplitudes ($p = 0.01$) compared to HCs. However, consistent with spared stimulus-driven movements, there was a trend towards more rapid RTs for PD patients compared to HCs ($p = 0.06$). To better understand the reason for spared movement initiation, we examined EMG activity, and found that express reaching responses were more frequent ($p = 0.017$) and larger (albeit not significantly, p = 0.07) in PD patients compared to HC. Furthermore, DA treatment did not affect the express reaching responses or RTs. Our findings indicate that multiple descending motor pathways contribute to key phases of reaching movements toward a moving target. PD patients retain the first phase of stimulus-driven muscle recruitment, while simultaneously exhibiting degraded volitional movement in later parts of the reach. Furthermore, rapid movement initiation was not sensitive to DA manipulation. Taken together, we suggest that a tecto-reticulospinal tract remains intact in PD patients, making this tract an attractive therapeutic target in clinical populations.

15:00 – 17:00 SESSION 9, PANEL III

Motivational influences on motor performance

Vikram Chib[1], Court Hull[2], Amanda Therrien[3], Mati Joshua[4]

[1]Johns Hopkins University, [2]Duke University, [3]Moss Rehabilitation Research Institute, [4]The Hebrew University of Jerusalem

Motor performance is motivated by the rewards and costs at stake. Historically the basal ganglia have been implicated in the representation of motivational factors that drive motor performance; however recent studies have also identified motivational signals in cerebellum, suggesting an interaction between cerebellum and basal ganglia to generate motivated motor behavior. In this session we will present recent evidence for the roles of basal ganglia and cerebellum in motivated performance, across human and animal models. We will discuss the similarities and differences between cerebellar and striatal signals and why these seemingly disparate brain regions might encode affective information. First, Vikram Chib will present data that examine how fatigue influences motivational state, making human participants less willing to engage in effortful exertion. Using fMRI data, he will describe how signals related to motor cortical state in premotor cortex influence computations of effort value in the basal ganglia, decreasing motivation and willingness to exert. Vikram's data will provide an account of how the basal ganglia incorporates information about bodily state to motivate motor performance. Second, Amanda Therrien will present a series of studies that examine state estimation and its relationship with reward learning in individuals with cerebellar degeneration. Estimations of body state are hypothesized to depend on computations within the cerebellum. Cerebellar damage in humans significantly impairs state estimation, which in turn impairs motor control and learning. Amanda will show that estimations of body state are incorporated in the processing of reinforcement and reward information, and that the cerebellum mediates this function. Third, Court Hull will present data testing how signals in the cerebellum might convey reward predictions in order to guide motor learning. Using a combination of calcium imaging and electrophysiology in awake behaving mice, he is testing whether cerebellar climbing fibers obey the requirements of reward prediction error, how behavioral context affects these signals, and how these signals might act to shape cerebellar output. Court's data will address the mechanisms of reward signaling in the cerebellum, and how they compare with what is known for basal ganglia circuits. Finally, Mati Joshua will present studies that recorded neural data from eye-movement areas in the basal ganglia and cerebellum of monkeys, while manipulating eye-movement parameters and reward. Recent findings of reward signals in the cerebellum challenge the view that the cerebellum performs error-based learning, whereas the basal ganglia are involved in reward-based learning. While cerebellar reward signals demonstrate some resemblance to those in the basal ganglia, a direct comparison has been lacking. Mati's data will provide a direct comparison between reward and eye-movement signals in the cerebellum and the basal ganglia.

08:00 – 10:00 SESSION 10, INDIVIDUAL III

Beyond remapping: how is cortical information content altered following hand loss?

Dollyane Muret[1], Maria Kromm[1], Arabella Bouzigues[1], Vijay Kolli[2], Tamar Makin[1]
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Hand loss is a key model for studying reorganisation in the human brain, but the functional consequences of these large-scale changes in brain activity are still unknown. Specifically, remapping of multiple body-parts (indexed by increased BOLD activity) was reported in the missing hand cortex during arm, face and feet movements of congenital one-handers, and during intact hand movements in acquired amputees (Makin et al., 2013; Hahamy et al., 2017). However, it is not clear whether this dramatic brain remapping bears any functional relevance (Muret and Makin, 2021), and how the developmental stage of remapping (early or late in life) may impact this relevance. As a first step towards answering these questions, we investigate the information content of the remapped activity observed following congenital or acquired hand loss. To this end, we scanned (3T fMRI) congenital one-handers (n=21) and amputees (n=18) as well as two-handed controls (n=22). All participants performed two actions (i.e., squeeze or push) with each of 4 different body-parts involved in hand-loss compensatory behaviour: the intact Hand, residual Arm, Lips and Feet. Data from an independent localiser was combined with anatomical masks of primary sensorimotor cortex to define the Face, Leg and Hand regions in the deprived hemisphere. Univariate activity evoked by the different actions and body-parts was extracted to assess remapping. Representation Similarity Analysis was then used to identify changes in representational dissimilarities between two actions or pairs of body-parts (i.e., information content) in the respective regions. Using conventional univariate analysis, we found an increased activity in one-hander's missing Hand region relative to controls (i.e., remapping) for the Arm, Lips and Feet (all $p < 0.001$) but not in the primary region of each body-part. In other words, the increased activity for each of these body-parts was uniquely expressed in the deprived cortex. However, this was not reflected in increased information content; when comparing dissimilarities between actions performed with these body-parts, we merely observed a trend for the Arm only ($U = 158$, $p = 0.078$). This result calls to question the notion that the widespread remapping due to early life handlessness is functionally relevant. Conversely, similar analyses in acquired amputees revealed significant remapping of the intact Hand ($p < 0.001$) in the missing Hand region relative to controls, with a corresponding increase in action dissimilarity ($p = 0.002$) and thus information content. This suggests that some remapping happening later in life might bear functional significance. To conclude, even though the critical period is a necessary condition for remapping to happen at a large scale, our results challenge the notion that such remapping actually reflects functional relevance, and thus true reorganisation.

The effect of tactile augmentation on force field adaptation

Chen Avraham[1], Ilana Nisky[1]
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When exposed to a novel dynamic environment, we adapt by changing our movements' dynamics. Adaptation occurs through the development of an internal representation of the perturbation, which allows us to predict the disturbance and apply compensatory forces. To form an internal representation, the sensorimotor system gathers and integrates sensory inputs, including kinesthetic and tactile information about the external load. Currently, the relative contribution of kinesthetic and tactile information to the adaptation process is poorly understood. In our previous study, we examined the effect of augmented tactile information on force field adaptation, and found that this stimulation had no effect on movement kinematics, but had a pronounced effect on movement dynamics. Here, we aim to further investigate this integration process of kinesthetic and tactile information, by using an innovative approach of probe trials along the adaptation process. Specifically, participants were exposed to a velocity-dependent force field while performing reaching movements, and in random trials during adaptation, we applied a sequence of force channel - force field - force channel trials. Within each sequence, the force field was accompanied with a velocity-dependent tactile stimulation in the form of moving tactor, which induced three types of stretch: (1) same direction as the force field, (2) opposite direction to the force field, and (3) no skin stretch. Then, by examining the difference between the force channel trials before and after the augmented tactile stimulation, we were able to thoroughly assess the effect of the skin stretch on the adaptation process. We found that consistently with our previous results, the skin stretch in the same direction as the force field impaired the adaptation, while skin stretch in the opposite direction slightly improved the adaptation. In addition, we found that the same direction skin stretch caused a short-lasting decrease in muscles activity due to both feedforward and feedback commands. Regarding to grip force control, the reactive component of the grip force was increased for both same and opposite direction stimulations, with higher increase for the same direction stimulation. Moreover, we found an increase of the predictive component for the opposite direction stimulation. Overall, the results lead us to conclude that skin stretch in the same direction as the external load has a strong but short-lasting effect on adaptation, while skin stretch in the opposite direction to the external load has a weak but long-lasting effect on adaptation. This may indicate that the skin stretch has a different effect on the fast and slow components of the adaptation according to the direction it is applied. This study is an important milestone in the process of understanding force adaptation and sensory integration, which can help in promoting the use of tactile stimulation in medical and assistive devices.

Effects of task-irrelevant visual feedback on motor adaptation in a bimanual redundant motor task

Toshiki Kobayashi[1], Daichi Nozaki[1]
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Redundancy is inherent in motor tasks. The minimal intervention principle (MIP) suggests that the motor system focuses on the movement variability in the task-relevant dimension while ignoring it in the task-irrelevant dimension (Todorov, Nat Neurosci 2004). However, it has not been directly tested how the motor system adaptively corrects the movement when it encounters perturbations in both dimensions. Here, we developed a novel stick-manipulating task using a KINARM. Subjects manipulated a virtual stick with both hands (distance: 15 cm) and moved the right tip (a cursor) of the horizontal stick (length: 40 cm) from a starting point to a visual target (10 cm). During the baseline phase (360 trials) to reach each of 9 targets (0°: horizontal direction, ±10°, ±20°, ±30°, ±40°), the subjects tended to tilt the stick slightly while moving the cursor. Typically, CW (CCW) cursor-movement direction (CMD) accompanied CW (CCW) stick-tilting angle (STA). We identified the inherent relationship between the CMD and the STA (CMD-STA map) that reflects the stereotypical strategy for performing this redundant task. During the subsequent adaptation phase (240 trials), visual perturbations were introduced when reaching the target in the 0° direction. In Experiment 1 (N = 20), the CMD was gradually rotated in 1° increment per trial over 30° around the starting point. The implicit adaptation to the CMD rotation accompanied the stick tilt predicted from the CMD-STA map in the baseline phase. Experiment 2 directly tested if the motor system was indifferent about task-irrelevant errors by imposing the STA rotation around the cursor by 6° (CW: N = 10, CCW: N = 10). The MIP predicted that the subjects did not change their movement patterns because this perturbation did not affect the cursor position. However, the subjects implicitly corrected the STA. If the CMD-STA map constrained their relationship as observed in Exp.1, this STA correction should accompany the CMD change. Notably, the STA correction induced the unnecessary CMD error. Experiment 3 examined how the task-irrelevant errors (CW (N=10) or CCW (N=10) STA rotation) influenced the adaptation to the CW CMD rotation. Under the constraint by the CMD-STA map, the CCW (CW) STA rotation might facilitate (interfere with) the adaptation to the CW CMD rotation. Indeed, the facilitating (interfering) effect between the adaptations to CW CMD rotation and CCW (CW) STA rotation decreased (increased) the trial-by-trial variability of the CMD. In summary, we show that the perturbation in the task-irrelevant dimension could influence motor control and adaptation in the task-relevant dimension. This inconsistency with the MIP is likely to arise from the inherent relationship constraining the movement pattern in task-relevant and -irrelevant space. We speculate that, under such a relationship, the motor system cannot ignore the error in the task-irrelevant dimension because it implies the error in the task-relevant dimension.

Distinct functional architectures for implicit and explicit motor learning from reinforcement signals

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Motor learning can be dichotomized based on the level of conscious control into implicit or explicit learning but also based on the nature of the available teaching signal into reward or error-based learning. A fundamental question is the extent to which implicit and explicit adaptive processes learn directly from teaching signals versus from one another. In particular, we tested the idea that implicit learning on a reinforcement task may be primarily driven by the implicitization of explicit learning rather than directly driven by reward information. In Expts 1-4, participants made 10cm reaching movements to a target in a force channel, rewarded based on the pattern of force they applied to the side of the channel. To ensure that the reward feedback (FB) we provided contained useful information even when performance was poor, we rewarded movements that were better than the median match to the ideal force pattern over the last 40 trials. Participants readily learned this task when verbal instructions were provided alongside a diagram illustrating the rewarded force pattern. However, decreasing the instruction quality by withholding the diagram reduced learning, and removing all instructions about the reward contingency so that participants were not told how they could increase reward, completely abolished learning, even when training was continued for 2000 trials over 3 days. The finding that this learning improves when instructions improve, indicates that reinforcement drives explicit learning, and the absence of any evidence for learning when instructions are withheld, suggests that reinforcement induces little implicit learning. In Expts 5-6, we examined the effect of instructions in a different reward-based task. Here we specifically measured implicit and explicit components of learning based on an aim-report paradigm for VMR learning where reward FB was provided in lieu of visual FB about cursor direction, and the VMR was gradually changed from one trial to the next in a sum-of-sinusoids pattern. We again found that learning was dramatically reduced when reward-contingency instructions were withheld, with a greater than 20-fold reduction in overall learning and a more specific 10-fold reduction in implicit learning. This indicates that successful explicit learning dramatically improves implicit learning compared to when successful explicit learning is not present in a reward-based task. We thus uncover a remarkable difference between how implicit and explicit learning interact when learning is driven by reinforcement vs error-based teaching signals. Whereas error-based teaching signals can readily drive both implicit and explicit learning (e.g., Taylor et al 2014, Miyamoto et al 2020), here we find that reward-based teaching signals can readily drive explicit learning, but provide little direct drive for implicit learning, which primarily arises from the implicitization of explicit strategy, perhaps via a use-dependent learning process.

Blocking cerebellar signals increases internal noise and impairs motor adaptation

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The motor system can rapidly adapt to changes in the body or the environment. During adaptation to external perturbations, the motor system continuously calibrates its sensitivity to errors to allow for more efficient adaptation. The cerebellum is considered as a key player in adaptation, but the neural mechanism underlying adjustments of error sensitivity during adaptation remains unknown. We previously showed that high-frequency stimulation (HFS) in the superior cerebellar peduncle (SCP) effectively and reversibly blocks cerebellar outflow and impedes motor timing and coordination. Here we used this approach to study the effects of a cerebellar block on motor behavior and motor cortical activity when monkeys adapt to an external perturbation. Monkeys (n=2) were trained to wear an exoskeleton (KINARM system) and made center-out movements to 1 of 8 pre-cued targets. After training was completed, a recording chamber was attached to the monkey's skull above the hand-related area of the motor cortex, and a chronic stimulating electrode was inserted into the SCP. High-frequency biphasic stimulation pulses (130 Hz, 100-200 uA) were delivered through the electrode to interfere with the outflow of cerebellar signals. The experimental protocol included an HFS stimulation condition (on/off) and a velocity-dependent force field (FF) perturbation condition (on/off). In the presence of FF, hand trajectories deviated from the straight line but monkeys compensated for the perturbation and gradually decreased the amount of the deviation. Applying HFS during FF trials significantly impaired adaptation as was evident in the monkeys' decreased capacity to consistently reduce movement errors and the residual deviations in late adaptation trials were significantly higher than control (p=3.36e-08, computed during late adaptation trials). In addition, we found that HFS alone (in the absence of FF) increases the level of noise as measured by the variability of maximal deviations across trials compared to control trials (t-test, p = 2.6e-11). To identify the mechanism(s) through which HFS impairs adaptation we used a state space mode, which posits that adaptation is an adaptive process driven by the extent of learning from past errors (i.e., error sensitivity) balanced by the amount of forgetting (i.e., retention factor). The results showed that during HFS, error sensitivity was significantly reduced (22.1%, p=1.2e-27) whereas the retention factor was decreased slightly by 4.7% (p=0.003). Next, we tested the possibility that the increase noise caused by HFS acts as a noisy perturbation on top of the external FF that interferes with the learning process. Although HFS significantly increased motor variability compared to the control trials, the increased variability did not trigger an adaptive response, indicating HFS increases internal and not external noise. Finally, error sensitivity for adaptation during HFS was significantly lower than in FF trials even

Probing the foundations of motor learning for physical Human-AI collaboration

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Physical interaction of humans with "dumb" devices have been in recent times well investigated. Much of the motor learning required has been studied in the framework of motor adaptation, and it remains elusive how motor control strategies (i.e. control policies) are being learned in the first place. This is essential for any form of Human-AI physical interaction as we cannot assume that the two entities need to start learning new control policies without being able to rely on an agreed common control policy; a caveat that also applies for human-human interaction. We present an experimental and computational framework to study the learning of collaborative motor policies by human and AI agents. We have created a test rig for real-time, real-world human-human and human-AI motor collaboration. The rig involves a non-trivial motor task, where a ball must roll on a square tray with obstacles, to reach a goal hole it

to fall into. The tray motions are limited to two degrees of freedom, as rotations along its lateral and longitudinal axes. We assign the control of each degree of freedom to one entity. In this manner, and by the way in which the obstacles are placed upon the tray, the only way to solve the task is for the two entities to work together; none of them can solve it on their own. Tray motions are controlled by a robotic manipulator, with human commands captured through optical tracking of controller trays they hold in their hands. AI commands are directly applied by the robot on the respective axis. The AI is implemented as a data-efficient, off-policy, deep reinforcement learner, which receives as its states the position and velocity of the ball as well as the tray angle and angular velocities, all along the two axes of the tray. We have run experiments involving human-human and human-AI teams using this setup. Using this framework we have complete access to the AI's control policy as it is evolving and learning, and implicitly, we can also learn a model of the human's control policy as it evolves, providing a rich framework for studying motor control. We are able to show that Humans and AI can learn to collaborate in a short period of time with suitable use of data-efficient reinforcement learning. Crucially we are seeing that different users develop different control strategies, and correspondingly, the AI system learns different cooperative strategies in response to that. We can show that "transplanting" different collaborative AI policies for one user and exposing them to another leads to substantial decrease in overall task performance. Studying human control policies more closely we observe clusters being formed with common approaches, resulting in more similar collaborative AI agents for humans within that cluster. Our collaborative framework provides an ideal window in studying Human-AI, but also Human-Human interaction.

FRIDAY JULY 29, 2022

08:00 – 10:00 SESSION 13, PANEL IV

Interrogating the neural control of movement during free behavior

David Xing[1], Ilka Diester[2], Ann Kennedy[1], Jesse Marshall[3]
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Our nervous system is capable of generating an amazingly rich variety of movements across a diverse set of contexts and environments. Yet, traditionally, the motor system has been studied using constrained paradigms that involve highly stereotyped and overtrained movements. While such approaches are important for the controlled study of individual aspects of motor control, they are unable to capture the underlying neural principles governing naturalistic movements, and are insufficient for determining whether these principles generalize across the full behavioral repertoire of the animal. For example, research has revealed that aspects of motor control may be heterogenous across different movement modalities. Fast optogenetic inactivation of motor cortex revealed different muscle response latencies between reaching and locomotion. How does cortical influence on downstream muscles vary across a wider variety of movements? New paradigms that facilitate motor system study across multiple behaviors in unconstrained animals are necessary to address these questions. One reason for the lack of such studies is due to the historical challenge of obtaining electrophysiological and behavioral data from unrestrained animals. However, recent advances in computer vision, large-scale electrophysiology, and wireless data transfer have enabled the development of novel freely-moving paradigms. In this panel, we will present and discuss recent technical developments in video-based kinematic tracking and the resultant freely-behaving experiments enabled by these advances. We will present the findings of four lines of research, revealing novel principles underlying the neural control of unconstrained, naturalistic movements. First, David Xing will present on the development of a novel freely-climbing paradigm in mice with simultaneous large-scale neural and EMG recordings. Animals in this paradigm perform a variety of motor actions such as dexterous climbing and locomotion, as well as grooming, eating and leaping. Next, Ilka Diester will introduce a virtual head-fixation approach based on 3D motion tracking combined with a model which removes the influence of undesired body movements on neuronal activity. She will report how this strategy allows the analysis of defined behaviors, unveiling an unexpectedly large fraction of neurons in the rat motor cortex tuned to paw movements, which was previously masked by body posture tuning. Next, Ann Kennedy will present findings indicating preserved covariance patterns among monkey M1 neurons across a range of unconstrained behaviors in a large telemetry cage requiring limb coordination and body posture changes. Finally, Jesse Marshall will discuss recent advances in 3D behavioral measurement tools, and how they facilitate quantitative comparisons between the neural codes underlying natural and learned behaviors.

10:30 – 12:30 SESSION 14, INDIVIDUAL IV

Postural and volitional signals occupy separate neural dimensions in motor cortex

Patrick Marino[1], Lindsay Bahureksa[2], Carmen Fisac[2], Emily Oby[1], Asma Motiwala[2], Erinn Grigsby[1], Adam Smoulder[2], Alan Degenhart[3], Wilsaan Joiner[4], Steven Chase[5], Byron Yu[2], Aaron Batista[1]

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Motor cortex (M1) generates time courses of neural population activity, or ‘neural trajectories,’ that drive movement. These trajectories are shaped by inputs from other areas, such as volitional signals encoding movement goals and sensory signals encoding arm posture. How do postural and volitional signals interact to shape neural trajectories in M1? We examined neural population activity across a variety of tasks and found a strikingly simple organization: first, postural and volitional information were isolated in separate neural dimensions, producing a postural representation that was stable across tasks. Second, the interactions between postural and volitional signals were small and depended on task demands. To ask how postural and volitional signals interact in M1, we started with a brain-computer interface (BCI) task in which Rhesus monkeys volitionally modulated M1 activity to drive a computer cursor to a target. To vary postural input to M1, we placed the monkey’s arm in different postures while the animal used the BCI. Because this task did not require arm movement, arm posture was fixed during individual trials, and target-specific volitional inputs to M1 did not need to change across postures. Individual neurons exhibited mixed responses, but at the population level, we found that postural and volitional information were isolated in separate neural dimensions. Neural trajectories did not change shape across postures, despite large, posture-driven changes in trajectory starting points. This indicates that postural inputs, which convey critical information for movement control, do not always affect dynamics in M1. Next we asked whether this organization was present during arm movements. We recorded from M1 while monkeys engaged in multi-posture isometric force and delayed center-out reaching paradigms. In these tasks, arm posture was time-varying, and different initial postures required different movements for task success. The organization seen in the BCI task was visible: postural and volitional information occupied separate neural dimensions. When multiple tasks were run within a session, a single classifier could decode posture across tasks. Neural trajectories displayed limited reshaping across postures, reflecting the necessary interactions between posture and movement in these tasks. We found time-varying activity in the posture subspace, consistent with the possibility that arm posture was represented in this space in an ongoing manner. These findings demonstrate that postural and volitional information occupy separate dimensions of M1 activity, allowing for a stable postural representation across tasks. Sensory information is used differently across tasks, and this was reflected in the task-dependent interactions we observed between postural and volitional signals. Our results shed new light on how M1 accomplishes sensorimotor integration and can inform the design of BCI decoders that are robust to changes in user posture.

Vestibular reflexes in neck muscles contribute to stabilizing the head across the range of dynamic motion experienced during everyday life

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The vestibular system senses motion of the head in space and provides rapid reflex responses in muscles throughout the body to ensure stable posture and gaze. The vestibular reflex in neck muscles (vestibulocollic reflex; VCR) can contribute to stabilizing the head in space, which is vital to enable accurate motor control since the head serves as the reference frame for visual and vestibular information. However, to date our understanding of the efficacy of the VCR in stabilizing the head during motion experienced in everyday life is limited. Previously, the function of the VCR has been inferred from modelling the biomechanics of the head-neck system, or by recording neck muscle activity in response to slow, low frequency motion in cats. Meanwhile, frequencies up to 20 Hz are contained in dynamic motion experienced by humans and non-human primates. Thus, to date the functional efficacy of the VCR during motion relevant to everyday life remains unknown. Here we probed the characteristics of the VCR by recording neck muscle activity during passive whole-body motion in the yaw plane in alert rhesus monkeys. First, to examine the characteristics of the VCR, we applied sinusoidal vestibular stimulation at 18 frequencies from 0.5-20 Hz in 2 healthy monkeys in the dark. Phase indicated that motor units increased activity during contralateral motion (e.g., leftward motion activated the right SPL muscle to stabilize the head in space), and gain increased with the frequency of stimulation up to ~15 Hz. To examine if the response was purely vestibular in origin, we applied sinusoidal vestibular stimulation to a bilateral vestibular loss (BVL) monkey in the dark. Responses were strikingly absent in the BVL monkey, confirming vestibular feedback drives the neck motor unit responses. Next, to examined multisensory integration of visual and vestibular information, we compared responses to motion under 3 different visual conditions (dark, world-fixed surround, and head-fixed surround). In comparison to the dark condition, response gain was higher with the world-fixed visual surround at frequencies beyond ~8 Hz, suggesting visual input may modulate the gain of the VCR. Interestingly, when visual information about self-motion was provided to the BVL monkey (world-fixed visual surround), neck motor unit responses were still absent even at low frequencies, suggesting visual information could not substitute for the lack of vestibular feedback. Finally, we investigated whether motor units show non-linear responses to vestibular input by applying broadband white-noise stimulation. In comparison to sinusoidal stimulation, gain was attenuated at low frequencies during white noise stimulation, a phenomenon previously observed in central vestibular neurons. Altogether, our results demonstrate vestibular projections to neck muscles play a vital role in posture and accurate motor control in primates across the range of dynamic motion experienced during everyday life.

Resting-state functional connectivity predicts postural deficits following spaceflight

Heather McGregor[1], Nichole Beltran[2], Yiri De Dios[2], Jacob Bloomberg[3], Scott Wood[4], Ajitkumar Mulavara[2], Roy Riascos[5], Patricia Reuter-Lorenz[6], Rachael Seidler[1]
[1]*University of Florida*, [2]*KBR*, [3]*NASA Johnson Space Center, retired*, [4]*NASA Johnson Space Center*, [5]*University of Texas Health Science Center at Houston*, [6]*University of Michigan*

During spaceflight, astronauts adapt to sensorimotor changes induced by the microgravity environment. These include altered vestibular signaling, body unloading (“weightlessness”), and reductions in both lower limb motor outputs and somatosensory inputs. When astronauts are reintroduced to gravity, these in-flight sensorimotor adaptations are maladaptive, manifesting as significant post-flight balance impairments. All astronauts exhibit balance deficits immediately post-flight, but there is considerable individual variability in the extent of impairment and the rate of readaptation to gravity. We have recently shown that astronauts compensate for post-flight vestibular deficiency by upweighting visual

and somatosensory inputs to maintain their balance. Predicting a crewmember's post-flight balance impairment would offer insights for pre-flight training and countermeasure development. In this fMRI study, we investigated if resting-state functional connectivity (FC) involving sensorimotor and association brain areas prior to spaceflight is associated with post-flight balance impairments. Fifteen astronauts completed pre-flight test sessions approximately 180 and 60 days prior to launch and a post-flight session within 5 days after their return from a 6-12 month mission to the International Space Station. Test sessions consisted of a 10-min resting-state fMRI scan as well as balance assessments using Sensory Organization Tests. During balance tests, astronauts performed three 20-s trials while standing on a sway-referenced (unstable) support platform, closing their eyes, and performing rhythmic head pitches. Per-trial equilibrium scores were calculated based on anterior-posterior peak-to-peak sway angle. We assessed the change in median equilibrium score from pre- to post-flight. Pre-flight neuroimaging data were preprocessed using a standard pipeline followed by a seed-based connectivity analysis. We tested for associations between pre-flight FC and post-flight changes in postural stability. Resting-state FC between a seed region in the left insula and clusters in left primary somatosensory cortex and left lateral occipital cortex prior to flight was associated with post-flight changes in postural stability. Weaker pre-flight FC between these brain areas was associated with larger postural deficits following spaceflight whereas stronger FC was associated with smaller postural deficits -- or in some cases stability improvements -- following spaceflight. These individual differences in pre-flight FC between regions involved in somatosensation and higher-order visual processing suggest that pre-flight training targeting the visual and/or somatosensory systems may help to reduce postural deficits in astronauts following spaceflight.
Supported by NASA grant #NNX11AR02G.

Basal ganglia-spinal cord pathway that commands locomotor asymmetries

Jared Cregg[1], Simrandeep Kaur Sidhu[1], Ilary Allodi[1], Roberto Leiras[1], Ole Kiehn[1]
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Motor impairments in Parkinson's disease are caused by loss of dopamine input to basal ganglia circuits. Although the basal ganglia are important for locomotion in particular, mechanisms underlying basal ganglia control over spinal locomotor networks remain unclear. One hallmark feature of human Parkinsonism is an exacerbated turning gait and failure to negotiate turns. Chx10 gigantocellular (Gi) neurons are required for turning gait asymmetries (Cregg et al., 2020; Usseglio et al., 2020), suggesting that turning deficits in Parkinson's disease may arise via this spinal projection pathway. Using deep brainstem calcium recording in mice, we found that D1 and D2 striatal projection neurons (SPNs) evoke discrete changes in Chx10 Gi activity during locomotor turns. Leveraging Chx10 Gi neurons as an entry point, we used a reverse dissection approach to uncover the dominant basal ganglia-spinal cord pathway for locomotor asymmetries in mammals: striatal projection neurons -> substantia nigra pars reticulata (SNr) --> pontine nucleus oralis (PnO) -> Chx10 Gi neurons -> spinal locomotor networks. PnO was identified using an intersectional viral screening strategy, where a subset of PnO neurons defined by Vglut2 expression and commissural projection proved to act as the critical link between basal ganglia output and Chx10 Gi neurons. Stimulation of this small cluster of neurons evoked contralateral turning, whereas photoinhibition evoked ipsilateral turning. Finally, chemogenetic or optogenetic manipulation of motor targets downstream of the basal ganglia restored contralateral turning in unilateral 6-OHDA lesioned mice. Our results reveal the circuit logic underlying a critical motor program, from action commitment in the basal ganglia to execution by spinal locomotor networks.

Data-driven gait signatures reveal individual-specific differences in gait dynamics post-stroke

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[1]Georgia Institute of Technology and Emory University, [2]Department of Rehabilitation Medicine, Division of Physical Therapy, Emory University, [3]Department of Biology, Emory University

Modeling the neuromechanics of walking, particularly in neurological disorders, is challenging because current biomechanical simulations lack appropriate neural control mechanisms and constraints. Prior work has shown that at least three distinct groups of muscle coordination impairment exist in post-stroke individuals who have similarly slowed walking speeds. However, we do not know how these neural control deficits manifest in movement features. Here we use a Recurrent Neural Network (RNN) to model the neuromechanical dynamics of gait in a data-driven manner based on capturing spatiotemporal dependencies between sagittal plane lower-limb joint angles during treadmill walking, to compare stroke survivors to each other as well as to able-bodied controls (AB). We generated and analyzed individual-specific 'gait signatures': low-dimensional representations of the parameters of a data-driven gait dynamics model that gives rise to an individual's unique kinematic patterns. We predicted that stroke survivors with faster walking speeds would have gait signatures that more closely resembled that of AB but that those with slower walking speeds would deviate from AB gait signatures in a variety of ways, presumably as a result of differences in their motor coordination deficits. We collected continuous, bilateral, lower limb, sagittal plane joint angles (hip, knee, and ankle) from AB (N=5) and post-stroke (N=7, > 6 months after stroke onset) participants who walked on a treadmill at six different speeds. Kinematic data from all individuals served as inputs to an RNN model, which was trained to predict a time-shifted version of the kinematic input data. Internal activations for all individuals' gaits were extracted from the trained model and reduced in dimension using principal components (PC) analysis. The differences between gait signatures were visualized using two-dimensional t-distributed stochastic neighbor embedding (t-SNE) maps. Gait signatures for each individual walking at different speeds were closely clustered to each other, suggesting that individual-specific differences in gait signature representation are relatively invariant across walking speed. AB gait signatures clustered tightly together, whereas stroke individuals were more separated. Higher-functioning stroke survivors (preferred speed > 0.4 m/s) had more similar gait dynamics to AB, as were clustered in close proximity to the AB gait signatures. Conversely, lower-functioning stroke survivors (preferred speed < 0.4 m/s) were most distant and less clustered, indicating more heterogeneity in gait dynamics. We infer that slow walking can result from disparate neural control mechanisms across individuals allowing potential discrimination in underlying neuromechanics. Gait signatures use kinematic information to capture individual-specific dynamic differences irrespective of walking speed and may enable holistic and objective metrics for characterizing post-stroke and other gait deficits.

Movement is governed by rotational dynamics in spinal motor networks

Rune Berg[1]

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Although the nervous system is elegantly orchestrating movements, the underlying neural principles remain unclear. Since flexor- and extensor-muscles alternate during movements like walking, it is often assumed that the responsible neural circuitry is similarly alternating in opposition. Here, we present ensemble recordings of neurons in the lumbar spinal cord that indicate that, rather than alternation, the population is performing a "rotation" in neural space, i.e. the neural activity is cycling through all phases continuously during the rhythmic behavior. The radius of rotation correlates with the intended muscle force. Since existing models of spinal motor control offer an inadequate explanation of rotation, we propose a new theory of neural generation of movement from which this and other unresolved issues, such as speed regulation, force control, and multi-functionalism, are conveniently explained.

15:00 – 17:00 SESSION 16, PANEL V

Basal ganglia circuit communication for movement execution and motor learning: The vigorous tutor revisited

Andreea Bostan[2], David Robbe[3], Roxanne Lofredi[1], Wolf-Julian Neumann[1], Robert Turner[2]

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What are the functions of the basal ganglia? Thirty years ago, the answer to this question seemed to be within reach, but lasting efforts in search for a unifying framework were of no avail. Indeed, behavioral correlates of basal ganglia activity seem as diverse as the ever-increasing complexity of their anatomical and molecular circuit characteristics. The basal ganglia network is uniquely positioned at the center of the motor network to integrate widespread cortical and subcortical information and, under the influence of dopamine, distribute the result of these computations to a similarly diverse array of cortical and subcortical outputs. Whatever the function of the basal ganglia, it is likely embedded in the ability of this web of long-range synaptic connections to shape motor control and learning across the brain. Conversely, the power of these network level connections can be observed in the synchronous oscillations across cortex, basal ganglia and thalamus that are pathologically exaggerated in basal ganglia- based movement disorders. The present panel reviews recent advances in pathway-specific functional anatomy and physiological mechanisms of basal ganglia dependent motor control. It aims to integrate findings from rodent, non-human primate and human clinical research spanning a variety of research methods including trans-synaptic tracing, behavoiur, invasive electrophysiology, neuroimaging and computational modelling. While these methods are diverse, the studies presented all focus on structural and functional basal ganglia networks for motor learning and kinematic control. Research highlights include the overlap of basal ganglia and cerebellar circuits in non-human primates with neuromodulation induced changes in human trial to trial motor improvement, an interrogation of potential roles of the dorsal striatum in motor learning, effort and cost signalling and dopamine dependent vigor signals reflected in temporal dynamics in human basal ganglia beta and gamma band activity. The findings presented here serve as case studies to challenge the resilience of influential basal ganglia theories such as the vigorous tutor paradigm, habit formation, reward prediction error signals and energy cost discounting. Our studies suggest that basal ganglia computations result in synaptic modulation of distributed motor networks for motor plan invigoration and consolidation. Importantly, input and output feedback loops may prevail at each stage of the circuit from pre- and primary motor cortex, thalamus and cerebellum. Beta and gamma band oscillatory synchronization may reflect a physiological mechanism for communication in these distributed neural populations, through dopamine-dependent changes in excitability and vulnerability for synaptic potentiation. In summary, our panel highlights the importance of circuit-level computations for understanding basal ganglia function and discusses the translational implications for DBS in basal ganglia disorders.

17:00 – 18:00 DISTINGUISHED CAREER AWARD TALK

How to select the best balance and gait outcomes for clinical trials

Fay Horak, *Oregon Health and Science University*

The technology to collect Balance and Gait Digital Health Outcomes are Ready for Clinical Trials. However, wearable, inertial sensors provide a myriad of potential measures during prescribed tasks and even more measures during passive monitoring in daily life. Studies have shown that both balance and gait are controlled by several relatively independent neural control systems (domains) that can be affected differently by each neurological disease and by each intervention. Clinical validity includes discovery of which, particular domain is affected by a specific cohort. Evidence to support the use of a particular balance or gait measure as an outcome for a clinical trial includes determining the extent to which measures show: Verification of accuracy, Sensitivity/Specificity, Reliability, Face Validity, Related to Patient-Reported Outcomes and/or Fall Risk, Responsive to Progression, Related to Physiological Biomarkers, Responsive to Change (Effect Size). No one measure will be the best in all categories of evidence so we recommend developing a composite score including several, independent measures using Multiple Criteria Decision Analysis (MCDA). MCDA is a systematic approach to determining the best outcome. Experts weigh the relative importance of all available evidence and the weighted sum of evidence is used to determine the most useful outcome. Examples of evidence supporting balance and gait outcomes for Parkinson's disease, Cerebellar ataxia, Multiple Sclerosis, and other neurological disorders will be discussed. Benefits and challenges of measuring gait passively in daily life compared to prescribed test in the laboratory or clinic will also be discussed.

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NOTES

Poster Sessions

The Society for the Neural Control of Movement is pleased to present a wide range of current research through the poster sessions. The posters have been divided over four sessions, each on display for one day.

SESSION 1

Tuesday, July 26, 2022 08:00 – 18:00

SESSION 2

Wednesday, July 27, 2022 08:00 – 17:30

SESSION 3

Thursday, July 28, 2022 08:00 – 14:00

SESSION 4

Friday, July 29, 2022 08:00 – 15:00

The poster numbers are divided first by session, then by theme, and finally with a unique number.

Session – Theme – Board Number (ex. 1-A-1)

THEMES

A – Control of Eye & Head Movement

B – Fundamentals of Motor Control

C – Posture and Gait

D – Integrative Control of Movement

E – Disorders of Motor Control

F – Adaptation & Plasticity in Motor Control

G – Theoretical & Computational Motor Control

POSTER SESSION 1

TUESDAY, JULY 26, 2022

A – CONTROL OF EYE & HEAD MOVEMENT

1-A-1 ***Information transmission in the cerebellum: the role of rate and synchrony during smooth pursuit***

David Herzfeld[1], Mati Joshua[2], Stephen Lisberger[1]

[1]Duke University, [2]The Hebrew University of Jerusalem

1-A-2 ***Discharge properties of neurons in the 8th nerve, vestibular nucleus and abducens nucleus may explain suboptimal VOR characteristics in response to neuroprosthetic stimulation***

James Phillips[1], Leo Ling[1], Christopher Phillips[2], Amy Nowack[1], Yoshiko Kojima[1], Jay Rubinstein[1], Shawn Newlands[3]

[1]University of Washington, [2]University of California Davis, [3]University of Rochester

1-A-3 ***The surprising inter-subject stereotypicality by which limb movements quantitatively predict eye movements in real-world tasks***

J. Alex Harston[1], Aldo Faisal[1]

[1]Imperial College London

1-A-4 ***Neural substrates for generation of oblique saccades -Branching patterns of single tectofugal neurons-***

Mayu Takahashi[1], Yuriko Sugiuchi[1], Yoshikazu Shinoda[1]

[1]Tokyo Medical and Dental University

1-A-5 ***Neck EMG and Head Stabilization by Vestibulocollic Reflexs (VCRs) during Walking***

Oliver Stanley[1], Kathleen Cullen[1]

[1]Johns Hopkins University

B – FUNDAMENTALS OF MOTOR CONTROL

1-B-6 ***Dissociation between stiffness perception and action during uncoupled bimanual interaction***

Shani Arusi[1], Ilana Nisky[1]

[1]Ben Gurion University

1-B-7 ***Evidence for dual processes in motor working memory***

Hanna Hillman[1], Tabea Botthof[1], Alexander Forrence[1], Samuel McDougle[1]

[1]Yale University

1-B-8 ***The relevance of identity-specific action-effects, sensory attenuation and the sense of agency: An EEG study***

Elisabeth Lindner[1], Felicia Cheng[1], Andrea Desantis[2], Alexander Gail[1]

[1]German Primate Center, [2]The French Aerospace Lab ONERA

1-B-9 ***Deciding how to move in the face of uncertainty***

Aaron Wong[1], Audrey Green[2], Mitchell Isaacs[1]

[1]Moss Rehabilitation Research Institute, [2]Holy Family University

1-B-10 ***Effects of implicit and explicit motor learning on the pre-and post-movement cortical beta rhythm***

Betina Korka[1], Matthias Will[1], Max-Philipp Stenner[1]

[1]Otto-von-Guericke University

1-B-11 ***Explicit and implicit learning in the wild: Sensory prediction error learning occurs outside the laboratory***

Dan Blustein[1], Emily Blaum[2], Scott Albert[3]

[1]Acadia University, [2]Rhodes College, [3]University of North Carolina Chapel Hill

1-B-13 ***Contact instability of fingers in precision gripping***

Neelima Sharma[1], Madhusudhan Venkadesan[2]

[1]University of Chicago, [2]Yale University

1-B-14 ***Kinematic adaptation to a normal but negative gravitational field: Feedforward or feedback control?***

Denis Barbusse[1], Jérémie Gaveau[1], Olivier White[1]

[1]Inserm CAPS U1093

1-B-15 ***Startling acoustic stimuli hasten choice reaching tasks by strengthening express visuomotor responses without changing their timing***

Sarah Kearsley[1], Aaron Cecala[1], Ewan Macpherson[1], Brian Corneil[1], Vivian Weerdesteyn[2]

[1]Western University, [2]Donders Institute for Brain, Cognition and Behaviour

1-B-16 ***A network information theoretic framework to characterise muscle synergies in space and time***

David O' Reilly[1]

[1]University of Leeds

1-B-17 ***Comparing latent dynamics extraction methods on movement decoding for brain machine interface applications***

Mohammadali Ganjali Bonjar[1], Abed Khorasani[2], Alireza Mehri Dehnavi[1]

[1]School of Advanced Technologies in Medicine, Isfahan University of Medical Sciences, [2]Northwestern University, Chicago

1-B-18 ***Aging decreases the lateralization of gravity-related effort minimization during vertical arm movements***

Gabriel Poirier[1], Charalambos Papaxanthis[1], Adrien Juranville[1], Melanie Lebigre[1], France Mourey[1], Jeremie Gaveau[1]

[1]Université de Bourgogne

1-B-19 ***Motor vigour and motor sequence learning are differentially affected by dopamine modulation***

Sebastian Sporn[1], Joseph Galea[2]

[1]University College London, [2]University of Birmingham

1-B-20 ***Modulation of corticospinal excitability while preparing to intercept a moving target***

Justin McCurdy[1], Daniel Zlatopolsky[1], Asher Khan[1], Jing Xu[1], Deborah Barany[1]

[1]University of Georgia

1-B-21 ***Manipulating movement related brain activity with mechanical stimulations***

Nathan Steadman[1], Thomas Martineau[1], Ravi Vaidyanathan[1], Shlomi Haar[1], Huiling Tan[2]

[1]Imperial College, [2]University of Oxford

1-B-22 ***Learning high dimensional hand control of a robot arm is largely independent of mapping structure***

Steafan Khan[1], Zachary Danziger[1]

[1]Florida International University

C – POSTURE AND GAIT

1-C-23 ***Faithful encoding of locomotor coordination by individual Purkinje cells***

Hugo Marques[1], Jorge Ramirez-Buritica[1], Pedro Castelhanito[1], Ana Gonçalves[1], Megan Carey[1]

[1]Champalimaud Foundation

1-C-24 *Running development follows walking age. A longitudinal case study*

Margit Bach[1], Coen Zandvoort[1], Germana Cappellini[2], Yury Ivanenko[2], Francesco Lacquaniti[3], Andreas Daffertshofer[1]

[1]Vrije Universiteit Amsterdam, [2]Istituto di Ricovero e Cura a Carattere Scientifico Fondazione Santa Lucia, [3]Istituto di Ricovero e Cura a Carattere Scientifico Fondazione Santa Lucia & University of Rome Tor

1-C-25 *Generalization of learning to stand with unexpected sensorimotor delays*

Brandon Rasman[1], Jean-Sébastien Blouin[2], Remco van Woerkom[1], Maarten Frens[1], Patrick Forbes[1]

[1]Erasmus University Medical Center Rotterdam, [2]University of British Columbia

1-C-26 *Uneven terrain walking costs differ from dual-task walking in older adults: Preliminary results of the Mind in Motion study*

Valay Shah[1], Ryan Downey[1], Tyler Fettrow[2], Arkaprava Roy[1], Chris Hass[1], David Clark[1], Patricia Reuter-Lorenz[3], Daniel Ferris[1], Todd Manini[1], Rachael Seidler[1]

[1]University of Florida, [2]NASA Langley Research Center, [3]University of Michigan

1-C-27 *PPN-stimulation induced freezing-response and its impact on the activity of spinal motor circuits in freely moving rats*

Jaspreet Kaur[1], Nicolas Bertram[1], Rune Berg[1]

[1]University of Copenahgen

1-C-28 *Individual differences in neural connectivity from prefrontal cortex to cortical and spinal motor circuits during tandem stance are associated with balance ability*

Catherine Mason[1], Alejandro Lopez[1], Terrence Glover[1], Lena Ting[2], Michael Borich[1], Trisha Kesar[1]

[1]Emory University, [2]Emory University & Georgia Tech

1-C-29 *Longitudinal volume loss after traumatic brain injury predicts vestibular dysfunction*

Mohammad Mahmud[1], Zaeem Hadi[1], Rebecca Smith[2], Yuscah Pondeca[2], Barry Seemungal[2]

[1]Imperial College London, [2]Imperial College

D – INTEGRATIVE CONTROL OF MOVEMENT

1-D-30 *Neural encoding of proprioception of the limbs in the mouse primary somatosensory and motor cortices*

Megan Lipton[1], Maria Dadarlat[1]

[1]Purdue University

1-D-31 *An immutable control policy governs fingers closure during reach-to-grasp coordination*

Madhur Mangalam[1], Mariusz Furmanek[1], Kyle Lockwood[1], Mathew Yarossi[1], Eugene Tunik[1]

[1]Northeastern University

1-D-32 *Activity in mouse motor cortex reflects action and its expected sensory consequence*

Brooke Holey[1], David Schneider[1]

[1]New York University

1-D-33 *Drawing performance with the non-dominant hand is supported by bilateral parietal cortex*

Taewon Kim[1], Alexandre Carter[1], Ian Dobbins[1], Lei Liu[1], Mark McAvoy[1], Zihan Sun[1], Yong Wang[1], Benjamin Philip[1]

[1]Washington University

1-D-34 *The role of motor commands in modulation of auditory evoked responses*

Batel Buaron[1], Roy Mukamel[1]

[1]Tel Aviv University

1-D-35 *Neural mechanisms underlying expectations and feedback of reward-based task performance*

Joonhee Lee[1], Agostina Casamento-Moran[1], Vikram Chib[1]

[1]Johns Hopkins University

1-D-36 *Distinctive motor neuron recruitment with intracortical microstimulation and wireless cortical stimulation using targeted delivery of magnetoelectric nanotransducers*

Jonathan Shulgach[1], Max Murphy[1], Elric Zhang[2], Mostafa Abdel-Mottaleb[2], Manuel Campos[2], Shawnus Chen[3], Sakhrat Khizroev[2], Ping Liang[3], Douglas Weber[1], Darcy Griffin[1]

[1]*Carnegie Mellon University,* [2]*University of Miami,* [3]*Cellular Nanomed*

E – DISORDERS OF MOTOR CONTROL

1-E-37 *The positive dimension of schizotypy is associated with a reduced attenuation and precision of self-generated touch*

Xavier Job[1], Evridiki Asimakidou[1], Konstantina Kilteni[1]

[1]*Karolinska Institutet*

1-E-38 *Impaired sequential but preserved motor memory consolidation in Multiple Sclerosis Disease*

Charles-Etienne Benoit[1]

[1]*Univ Lyon 1 Claude Bernard*

1-E-39 *Impaired inter-joint coordination in sub-acute stroke participants contribute to performance impairments but cannot be explained by intrusion of pathological synergies*

Inbar Avni[1], Ahmet Arac[2], Reut Binyamin-Netser[1], John Krakauer[3], Lior Shmuelof[1]

[1]*Ben-Gurion University,* [2]*University of California Los Angeles,* [3]*Johns Hopkins University*

1-E-40 *Using movement data to classify autism: Challenging an algorithm built for autism classification with Parkinson's data*

Theofaneia Ntounia[1], Ellen Poliakoff[1], Alex Casson[1], Emma Gowen[1]

[1]*The University of Manchester*

1-E-41 *Directional and general impairments in initiating motor responses after stroke*

Kayne Park[1], Matthew Chilvers[2], Trevor Low[2], Sean Dukelow[2], Stephen Scott[1]

[1]*Queen's University,* [2]*University of Calgary*

1-E-42 *Robotic assessment of unilateral and bilateral upper limb performance in adults living with hemiparetic cerebral palsy*

Isabelle Poitras[1], Alexandre Campeau-Lecours[1], Catherine Mercier[1]

[1]*Laval university*

1-E-43 *Relationship of movement kinematics and motor circuit beta burst dynamics in Parkinson's disease and its modulation by pallidal stimulation*

Koorosh Mirpour[1], Jeong Woo Choi[1], Katy Cross[2], Nader Pouratian[1]

[1]*University of Texas Southwestern Medical Center,* [2]*University of California Los Angeles*

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

1-F-44 *The effect of detuning on interlimb coordination*

Jaskanwaljeet Kaur[1], Shannon Proksch[1], Ramesh Balasubramaniam[1]

[1]*University of California, Merced*

1-F-45 *Electrical and optogenetic stimulation for stroke recovery in rats*

Windsor Ting[1], Derek Burns[2], Maxime Huot Lavoie[3], Zohreh Vaziri[3], Christian Éthier[3]

[1]*Columbia University,* [2]*Doric Lenses Inc,* [3]*Université Laval*

1-F-46 *Using tools as cues for dual adaptation to opposing visuomotor rotations in virtual reality*

Laura Mikula[1], Andrew King[1], Shanaathanan Modchalingam[1], Bernard Marius 't Hart[1], Denise Y P Henriques[1]

[1]*York University*

1-F-47 *Updates of explicit re-aiming to a visuomotor rotation occur via reinforcement learning*

Jonathan Tsay[1], Hyosub Kim[2], Jordan Taylor[3], Samuel McDougle[4], Adrian Haith[5], John Krakauer[5], Rich Ivry[1], Anne Collins[1]

[1]*University of California Berkeley,* [2]*University of Delaware,* [3]*Princeton Unversity,* [4]*Yale University,* [5]*Johns Hopkins University*

1-F-48 ***Learning in a mirror reversal task provides distinct mechanisms between de novo learning and motor adaptation***

Raphael Gastrock[1], Bernard Marius 't Hart[1], Denise Henriques[1]

[1]*York University*

1-F-49 ***Non-invasive temporal interference stimulation of the human striatum at 80 Hz, but not 20 Hz, disrupts reinforcement motor learning***

Pierre Vassiliadis[1], Elena Beanato[1], Traian Popa[1], Fabienne Windel[1], Takuya Morishita[1], Nir Grossman[2], Esra Neufeld[3], Julie Duque[4], Gerard Derosiere[4], Maximilian Wessel[5], Friedhelm Hummel[1]

[1]*EPFL*, [2]*Imperial College London*, [3]*IT'IS Research Foundation*, [4]*Université Catholique de Louvain*, [5]*Julius-Maximilians-University*

1-F-50 ***The effect of combining punishment and reward can transfer to opposite motor learning***

Cong Yin[1]

[1]*Capital University of Physical Education and Sports*

1-F-51 ***Implicit reward-based motor learning***

Nina van Mastrigt[1], Jonathan Tsay[2], Tianhe Wang[2], Guy Avraham[2], Sabrina Abram[2], Rich Ivry[1]

[1]*Vrije Universiteit Amsterdam*, [2]*University of California Berkeley*

1-F-52 ***Changes in interlimb corticospinal facilitation between upper and lower limbs after interlimb coordination task***

Tatsuya Kato[1], Atsushi Sasaki[2], Keiichi Ishikawa[1], Kimitaka Nakazawa[1]

[1]*The University of Tokyo*, [2]*Osaka University*

1-F-53 ***Strategic re-aiming decreases perceptual precision during motor adaptation***

Matthias Will[1], Max-Philipp Stenner[1]

[1]*Otto-von-Guericke-University*

1-F-54 ***Differential contributions of task performance errors and sensory prediction errors to motor learning***

Gaurav Panthi[1], Pratik Mutha[1]

[1]*Indian Institute of Technology Gandhinagar*

1-F-55 ***Does ipsilateral remapping following hand-loss impact motor control of the intact hand?***

Raffaele Tucciarelli[1], Daan Wesselink[2], Naveed Ejaz[3], Carl Hodgetts[4], Jörn Diedrichsen[5], Tamar Makin[6]

[1]*University College London*, [2]*Harvard Medical School*, [3]*MindMaze*, [4]*Royal Holloway University of London*, [5]*Western University, London*, [6]*MRC Cognition & Brain Sciences Unit, Cambridge*

1-F-56 ***Is the human body the best model for controlling artificial limbs? Comparing biomimetic vs arbitrary motor control strategies***

Hunter Schone[1], Malcolm Udeozor[1], Mae Moninghoff[1], Beth Rispoli[1], James Vandersea[2], Blair Lock[3], Levi Hargrove[4], Grace Edwards[1], Shruti Japee[1], Tamar Makin[5], Chris Baker[1]

[1]*National Institutes of Health*, [2]*Medical Center Orthotics and Prosthetics*, [3]*Coapt Engineering*, [4]*Shirley Ryan AbilityLab*, [5]*University of Cambridge*

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

1-G-56 ***Investigation of the effect of an external input in executed movement***

Seunghan Lee[1], Eunseo Oh[1], Soyoung Chae[1], Sung-Phil Kim[1]

[1]*UNIST*

1-G-57 ***Internal states as a source of subject-dependent movement variability and their representation by large-scale networks in the human brain***

Macauley Breault[1], Pierre Sacre[2], Jorge González-Martínez[3], Sridevi Sarma[4]

[1]*Massachusetts Institute of Technology*, [2]*University of Liège*, [3]*University of Pittsburgh*, [4]*Johns Hopkins University*

1-G-58 ***Effects of task conditions on human hand pose selection strategies in a bimanual fine manipulation task***

Kunpeng Yao[1], Dagmar Sternad[2], Aude Billard[1]

[1]*EPFL*, [2]*Northeastern University*

1-G-59 ***The goalkeeper dilemma at the penalty kick***

Noslen Hernández[1], Antonio Galves[1], Claudia Vargas[2]

[1]Universidade de São Paulo (USP), [2]Institute of Biophysics Carlos Chagas Filho of the Federal University of Rio de Janeiro

1-G-61 ***Exploring neural states in the parietal cortex during arm reaching movements with hidden markov models***

Stefano Diomedi[1], Francesco Vaccari[1], Matteo Filippini[1], Kostas Hadjidimitrakis[1], Patrizia Fattori[1]

[1]University of Bologna

1-G-62 ***Rapid switching between learned controllers for different visuomotor maps***

Kahori Kita[1], Yue Du[1], Adrian Haith[1]

[1]Johns Hopkins University

1-G-63 ***Model of gait control in Parkinson's disease and prediction of robotic assistance***

Clémence Vandamme[1], Virginie Otlet[1], Renaud Ronsse[1], Frédéric Crevecoeur[1]

[1]UCLouvain

1-G-64 ***Grasping decoder recalibration is facilitated by the alignment of neural manifolds throughout the frontoparietal network***

Jannik Luff[1], James Goodman[1], Andres Agudelo-Toro[1], Stefan Schaffelhofer[2], Hansjörg Scherberger[3]

[1]Deutsches Primatenzentrum GmbH (German Primate Center), [2]Deutsches Primatenzentrum GmbH (German Primate Center), cortEXplore GmbH, [3]Deutsches Primatenzentrum GmbH (German Primate Center), Department of Biology University of Göttingen

1-G-65 ***Goal-oriented correction during continuous sensori-motor action can be discriminantly identified with dynamic programming methods and uniquely modulates activity in human basal forebrain***

Neil Dundon[1], Dengxian Yang[1], Jaron Colas[1], Viktoriya Babenko[1], Elizabeth Rizor[1], Linda Petzold[1], Scott Grafton[1]

[1]University of California, Santa Barbara

1-G-66 ***Is co-contraction good or bad for movement control? A simulation study using a single model for various movements***

Hansol Ryu[1], Manoj Srinivasan[2]

[1]University of Calgary, [2]The Ohio State University

1-G-67 ***A neural hashcode model of basal ganglia function***

Terence Sanger[1]

[1]University of California, Irvine

POSTER SESSION 2

WEDNESEDAY, JULY 28, 2022

A – CONTROL OF EYE & HEAD MOVEMENT

2-A-1 ***Body-state modulates head-body coordination in Drosophila courtship pursuit***

Nuno Rito[1], Eugenia Chiappe[1]

[1]Champalimaud Research

2-A-2 ***Perception of time-varying envelopes begins at the single-neuron level in central vestibular pathways: Implications for perception and motor control***

Isabelle Mackrous[1], Jerôme Carriot[1], Kathleen Cullen[2], Maurice Chacron[1]

[1]McGill University, [2]Johns Hopkins University

2-A-3 ***Eye-hand coordination at the frontier between discrete and continuous movements***

Adrien Coudiere[1], Frederic Danion[1]

[1]Université de Poitiers

2-A-4 ***Programming and triggering of catch-up saccades to accelerating targets***

Sydney Doré[1], Jonathan Coutinho[1], Omri Nachmani[1], Emma Brooks[1], Aarlenne Khan[2], Phillipe Lefevre[3], Gunnar Blohm[1]

[1]Queen's University, [2]Université de Montreal, [3]Université catholique de Louvain

2-A-5 ***Eye-head coordination during active head-unrestrained gaze shifts in mice***

Brandie Verdone[1], Dale Roberts[1], Kathleen Cullen[1]

[1]Johns Hopkins University

B – FUNDAMENTALS OF MOTOR CONTROL

2-B-6 *Long-term, stable 2D direct cursor control by neural manifold dynamics*

Elena Losanno[1], Marion Badi[2], Evgenia Roussinova[2], Andrew Bogaard[3], Maude Delacombaz[3], Solaiman Shokur[2], Silvestro Micera[1]

[1]*Scuola Superiore Sant'Anna,* [2]*École Polytechnique Fédérale de Lausanne,* [3]*University of Fribourg*

2-B-7 *Age-related differences in finger kinematics during daily-life hand movements*

Lisa Klemm[1], Avinash Kalyani[1], Stefanie Schreiber[1], Esther Kühn[1], Christoph Reichert*[2], Elena Azañón*[1]

[1]*University Hospital Magdeburg,* [2]*Leibniz Institute for Neurobiology Magdeburg*

2-B-8 *Sensorimotor integration and motor learning during a novel visuomotor task in young adults with Attention-Deficit/Hyperactivity Disorder*

Heather McCracken[1], Bernadette Murphy[1], Ushani Ambalavanar[1], Mahboobeh Zabihhosseinian[1], Paul Yielder[1]

[1]*Ontario Tech University*

2-B-9 *New technology for high-resolution muscle recording during skilled behavior in rodents, songbirds, and primates*

Samuel Sober[1]

[1]*Emory University*

2-B-10 *Motor sequence learning: different effectors, similar processes*

Angèle Métais[1], Youssif Taza[1], Yoann Blache[1], Christian Collet[1], Arnaud Saimpont[1]

[1]*Inter-University Laboratory of Human Movement Science, Claude Bernard University Lyon 1*

2-B-11 *A novel force-constrained non-negative matrix factorization algorithm reveals that muscle synergies are effective in the task space*

Denise Berger[1], Francesco Lacquaniti[1], Andrea d'Avella[1]

[1]*IRCCS Fondazione Santa Lucia*

2-B-12 *Cerebellar thalamocortical interactions during motor preparation*

Hillary Wehry[1], Daisuke Kase[2], Byron Yu[1], Robert Turner[2]

[1]*Carnegie Mellon University,* [2]*University of Pittsburgh*

2-B-13 *A geometric approach to distinguish feedforward planning from feedback control*

Niranjan Chakrabhavi[1], Varadhan SKM[2], Ashitava Ghosal[1], Aditya Murthy[1]

[1]*Indian Institute of Science Bangalore,* [2]*Indian Institute of Technology Madras*

2-B-14 *Tactile suppression stems from specific sensorimotor predictions*

Elena Fuehrer[1], Dimitris Voudouris[1], Alexandra Lezkan[1], Knut Drewing[1], Katja Fiehler[1]

[1]*Justus-Liebig-Universität Gießen Fachbereich 06*

2-B-15 *A simplified framework of motor control*

Kabir Arora[1], Samit Chakrabarty[1]

[1]*University of Leeds*

2-B-16 *Motor cortical activity in a control space predicts muscle state-dependent cortical influence during naturalistic behavior*

Natalie Koh[1], Zhengyu Ma[1], Abhishek Sarup[1], Amy Kristl[1], Mark Agrios[1], Andrew Miri[1]

[1]*Northwestern University*

2-B-17 *Neural integration of movement order and timing occurs during motor sequence execution, but not planning*

Rhys Yewbrey[1], Myrto Mantziara[1], Katja Kornysheva[2]

[1]*Bangor University,* [2]*University Of Birmingham*

2-B-18 *Reorganization of distinct low-frequency and beta networks of neurons underlies different behavioral states and conditions in monkey fronto-parietal cortex*

Benjamin Dann[1], Swathi Sheshadri[1], Hansjörg Scherberger[1]

[1]*German Primate Center*

2-B-20 ***Distinct control processing of finger flexion and extension during dexterous behavior***

Ohad Rajchert[1], Yoel Melul[1], Firas Mawase[1]
[1]*Technion - Israel Institute of Technology*

2-B-21 ***Stimulus-locked muscle responses to visual disturbances are impacted by urgency and certainty to move***

Parsa Balalaie[1], Kayne Park[1], Stephen Scott[1]
[1]*Queen's University*

C – POSTURE AND GAIT

2-C-22 ***Predicting vertical ground reaction forces from 3D accelerometery using reservoir computers leads to accurate gait event detection***

Margit Bach[1], Nadia Dominici[1], Andreas Daffertshofer[1]
[1]*Vrije Universiteit Amsterdam*

2-C-23 ***Postural sway characteristics of professional dance couples - partnering effects***

Justyna Michalska[1], Zaneta Szuplak[1], Anna Kamieniarz[1], Kajetan Slomka[1], Grzegorz Juras[1]
[1]*The Jerzy Kukuczka Academy of Physical Education in Katowice*

2-C-24 ***Cerebellar population recordings during mouse locomotion***

Diogo Duarte[1], Hugo Marques[1], Jorge Ramirez[1], Megan Carey[1]
[1]*Champalimaud Foundation*

2-C-25 ***The influence of anxiety on feedforward locomotor (de)adaptation***

Toby Ellmers[1], Morgan Durkin[1], Karthigan Sriranganathan[1], David Harris[2], Adolfo Bronstein[1]
[1]*Imperial College London,* [2]*University of Exeter*

2-C-26 ***Humans optimize energy and time for point-to-point walking movements***

Elizabeth Carlisle[1], Arthur Kuo[1]
[1]*University of Calgary*

2-C-27 ***Biomimetic stimuli from a vestibular prosthesis improve postural control in a nonhuman primate***

Olivia Leavitt[1], Kathleen Cullen[1]
[1]*Johns Hopkins University*

2-C-28 ***Optogenetic perturbation of distinct cerebellar nuclei differentially affects coordinated locomotion in mice***

Ana Machado[1], Dennis Eckmeier[1], Megan Carey[1]
[1]*Champalimaud Foundation*

D – INTEGRATIVE CONTROL OF MOVEMENT

2-D-29 ***Ocular eccentricity affects subjective visual vertical perception in health and disease***

Catherine Agathos[1], Anca Velisar[1], Natela Shanidze[1]
[1]*Smith-Kettlewell Eye Research Institute*

2-D-30 ***Adaptive eye-hand coordination when manipulating and monitoring the environment in parallel***

Jolande Fooken[1], Roland Johansson[2], John Flanagan[1]
[1]*Queen's University,* [2]*Umea University*

2-D-31 ***Anterolateral motor cortex involvement and cortical network processing in a cued left/right lick motor task in mice***

Dieter Jaeger[1], Eduardo Maristany de las Casas[2], Yunmiao Wang[1], Robert Sachdev[2], Matthew Larkum[2]
[1]*Emory University,* [2]*Humboldt University*

2-D-32 ***Motor control beyond reach - How humans hit a target with a whip***

Aleksei Krotov[1], Marta Russo[2], Moses Nah[3], Neville Hogan[3], Dagmar Sternad[1]
[1]*Northeastern University,* [2]*Tor Vergata University, IRCCS Fondazione Santa Lucia,* [3]*MIT*

2-D-33 ***Neural signatures in the fronto-parietal reach network for planning subsequent reaches in a sequential action selection task***

Laura Hansmeyer[1], Naubahar Agha[1], Attila Trunk[1], Alexander Gail[1]
[1]*German Primate Center*

2-D-34 ***Context coding in the mouse nucleus accumbens modulates motivationally relevant information***

Jimmie Gmaz[1], Matthijs van der Meer[2]
[1]*Imperial College,* [2]*Dartmouth College*

2-D-35 ***Inferring function from information transfer during coordinated eye and arm movements***

Jung Uk Kang[1], Eric Mooshagian[2], Lawrence Snyder[1]

[1]*Washington University at St. Louis Medical Center,* [2]*University of California at San Diego*

E – DISORDERS OF MOTOR CONTROL

2-E-36 ***Postural instability in DYT-TOR1A dystonia dynamically dependent on sensory feedback***

Anna Sadnicka[1], Elena Dennis[2], Kailash Bhatia[3], John Rothwell[2], Joe Galea[4]

[1]*St George's University of London, University College London,* [2]*University College London,* [3]*National Hospital for Neurology and Neurosurgery,* [4]*University of Birmingham*

2-E-37 ***Deep brain stimulation frequency affects evoked potential delay, amplitude, and frequency components***

Jessica Vidmark[1], Estefania Hernandez-Martin[2], Terence Sanger[1]

[1]*University of California, Irvine,* [2]*University of La Laguna*

2-E-39 ***Pallidal beta activity correlates with stimulation-induced bradykinesia in dystonia patients***

Roxanne Lofredi[1], Ute Scheller[1], Aurika Mindermann[1], Joachim Krauss[2], Assel Saryyeva[2], Gerd-Helge Schneider[1], Andrea Kühn[1]

[1]*Charité-Universitätsmedizin Berlin,* [2]*Medizinische Hochschule Hannover*

2-E-40 ***Unilateral and bilateral subthalamic nucleus deep brain stimulation improves motor function while impairing cognitive function during memory-guided reaching***

Yessenia Rivera[1], Quentin Drane[1], Rishabh Arora[1], Miranda Munoz[1], Michael Trevarrow[1], Edgar George[1], Antonio Bear[1], Gian Pal[2], Leonard Verhagan-Metman[3], Sepehr Sani[3], Joshua Rosenow[1], Lisa Chin-Goelz[4], Daniel Corcos[1], Fabian David[1]

[1]*Northwestern University,* [2]*Rutgers University,* [3]*Rush Medical Center,* [4]*University of Illinois Chicago*

2-E-41 ***The effect of age, sex, sport experience, and multiple concussion history on visuomotor performance.***

Shahab Entezami[1], Marc Dalecki[2], Nicole Smeha[1], Jeffrey Brown[3], Andrea Cavaliere[4], Johanna Hurtubise[5], Alison Macpherson[1], Lauren Sergio[1]

[1]*York University,* [2]*Louisianna State University,* [3]*Princess Alexandra Hospital,* [4]*Lifemark Health Group,* [5]*Camosun College*

2-E-42 ***Mechanisms of increased motor output following stimulation of the motor thalamus***

Erinn Grigsby[1], Jonathan Ho[1], Arianna Damiani[1], Lucy Liang[1], Josep-Maria Balaguer[1], Vahagn Karapetyan[1], Peter Gerszten[1], Marco Capogrosso[1], Jorge Gonzalez-Martinez[1], Elvira Pirondini[1]

[1]*University of Pittsburgh*

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

2-F-43 ***Can you imagine? Measures of motor imagery ability are related to the magnitude of corticospinal adaptation following motor imagery training***

Emma Yoxon[1], Molly Brillinger[1], Timothy Welsh[1]

[1]*University of Toronto*

2-F-44 ***Predictive feedback facilitates learning of novel sensorimotor transformations***

Britta Hinneberg[1], Lisa Maurer[1], Heiko Maurer[1], Hermann Müller[1], Mathias Hegele[1]

[1]*Justus Liebig University Gießen*

2-F-45 ***Motor adaptation and plasticity in Parkinson's Disease***

Alex Swainson[1], Kathryn Woodward[1], Mihaela Boca[2], Harry Rolinsky[2], Nadia Cerminara[1], Alan Whone[2], Richard Apps[1], Iain Gilchrist[1]

[1]*University of Bristol,* [2]*North Bristol NHS Trust*

2-F-46 ***Differential changes in early and middle-latency somatosensory evoked potentials and motor performance: Pursuit movement task versus force matching task***

Ushani Ambalavanar[1], Nicholas La Delfa[1], Heather McCracken[1], Mahboobeh Zabihhosseinian[1], Bernadette Murphy[1]

[1]*Ontario Tech University*

2-F-47 *Repetitive Somatosensory Stimulation of a finger affects some metric aspects of its mental representation*

Malika Azaroual[1], Silvia Macchione[1], Luke Miller[2], Eric Koun[3], Roméo Salemme[3], Dollyane Muret[4], Matthew Longo[5], Alessandro Farnè[3]

[1]*Lyon Neuroscience Research Center, ImpAct team / University UCBL Lyon 1,* [2]*Neuroscience Research Center, ImpAct team / University UCBL Lyon 1 / Donders Centre for Cognition of,* [3]*Lyon Neuroscience Research Center, ImpAct team / University UCBL Lyon 1 / Hos*

2-F-48 *Unique and interacting roles of reinforcement-based and error-based processes on exploratory motor behaviour*

Adam Roth[1], Jan Calalo[1], Rakshith Lokesh[1], Seth Sullivan[1], Michael Carter[2], Joshua Cashaback[1]

[1]*University of Delaware,* [2]*McMaster University*

2-F-49 *Modeling user-decoder learning dynamics in co-adaptive myoelectric interfaces*

Maneeshika Madduri[1], Momona Yamagami[1], Augusto Millevolte[1], Si Jia Li[1], Sasha Burckhardt[1], Samuel Burden[1], Amy Orsborn[1]

[1]*University of Washington*

2-F-50 *Humans can quickly and optimally adapt to non-Earth gravity fields locally induced by a robotic exoskeleton*

Dorian Verdel[1], Simon Bastide[1], Franck Geffard[2], Olivier Bruneau[3], Nicolas Vignais[1], Bastien Berret[1]

[1]*EA 4532 Complexité, Innovation, Activités Motrices et Sportives, Université Paris-Saclay,* [2]*Atomic Energy and Alternative Energies Commission (CEA),* [3]*LURPA, ENS Paris-Saclay, Université Paris-Saclay*

2-F-51 *Imaging Purkinje cell complex spikes during locomotor adaptation*

Ana Goncalves[1], Hugo Marques[1], Alessandra Trapani[2], Jorge Ramirez-Buritica[1], Megan Carey[1]

[1]*Champalimaud Foundation,* [2]*Politecnico di Milano*

2-F-52 *Predictive steering: integration of artificial motor signals in self-motion estimation*

Milou van Helvert[1], Luc Selen[1], Robert van Beers[2], Pieter Medendorp[1]

[1]*Radboud University, Donders Institute for Brain, Cognition and Behaviour, Nijmegen, The Netherlands,* [2]*Radboud University, Donders Institute for Brain, Cognition and Behaviour, Nijmegen, The Netherlands*

2-F-53 *Sensory adaptation to visuomotor errors limits motor adaptation*

Nobuhiro Hagura[1], Masaya Hirashima[1]

[1]*NICT*

2-F-54 *Evidence for automatization of temporal sequences through motor training*

Alexandros Karagiorgis[1], Anwesha Das[1], Jörn Diedrichsen[2], Elena Azañón[1], Max-Philipp Stenner[1]

[1]*Otto-von-Guericke Universität Magdeburg,* [2]*Western University*

2-F-55 *The effects of immersive visual cues on adaptation to internal and external errors*

Shanaathanan Modchalingam[1], Bernard Marius 't Hart[1], Denise Henriques[1]

[1]*York University*

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

2-G-56 *Movement primitives of the shoulder-arm in activities of daily living*

Viktorija Dimova-Edeleva[1], Tingli Hu[1], Melissa Zavaglia[1], Elisabeth Jensen[1], Sami Haddadin[1]

[1]*Technical University of Munich*

2-G-57 *Where is the target of our movement?*

Jeroen Smeets[1], Cristina de la Malla[2], Eli Brenner[1]

[1]*Vrije Universiteit Amsterdam,* [2]*Universitat de Barcelona*

2-G-58 *Predicting full-body proprioceptive cortical anatomy and neural coding with topographic autoencoders*

Max Grogan[1], Kyle Blum[2], Lee Miller[2], Aldo Faisal[1]

[1]*Imperial College London,* [2]*Northwestern University*

2-G-59 ***Characterization of head orientation and heading during everyday activity: Implications for modeling.***

Christian Sinnott[1], Peter Hausamann[2], Paul MacNeilage[1]

[1]University of Nevada - Reno, [2]KINEXON

2-G-60 ***An integrated model of muscle dynamics, motor unit recruitment, and energetic cost of movement***

Tim van der Zee[1], Arthur Kuo[1]

[1]University of Calgary

2-G-61 ***Inferring position and velocity control strategies of monkeys and humans in a virtual balancing task***

Mohsen Sadeghi[1], Reza Sharif Razavian[1], Salah Bazzi[1], Raeed Chowdhury[2], Aaron Batista[2], Patrick Loughlin[2], Dagmar Sternad[1]

[1]Northeastern University, [2]University of Pittsburgh

2-G-62 ***The parietofrontal cortical grasping network does not differentiate distinct grips during action observation***

James Goodman[1], Stefan Schaffelhofer[2], Hans Scherberger[3]

[1]Deutsches Primatenzentrum GmbH (German Primate Center), [2]cortEXplore GmbH, [3]Deutsches Primatenzentrum (German Primate Center)

2-G-63 ***Temporal structure of descending activations and their interplay with spinal reflexes in producing arm movements***

Lei Zhang[1], Cora Hummert[1], Gregor Schöner[1]

[1]Ruhr Universität Bochum

2-G-64 ***Context-dependent Sensorimotor Learning by Variational Inference***

Raphael Schween[1], David Franklin[2], Jordan Taylor[3], Nicolas Schweighofer[4], Dominik Endres[5]

[1]Philipps-University Marburg, [2]Technical University Munich, [3]Princeton University, [4]University of Southern California, Los Angeles, [5]Philipps-University, Marburg, Germany

2-G-65 ***Partner representation, action selection and learning in joint coordination: experimental results and computational model***

Cecilia De Vicariis[1], Vittorio Sanguineti[1]

[1]University of Genova

2-G-66 ***Trajectories in speech production: can optimal control markedly shape the intrinsic biomechanical dynamics?***

Ny Rakotomalala[1], Pascal Perrier[2], Pierre Baraduc[3]

[1]Gipsa-lab / University of Grenoble Alpes, [2]Gipsa-lab / Grenoble INP/ University of Grenoble Alpes, [3]Gipsa-lab / CNRS/ University of Grenoble Alpes

2-G-67 ***Neural representations of motor decision-making found to vary across planning strategy subgroups***

Elizabeth Rizor[1], Neil Dundon[1], Dengxian Yang[1], Jaron Colas[1], Viktoriya Babenko[1], Alexandra Stump[1], Scott Grafton[1]

[1]UC Santa Barbara

POSTER SESSION 3

THURSDAY, JULY 28, 2022

A – CONTROL OF EYE & HEAD MOVEMENT

3-A-1 ***Sensory tuning in neuronal movement commands***

Ziad Hafed[1], Amarender Bogadhi[2], Matthias Baumann[1], Anna Denninger[1]

[1]Centre for Integrative Neuroscience, [2]Boehringer Ingelheim Pharma GmbH & Co. KG

3-A-2 ***Coding strategies for representing natural self-motion strongly differ from those used to represent artificial self-motion across ascending vestibular pathways.***

Jerome Carriot[1], Isabelle Mackrous[1], Kathleen Cullen[1], Maurice Chacron[1]

[1]McGill University

3-A-3 ***Co-contraction of extraocular muscles during blinks causes eyeball lifting, retraction and compression. A high-speed MRI study.***

Johannes Kirchner[1], Tamara Watson[2], Jochen Bauer[1], Markus Lappe[1]

[1]University of Muenster, [2]Western Sydney University

3-A-4 ***Prosthesis-evoked eye and head movements are linear beyond the maximum afferent firing rate: implications for vestibular prosthesis dynamic range***

Kantapon Pum Wiboonsaksakul[1], Charles Della Santina[1], Kathleen Cullen[1]

[1]*Johns Hopkins University*

B – FUNDAMENTALS OF MOTOR CONTROL

POSTER CLUSTER: MOTOR CONTROL IN SEQUENTIAL ACTION

(3-B-5 to 3-B-7)

3-B-5 ***Repetition effects in extrinsic and intrinsic coordinates reveal shared representations of movement sequences across the two hands***

Mahdiyar Shahbazi[1], Giacomo Ariani[1], Andrew Pruszynski[1], Jörn Diedrichsen[1]

[1]*University of Western Ontario*

3-B-6 ***Distinct cortical areas for planning sequences before and during movement***

Giacomo Ariani[1], Mahdiyar Shahbazi[1], Jörn Diedrichsen[1]

[1]*Western University*

3-B-7 ***Planning multiple future actions in sequential reaching***

Mehrdad Kashefi[1], Giacomo Ariani[1], Jörn Diedrichsen[1], Andrew Pruszynski[1]

[1]*Western University*

3-B-8 ***Co-contraction and force generation are driven by separate synaptic inputs***

Daniele Borzelli[1], Taian Vieira[2], Alberto Botter[2], Marco Gazzoni[2], Francesco Lacquaniti[3], Andrea d'Avella[1]

[1]*University of Messina,* [2]*Politecnico di Torino,* [3]*University of Rome Tor Vergata*

3-B-9 ***Anticipatory force control for skilled manipulation of objects at variable contact points depend on visual feedback at grasp contact***

Joshua Bland[1], Marco Davare[2], Michelle Marneweck[1]

[1]*University of Oregon,* [2]*King's College London*

3-B-10 ***Restoring optimal motor sequence learning using brain stimulation***

Pablo Maceira Elvira[1]

[1]*EPFL*

3-B-11 ***Data-driven discovery of motor control circuits of locomotion on variable terrains***

Adam Gosztolai[1], Auke Ijspeert[1], Pavan Ramdya[1]

[1]*EPFL*

3-B-12 ***Taskload, workload and biomechanical criteria in movement control***

Kelly Steiner[1], Nicolas Lantos[1], Bruno Berberian[1], Christian Schulte[1], Thomas Rakotomamonjy[1], Nicolas Pélegrin[1], Sinan Haliyo[2], Jean-Christophe Sarrazin[1]

[1]*Processing and Systems, ONERA, Base Aérienne 701, Salon de Provence, France;,* [2]*ISIR, Université Pierre et Marie Curie, Paris VI ? CNRS, Paris, France*

3-B-13 ***Scalpels, skillets, and sports - What skilled motor behaviour actually looks like in the real-world***

Amr Nimer[1], J. Alex Harston[1], Dipankar Nandi[1], Aldo Faisal[1]

[1]*Imperial College London*

3-B-14 ***JARVIS: A toolbox for highly accurate 3D markerless pose estimation under heavy occlusion***

Timo Hüser[1], Swathi Sheshadri[1], Matthias Dörge[1], Frank Ohl[2], Michael Lippert[2], Hansjörg Scherberger[1], Benjamin Dann[1]

[1]*German Primate Center,* [2]*Leibniz Institute for Neurobiology*

3-B-15 ***Individual and dyadic learning with a Body-Machine Interface***

Amy Bellitto[1], Maura Casadio[1], Ferdinando Mussa-Ivaldi[2], Camilla Pierella[1]

[1]*University of Genoa,* [2]*Northwestern University and Shirley Ryan Ability Lab*

3-B-16 ***Sensorimotor predictions are dynamically modulated over the time-course of actions to attenuate the expected self-touch***

Noa Cemeljic[1], Xavier Job[1], Konstantina Kilteni[1]

[1]*Karolinska Institutet*

3-B-17 ***Pallidal neurons in a vocal motor basal ganglia nucleus reflect motor sequencing***

Alynda Wood[1], Raveena Chhibber[1], Samuel Sober[1]

[1]*Emory University*

3-B-18 ***Increased visual feedback contribution to online corrections during faster movements***

Anne Hoffmann[1], Frédéric Crevecoeur[1]

[1]*Université Catholique de Louvain-la-Neuve*

3-B-19 ***Reciprocal inhibition in spinal ipsilateral circuits***

Martha Bagnall[1], Mohini Sengupta[1]

[1]*Washington University*

3-B-20 ***Mental rotation strategies applied during sensorimotor learning incur a distinct cognitive effort cost***

Olivia Kim[1], Carlos Velásquez-Vargas[1], Jordan Taylor[1]

[1]*Princeton University*

3-B-21 ***A tripartite motor control strategy governing goal-directed reaching in Drosophila***

Pembe Gizem Ozdil[1], Auke Ijspeert[1], Pavan Ramdya[1]

[1]*École Polytechnique Fédérale de Lausanne (EPFL)*

3-B-22 ***Comparing cortical somatosensory and motor influences on visuo-proprioceptive realignment in the hand***

Reshma Babu[1], Manasi Wali[1], Trevor Lee-Miller[1], Hannah Block[1]

[1]*Indiana University Bloomington*

3-B-23 ***The influence of intersegmental dynamics on limb position sense***

Peyman Heidari[1], Natalia Mangos[1], Olivier Codol[1], Andrew Pruszynski[1], Paul Gribble[1]

[1]*Western University*

C – POSTURE AND GAIT

3-C-24 ***Older adults can maintain gait stability when dual tasking***

Eleni Patelaki[1], John Foxe[1], Edward Freedman[1]

[1]*University of Rochester*

3-C-25 ***Express visuomotor responses in hip abductor muscles: Evidence for an intricate relationship between fast stepping and postural control***

Lucas Billen[1], Brian Corneil[2], Vivian Weerdesteyn[1]

[1]*Donders Institute, Radboud University Medical Center,* [2]*Western University*

3-C-26 ***Humans plan optimal, multi-step control sequences for walking on uneven terrain***

Osman Darici[1], Arthur Kuo[1]

[1]*University of Calgary*

3-C-27 ***Mapping step-to-step exploration and energetic cost to comprehend human locomotor adaptation***

Inseung Kang[1], Nidhi Seethapathi[1]

[1]*Massachusetts Institute of Technology*

3-C-28 ***Common sensory information encoding balance error drives evoked cortical and muscle activity during reactive balance***

Scott Boebinger[1], Aiden Payne[2], Nina Ghosn[3], Jasmine Mirdamadi[4], Giovanni Martino[1], Michael Borich[4], Lena Ting[1]

[1]*Georgia Tech and Emory University,* [2]*Florida State University,* [3]*University of Pennsylvania,* [4]*Emory University*

3-C-29 ***Age-related EMG power spectrum changes in leg muscles during walking is not reflected in altered repeatability of gait cycle EMG profiles***

Naveed E Saba[1], Lisa Alcock[1], Mat Elameer[1], Rishad Shafik[1], Annette Pantall[1]

[1]*Newcastle University*

3-C-30 ***Modeling and simulations of muscle contracture observed during crouch gait in cerebral palsy patients***

Andrea Di Russo[1], Louise Placidet[1], Stephane Armand[2], Auke Ijspeert[1]

[1]*École polytechnique fédérale de Lausanne,* [2]*University Hospital of Geneva*

3-C-31 *Motor unit coordination during skilled behavior in mice*

Matthew Williams[1], Kyle Thomas[1], Bryce Chung[1], Muneeb Zia[2], Alexander Keim[3], Eiman Azim[4], Muhannad Bakir[2], Sam Sober[1]

[1]Emory University, [2]Georgia Institute of Technology, [3]University of California San Diego, [4]The Salk Institute

D – INTEGRATIVE CONTROL OF MOVEMENT

3-D-32 *Purkinje cell ablation reduces the flexibility of reach trajectories*

Teresa Serradas Duarte[1], Daniel Nunes[1], John Krakauer[2], Joseph Paton[1], Megan Carey[1]

[1]Champalimaud Foundation, [2]Johns Hopkins University

3-D-33 *Hasty sensorimotor decisions rely on an overlap of broad and selective changes in motor activity*

Gerard Derosiere[1], David Thura[2], Paul Cisek[3], Julie Duque[1]

[1]Catholic University of Louvain, [2]Lyon Neuroscience Research Center, [3]University of Montreal

3-D-34 *Exploring the relationship between sensory information, tactile perception, and action; a TMS study*

Yumna Ali[1], Veronica Montani[1], Paola Cesari[1]

[1]University of Verona, Italy.

3-D-35 *Optimization of postural accuracy and effort results in anticipatory postural adjustments (APAs) that precede limb movement*

Daniel Tanis[1], Jan Calalo[2], Joshua Cashaback[2], Isaac Kurtzer[1]

[1]New York Institute of Technology, [2]University of Delaware

3-D-36 *Proprioceptive sensory attenuation in area 3a during voluntary movement in macaque*

Satomi Kikuta[1], Shinji Kubota[1], Joachim Confais[1], Tomomichi Oya[2], Amit Yaron[3], Kazuhiko Seki[1]

[1]National Institute of Neuroscience, National Center of Neurology and Psychiatry, [2]Western University, [3]The University of Tokyo, Institutes for Advanced Study

3-D-37 *Examining optimal integration of vision and proprioception during target localization*

Trevor Lee-Miller[1], Kathryn Bonnen[1], Hannah Block[1]

[1]Indiana University

E – DISORDERS OF MOTOR CONTROL

3-E-38 *Despite cognitive impairments, stroke survivors do not show deterioration in adaptation savings and explicit learning compared to age-matched controls*

Reut Binyamin Netser[1], Noy Goldhamer[2], Inbar Avni[1], Adva Ressel Zviely[2], Lior Shmoelof[1]

[1]Ben Gurion University of the Negev and The Translational Neurorehabilitation Lab at Adi Negev Nahala, [2]The Translational Neurorehabilitation Lab at Adi Negev Nahalat Eran

3-E-39 *National Center for Medical Rehabilitation Research, National Institutes of Health*

Maria Nurminskaya[1]

[1]NIH

3-E-40 *Digital fingerprints of human movements that enable high-resolution patient-by-patient neuromotor disease progression prediction*

Balasundaram Kadirvelu[1], Valeria Ricotti[2], Victoria Selby[2], Richard Festenstein[1], Eugenio Mercuri[3], Thomas Voit[2], Aldo Faisal[4]

[1]Imperial College London, [2]NIHR Great Ormond Street Hospital Biomedical Research Centre/UCL Great Ormond Street Institute of Ch, [3]Universita Cattolica del Sacro Cuore, Policlinico A. Gemelli University Hospital, [4]Brain & Behaviour Lab, Imperial College L

3-E-41 *Medication adversely impacts visually guided eye movements in Parkinson's disease*

Miranda Munoz[1], James Reilly[2], Gian Pal[3], Leo Verhagen Metman[4], Yessenia Rivera[1], Quentin Drane[1], Daniel Corcos[1], Fabian David[1], Lisa Goelz[5]

[1]Northwestern University, [2]Northwestern University Feinberg School of Medicine, [3]Rutgers University, [4]Rush University Medical Center, [5]University of Illinois at Chicago

3-E-42 ***Different time course of recovery in reaching and grasping movement after reproducible cortical infarction in non-human primate***

Yosuke Saga[1], Moeko Kudo[1], Masashi Koizumi[1], Tatsuya Umeda[2], Kazuhiko Seki[1]

[1]National Institute of Neuroscience, National Center of Neurology and Psychiatry, [2]Kyoto University

3-E-43 ***Differences in resting-state functional connectivity underlie visuomotor task performance declines in older adults with a genetic (APOE e4) risk for Alzheimer's disease***

Alica Rogojin[1], Diana Gorbet[1], Kara Hawkins[1], Lauren Sergio[1]

[1]York University

3-E-44 ***Assessing finger individuation impairments in children with cerebral palsy***

Brooklyn Crabtree[1], Owais Ahmed Khan[1], De'Yana Hines[1], Cydney Barnes[1], Christopher Modlesky[1], Jing Xu[1]

[1]University of Georgia

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

3-F-45 ***Interference between competing motor memories occurs when they are implicitly, but not explicitly, acquired***

Aarohi Pathak[1], Adarsh Kumar[2], Tim Welsh[1], Pratik Mutha[2]

[1]University of Toronto, [2]Indian Institute of Technology Gandhinagar

3-F-46 ***An intention-based strategy for grasping prosthesis***

Andres Agudelo-Toro[1], Jonathan Michaels[2], Wei-An Sheng[3], Hansjörg Scherberger[4]

[1]German Primate Center, [2]Western University, [3]Institut des Sciences Cognitives Marc Jeannerod, [4]University of Göttingen

3-F-47 ***Cerebellar function for recalibrating visual space, motor space and internal movement predictions***

Jana Masselink[1], Alexis Cheviet[2], Denis Pélisson[2], Markus Lappe[1]

[1]University of Muenster, [2]University Claude Bernard Lyon 1

3-F-48 ***Nociception impedes grasping recovery in the spinal cord injured rat***

John Walker[1], Taegyo Kim[1], Simon Giszter[1], Megan Detloff[1]

[1]Drexel University College of Medicine

3-F-49 ***Transcranial direct current stimulation over motor cortex or prefrontal cortex both facilitate balance training***

Hadis Imani[1], Ben Godde[1]

[1]Jacobs University Bremen

3-F-50 ***The influence of conscious awareness on compensating for a visuo-proprioceptive mismatch***

Anna Hsiao[1], Hannah Block[1]

[1]Indiana University Bloomington

3-F-51 ***Implicit and explicit adaptation just don't add up***

Bernard 't Hart[1], Urooj Taqvi[2], Raphael Gastrock[1], Jennifer Ruttle[1], Shanaathanan Modchalingam[1], Denise Henriques[1]

[1]York University, [2]University of Waterloo

3-F-52 ***Dynamic arbitration between model-based and model-robust control in human reaching movements***

Hari Kalidindi[1], Frédéric Crevecoeur[1]

[1]Universite Catholique de Louvain, Belgium

3-F-53 ***The P300 event-related potential as a biomarker of sensorimotor memory updating during an object lifting task in which surface material changes.***

Jamie Scholl[1], Kelene Fercho[2], Lee Baugh[1]

[1]University of South Dakota, [2]Federal Aviation Administration

3-F-54 ***How autonomous is the rapid wakeful consolidation of a motor skill?***

Anwesha Das[1], Alexandros Karagiorgis[1], Jörn Diedrichsen[2], Elena Azanon[1], Max-Philipp Stenner[1]

[1]Leibniz Institute for Neurobiology/ Otto von Guericke University Magdeburg, [2]Brain Mind Institute/ University of Western Ontario

3-F-55 *Physical practice and observation induce similarly stable adaptation of limb dynamics*

Natalia Mangos[1], Christopher Forgaard[1], Paul Gribble[1]

[1]Western University

3-F-56 *Cerebellar inactivation increases internal noise and impairs motor adaptation*

Sharon Israely[1], Jonathan Kadmon[1], Firas Mawase[2], Yifat Prut[1]

[1]The Hebrew University, [2]Technion - Israel Institute of Technology

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

3-G-56 *Inter-individual variability in strategies for muscular null space control*

Sergio Gurgone[1], Daniele Borzelli[1], Paolo De Pasquale[1], Denise Berger[2], Andrea D'Avella[1]

[1]University of Messina, [2]IRCCS Fondazione Santa Lucia

3-G-57 *Influence of implicit and explicit feedback response to a visual error on visuomotor learning response*

Yuto Makino[1], keisyu Inoue[1], Toshiki Kobayashi[1], Daichi Nozaki[1]

[1]The University of Tokyo

3-G-58 *High-performance kinematic decoding and neural-state estimation that leverages general properties of motor-cortex population geometry*

Sean Perkins[1], Karen Schroeder[1], John Cunningham[1], Qi Wang[1], Mark Churchland[1]

[1]Columbia University

3-G-59 *Intentional and conflict-resolution components of movement: an active inference account for the motor control of embodied virtual limbs*

Antonella Maselli[1], Pablo Lanillos Pradas[2], Mar Gonzales Franco[3], Giovanni Pezzulo[1]

[1]CNR, [2]Radboud University, [3]Microsoft

3-G-60 *The art of neuroscience; two legs to stand on!*

Von Homer[1]

[1]Delaware State University

3-G-61 *Effects of training variability on the use of flexible sensorimotor mappings*

Carlos Velazquez[1], Jordan Taylor[1]

[1]Princeton University

3-G-62 *MotorNet: a Python toolbox for controlling biomechanical effectors with deep learning*

Olivier Codol[1], Jonathan Michaels[1], Mehrdad Kashefi[1], Andrew Pruszynski[1], Paul Gribble[1]

[1]University of Western Ontario

3-G-63 *Investigating the role of peripersonal space representation in contact-value visuomotor behaviour*

Aoife Fitzpatrick[1], Rory Bufacchi[1], Francesca Lanzarini[2], Davide Albertini[2], Monica Maranesi[2], Giacomo Novembre[1], Luca Bonini[2], Giandomenico Iannetti[1]

[1]Italian Institute of Technology, [2]University of Parma

3-G-64 *Neural code for online corrections to the center-out reaching movements: is it on the manifold?*

Nina Kudryashova[1], Matthew Perich[2], Lee Miller[3], Matthias Hennig[1]

[1]University of Edinburgh, [2]Université de Montréal and Mila, [3]Feinberg School of Medicine Northwestern

3-G-65 *Integration of corticospinal and proprioceptive EPSPs in motoneurons during electrical stimulation of the spinal cord*

Josep-Maria Balaguer[1], Genis Prat-Ortega[1], Lucy Liang[1], Jonathan Ho[1], Erinn Grigsby[1], Vahagn Karapetyan[1], Amr Manhaus[2], CJ Heckman[2], David Bennett[3], Jorge Gonzalez-Martinez[4], Peter Gerszten[4], Elvira Pirondini[1], Marco Capogrosso[1]

[1]University of Pittsburgh, [2]Northwstern University, [3]University of Alberta, [4]University of Pittsburgh Medical Center

3-G-66 *Long-term motor learning creates structure within neural activity space that shapes subsequent adaptation*

Joanna Chang[1], Matthew Perich[2], Lee Miller[3], Juan Gallego[1], Claudia Clopath[1]

[1]Imperial College London, [2]Université de Montréal, [3]Northwestern University

3-G-67 *Effects of semantic priming on involuntary imagery in the reflexive imagery task*

Alejandro Heredia Cedillo[1], Ezequiel Morsella[2], Mark Geisler[1]

[1]San Francisco State University, [2]San Francisco State University; University of California, San Francisco

POSTER SESSION 4

FRIDAY, JULY 29, 2022

B – FUNDAMENTALS OF MOTOR CONTROL

4-B-1 *Direction and history-dependent learning and generalization of human finger dexterity*

Ohad Rajchert[1], Gili Kamara[1], Yoel Melul[1], Firas Mawase[1]

[1]Technion - Israel Institute of Technology

4-B-2 *3D pose estimation enables virtual head-fixation in freely moving rats*

Artur Schneider[1], Christian Zimmermann[1], Thomas Brox[1], Ilka Diester[1]

[1]University Freiburg

4-B-3 *Generalization reveals asymmetric and history-dependent control networks for multi-finger dexterous movements*

Gili Kamara[1], Ohad Rajchert[1], Firas Mawase[1]

[1]Technion

4-B-4 *Evoked-movement biases in human cortex reflects execution history, not plan-based prediction of upcoming actions*

Abed Suleiman[1], Deborah Solomonow-Avnon[1], Firas Mawase[1]

[1]Technion- Israel Institute of Technology

4-B-5 *Spectral power fluctuations in the parietal cortex during real world table tennis*

Amanda Studnicki[1], Daniel Ferris[1]

[1]University of Florida

4-B-6 *The vigor of feedback control scales with the uncertainty of physical disturbances during goal-directed reaching movements*

Philipp Maurus[1], Kuira Jackson[1], Frédéric Crevecoeur[2], Joshua Cashaback[3], Tyler Cluff[1]

[1]University of Calgary, [2]Université catholique de Louvain, [3]University of Delaware

4-B-7 *Cerebellar internal models accurately detect errors introduced by small disturbances with a marked transition in encoding*

Omid Zobeiri[1], Robyn Mildren[2], Kathleen Cullen[2]

[1]McGill University, [2]Johns Hopkins University

4-B-8 *Greater muscular co-contraction but no changes in visuomotor feedback gains in response to visually amplified movement variability*

Jan Calalo[1], Rakshith Lokesh[1], Adam Roth[2], Seth Sullivan[1], Jeremy Wong[3], Jennifer Semrau[1], Joshua Cashaback[2]

[1]University of Delaware, [2]Univerisity of Delaware, [3]University of Calgary

4-B-9 *Corticomuscular coherence reflects evidence accumulation in perceptual decision making*

Yvonne Visser[1], Pieter Medendorp[1], Luc Selen[1]

[1]Radboud University, Donders Institute

4-B-10 *Corticomuscular coherence reveals engagement of different cortical regions in transient and sustained phases of an isometric motor task*

Saroj Bista[1], Amina Coffey[1], Matthew Mitchell[1], Antonio Fasano[2], Stefan Dukic[1], Teresa Buxo[1], Lara McManus[1], Mark Heverin[1], Muthuraman Muthuraman[3], Orla Hardiman[1], Bahman Nasseroleslami[1]

[1]School of medicine, Trinity College Dublin, [2]University of Modena and Reggio Emilia, [3]Johannes-Gutenberg-University Hospital

4-B-11 ***A new view on the spinal network mechanisms underlying rhythmic movements***

Rune Berg[1]

[1]*University of Copenhagen*

4-B-12 ***Enhanced efficiency of online motor corrections towards the body midline as revealed by redirected reaching actions***

Antonella Maselli[1], Eyal Ofek[1], Brian Cohn[2], Ken Hinckley[1], Mar Gonzalez Franco[1]

[1]*Microsoft Research,* [2]*University of Southern California*

4-B-13 ***Anticipatory and compensatory control modulation in a virtual catching task***

Ana Gómez-Granados[1], Tarkeshwar Singh[2], Deborah Barany[1]

[1]*University of Georgia,* [2]*The Pennsylvania State University*

4-B-14 ***Cortical control of individual fingers and finger combinations***

Brian Dekleva[1], Nathan Brantly[1], Anton Sobinov[2], Sliman Bensmaia[2], Jennifer Collinger[1]

[1]*University of Pittsburgh,* [2]*University of Chicago*

4-B-15 ***Complexity and high-dimensionality of motor cortex activity during a simple task***

Elom Amematsro[1], Najja Marshall[1], Eric Trautmann[1], Larry Abbott[1], Mark Churchland[1]

[1]*Columbia University*

4-B-16 ***Flexible multielectrode array for high-resolution motor unit recording during skilled behavior in rodents, songbirds, and primates***

Bryce Chung[1], Muneeb Zia[2], Kyle Thomas[1], Jonathan Michaels[3], Matt Williams[1], Kailash Nagapudi[1], Andrews Pruszynski[3], Muhannad Bakir[2], Samuel Sober[1]

[1]*Emory University,* [2]*Georgia Institute of Technology,* [3]*Western University*

4-B-17 ***At-home characterization of kinematic synergies supporting procedural skill learning***

William Kistler[1], Leonardo Cohen[2], Ethan Buch[1], Sven Bestmann[1], Rawan Fakhrenddine[3], Giselle Rodriguez[2], Margaret Hayward[2]

[1]*University College London / Institute of Neurology,* [2]*National Institutes of Health,* [3]*University of Texas*

C – POSTURE AND GAIT

4-C-18 ***Stiff with age: reduced proactive and reactive cognitive flexibility in older adults underlies dual-task walking performance costs***

David Richardson[1], John Foxe[1], Edward Freedman[1]

[1]*University of Rochester School of Medicine and Dentistry*

4-C-19 ***Gaze behaviors during macaque locomotion in the presence or absence of vestibular function***

Oliver Stanley[1], Ruihan Wei[1], Kathleen Cullen[1]

[1]*Johns Hopkins University*

4-C-20 ***Influence of trunk support and development on the evolution of spontaneous upper extremity behaviors in infants***

Sandra Saavedra[1], Adam Goodworth[2], Jesse Quarum[2], Emily Bowns[3]

[1]*University of Hartford,* [2]*Westmont,* [3]*University of Michigan*

4-C-21 ***The role of auditory and tactile noise in the control of upright posture***

Samuel Carey[1]

[1]*University of California Merced*

4-C-22 ***Tail motoneurons are targeted by vestibular complex axons in mice***

Salvatore Lacava[1], Marylka Uusisaari[1]

[1]*OIST*

4-C-23 ***Brain correlates mediating postural control of balance in traumatic brain injury: a systematic review***

Zaeem Hadi[1], Mohammad Mahmud[1], Matteo Ciocca[1], Abdel Rahman Saad[1], Barry Seemungal[1]

[1]*Imperial College London*

4-C-24 *Postural adaptation to allocentric task demands in a modified basketball paradigm*

Neil Dundon[1], Thomas Bullock[1], Jordan Garrett[1], Alex Stuber[1], Amanda McCandless[1], Jeanette Espinoza[1], Barry Giesbrecht[1], Scott Grafton[1]

[1]*University of California, Santa Barbara*

4-C-25 *The complexity of plantar pressure distributions during balance and locomotion tasks*

Luke Cleland[1], Holly Rowland[1], Claudia Mazzà[1], Hannes Saal[1]

[1]*University of Sheffield*

D – INTEGRATIVE CONTROL OF MOVEMENT

4-D-26 *Frontoparietal involvement in online updating of reach-to-grasp to mechanical perturbations of hand transport: A TMS study*

Mariusz Furmanek[1], Luis Schettino[2], Madhur Mangalam[1], Kyle Lockwood[1], Sergei Adamovich[1], Mathew Yarossi[1], Eugene Tunik[1]

[1]*Northeastern University,* [2]*Lafayette College*

4-D-27 *Novel contralateral monosynaptic stretch reflexes in the trunk - physiology and anatomy*

Kendall Schmidt[1], Simon Giszter[1]

[1]*Drexel University*

4-D-28 *Sensorimotor feedback loops are selectively sensitive to reward*

Olivier Codol[1], Mehrdad Kashefi[1], Christopher Forgaard[1], Joseph Galea[2], Andrew Pruszynski[1], Paul Gribble[1]

[1]*University of Western Ontario,* [2]*University of Birmingham*

4-D-29 *Expectation and attention influence early somatosensory processing in the human spinal cord*

Max-Philipp Stenner[1], Mohammed Istiaque Amin[2], Cindy Marquez[2], Izel Avci[2], Fabio Dukagjini[2], Elena Azanon Gracia[2], Martin Eimer[3], Lars Büntjen[2], Matthias Deliano[4]

[1]*Otto-von-Guericke-University Magdeburg/Leibniz Institute for Neurobiology,* [2]*Otto-von-Guericke-University Magdeburg,* [3]*Birkbeck, University of London,* [4]*Leibniz Institute for Neurobiology*

4-D-30 *Shared neural population dynamics across animals performing the same behaviour*

Mostafa Safaie[1], Junchol Park[2], Joanna Chang[1], Lee Miller[3], Joshua Dudman[2], Matthew Perich[4], Juan Gallego[1]

[1]*Imperial College London,* [2]*Janelia Research Campus,* [3]*Northwestern University,* [4]*Université de Montréal*

4-D-31 *Uncertainty differentially shapes premotor and primary motor activity during movement planning*

Bence Bagi[1], Brian Dekleva[2], Lee Miller[3], Juan Gallego[1]

[1]*Imperial College London,* [2]*University of Pittsburgh,* [3]*Northwestern University*

E – DISORDERS OF MOTOR CONTROL

4-E-32 *Connectivity indexes predict the motor improvements in secondary dystonia*

Sumiko Abe[1], Estefania Hernandez-Martin[2], Terence Sanger[1]

[1]*University of California Irvine,* [2]*Universidad de La Laguna*

4-E-33 *Ageing affects similarly the sense of force in wrist flexors and ankle plantar flexors*

Mélanie Henry[1], Alp Esrefoglu[1], Jacques Duchateau[1], Stéphane Baudry[1]

[1]*Laboratory of Applied Biology, Reseach Unit in Applied Neurophysiology (Université libre de Bruxelle*

4-E-34 ***Signatures of motor learning of trunk posture in moderate-to-severe cerebral palsy***

Sandra Saavedra[1], Adam Goodworth[2], Jonny Reitinger[2]
[1]University of Hartford, [2]Westmont College

4-E-35 ***Myoelectric interface conditioning in chronic stroke survivors leads to targeted reduction in abnormal co-activation and improved arm function***

Marc Slutzky[1], Abed Khorasani[1], Vivek Paul[1], Na-Teng Hung[1], Gang Seo[2], Jinsook Roh[2], Prashanth Prakash[1], Ameen Kishta[1], Joel Hulsizer[1]
[1]Northwestern University, [2]University of Houston

4-E-36 ***Cerebellar output to the motor cortex facilitates the control for interaction torques during reaching movements***

Nirvik Sinha[1], Sharon Israely[2], Julius PA Dewald[1], Yifat Prut[2]
[1]Northwestern University, [2]Hebrew University

4-E-37 ***Long-latency feedback responses preserved in Essential Tremor patients***

Florence Blondiaux[1], Louisien Lebrun[1], Lise Colmant[1], Bernard Hanseeuw[1], Frédéric Crevecoeur[1]
[1]UCLouvain

4-E-38 ***Binocular coordination of horizontal saccades in mTBI and cerebellar dysfunction***

John Anderson[1]
[1]Minneapolis VA Health Care System - University of Minnesota

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

4-F-39 ***Transfer of visuomotor adaptation from mouse pointing to first-person shooter games***

Matthew Warburton[1], Carlo Campagnoli[1], Mark Mon-Williams[1], Faisal Mushtaq[1], J. Ryan Morehead[1]
[1]University of Leeds

4-F-40 ***Visuomotor rotation learning in a real world task using Embodied Virtual Reality***

Federico Nardi[1], Mabel Ziman[1], A Aldo Faisal[1], Shlomi Haar[1]
[1]Imperial College London

4-F-41 ***The influence of experience on cerebellar-dependent sensorimotor learning***

Tianhe Wang[1], Richard Ivry[1]
[1]University of California Berkeley

4-F-42 ***Toddlers' motor learning ability assessed: Adaptation to Coriolis forces in reaching***

Janny Stapel[1], Gustaf Gredebäck[1], Pieter Medendorp[2]
[1]Uppsala University, [2]Radboud University Nijmegen

4-F-44 ***Daily artificial gravity is associated with reduced brain activity during sensorimotor adaptation***

Grant Tays[1], Kathleen Hupfeld[1], Heather McGregor[1], Jessica Lee[2], Nichole Beltran[3], Edwin Mulder[2], Yiri De Dios[3], Scott Wood[4], Jacob Bloomberg[4], Rachael Seidler[1]
[1]University of Florida, [2]DLR, [3]KBR, [4]NASA

4-F-45 ***Similar oscillatory mechanisms map touch on hands and tools***

Cécile Fabio[1], Roméo Salemme[1], Alessandro Farnè[1], Luke Miller[2]
[1]Inserm, [2]Radboud University

4-F-46 ***Interference of motor memories***

Guy Avraham[1], Richard Ivry[1]
[1]University of California, Berkeley

4-F-47 ***Understanding strategic aiming by measuring it in isolation***

Max O Townsend[1], Mark Mon-Williams[1], Faisal Mushtaq[1], Ryan Morehead[1]
[1]University of Leeds

4-F-49 ***Interhemispheric balancing of M1 excitability through BCI-based neurofeedback***

Masaaki Hayashi[1], Kohei Okuyama[2], Nobuaki Mizuguchi[3], Ryotaro Hirose[1], Taisuke Okamoto[1], Michiyuki Kawakami[2], Junichi Ushiba[1]

[1]Keio University, [2]School of Medicine, Keio University, [3]Ritsumeikan University

4-F-50 ***Force synergies with and across the two hands in bimanual skill acquisition***

Kunpeng Yao[1], Caroline Savio[1]

[1]Ecole Polytechnique Fédérale de Lausanne

4-F-51 ***Accumulated uncertainty about the task during a task break slows the immediate movement down***

Atsushi Yokoi[1]

[1]National Institute of Information and Communications Technology

4-F-52 ***Effects of viral BDNF, alone or in combination with epidural stimulation, on locomotion and spinal inhibitory RORb interneurons after complete SCI in mouse.***

Nicholas Stachowski[1], Lihua Yao[1], Sebastian Atoche[1], Simon Giszter[1], Kimberly Dougherty[1]

[1]Drexel University College of Medicine

4-F-53 ***Difference between explicit and implicit motor learning during force field arm reaching task***

Tjasa Kunavar[1], Jan Babic;[1]

[1]Jozef Stefan Institute

4-F-54 ***Can the somatosensory system integrate a tactile model for an extra robotic body part?***

Lucy Dowdall[1], Giulia Dominijanni[2], Dani Clode[3], Tamar Makin[3]

[1]UCL, [2]EPFL, [3]University of Cambridge

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

4-G-56 ***Torque-muscular synergies extracted by the mixed-matrix factorization algorithm capture the functional characteristics of motor modules***

Marta Russo[1], Alessandro Scano[2], Andrea d'Avella[3]

[1]Fondazione Santa Lucia, [2]Italian National Research Council (CNR), [3]University of Messina

4-G-57 ***A unified mathematical model for locomotor learning across timescales***

Nidhi Seethapathi[1], Manoj Srinivasan[2]

[1]Massachusetts Institute of Technology, [2]The Ohio State University

4-G-58 ***Haptic communication improves dyadic collaboration in complex object manipulation tasks***

Yiming Liu[1], Raz Leib[1], William Dudley[2], Ali Shafti[2], Aldo Faisal[3], David Franklin[4]

[1]Technical University of Munich, [2]Imperial College London, [3]Imperial College London & University of Bayreuth, [4]TUM

4-G-59 ***Trajectories and durations of human reaching movements are explained by the minimization of time and energy***

Jeremy Wong[1], William Herspiegel[1], Art Kuo[1]

[1]University of Calgary

4-G-60 ***Body mechanics, optimality, and sensory feedback in the human control of complex objects***

Reza Sharif Razavian[1], Mohsen Sadeghi[1], Salah Bazzi[1], Rashida Nayeem[1], Dagmar Sternad[1]

[1]Northeastern University

4-G-61 ***Simultaneous yet separable population encoding of arm movement direction and kinematics in motor cortex***

Andrea Colins Rodriguez[1], Mark Humphries[1]

[1]University of Nottingham

4-G-62 ***Local field potentials reflect cortical population dynamics in a region-specific and frequency-dependent manner***

Cecilia Gallego-Carracedo[1], Matthew Perich[2], Raeed Chowdhury[3], Lee Miller[4], Juan Gallego[1]

[1]Imperial College London, [2]Université de Montréal, [3]University of Pittsburgh, [4]Northwestern University

4-G-63 ***Deep reinforcement learning mimics neural strategies for limb movements***

Muhammad Noman Almani[1], Shreya Saxena[1]

[1]*University of Florida*

4-G-64 ***Motor control can guide learning through feedback-driven plasticity***

Barbara Feulner[1], Matthew Perich[2], Lee Miller[3], Claudia Clopath[1], Juan Gallego[1]

[1]*Imperial College London,* [2]*Université de Montreal,* [3]*Northwestern University*

4-G-65 ***Finger individuation introduces extra motor plan noises in fine finger control that affects trajectory smoothness***

Jing Xu[1], Timothy Ma[2], Sapna Kumar[3], Kevin Olds[4], Jeremy Brown[4], Jaccob Carducci[4], John Krakauer[4]

[1]*University of Georgia,* [2]*National Institute of Health,* [3]*Moss Rehabilitation,* [4]*Johns Hopkins University*

Satellite Posters

SP1.1 ***Discharge properties of neurons in the 8th nerve, vestibular nucleus and abducens nucleus may explain suboptimal VOR characteristics in response to neuroprosthetic stimulation.***

James Phillips[1], Leo Ling[1], Christopher Phillips[2], Amy Nowack[1], Yoshiko Kojima[1], Jay Rubinstein[1], Shawn Newlands[3]

[1]*University of Washington,* [2]*University of California Davis,* [3]*University of Rochester*

SP1.2 ***Binocular coordination of horizontal saccades in mTBI and cerebellar dysfunction***

John Anderson[1]

[1]*Minneapolis VA Health Care System - University of Minnesota*

SP1.3 ***Information transmission in the cerebellum: the role of rate and synchrony during smooth pursuit***

David Herzfeld[1], Mati Joshua[2], Stephen Lisberger[1]

[1]*Duke University,* [2]*The Hebrew University of Jerusalem*

SP1.4 ***Inferring function from information transfer during coordinated eye and arm movements***

Jung Uk Kang[1], Eric Mooshagian[2], Lawrence Snyder[1]

[1]*Washington University at St. Louis Medical Center,* [2]*University of California at San Diego*

SP1.5 ***Ocular eccentricity affects subjective visual vertical perception in health and disease***

Catherine Agathos[1], Anca Velisar[1], Natela Shanidze[1]

[1]*Smith-Kettlewell Eye Research Institute*

SP1.6 ***Predictive steering: integration of artificial motor signals in self-motion estimation***

Milou van Helvert[1], Luc Selen[1], Robert van Beers[2], Pieter Medendorp[1]

[1]Radboud University, Donders Institute for Brain, Cognition and Behaviour, Nijmegen, The Netherlands, [2]Radboud University, Donders Institute for Brain, Cognition and Behaviour, Nijmegen, The Netherlands

SP1.7 ***Head stabilization strategies across adulthood during stepping in place: insights on aging and adaptation***

Catherine Agathos[1], Christine Assaiante[2], Konogan Baranton[3], Brice Isableu[2], Delphine Bernardin[3]

[1]Paris-Saclay University/Essilor International/ the Smith-Kettlewell Eye Research Institute, [2]Aix-Marseille University, [3]Essilor International

SP1.8 ***Tail motoneurons are targeted by vestibular complex axons in mice***

Salvatore Lacava[1], Marylka Uusisaari[1]

[1]OIST

SP1.9 ***Longitudinal volume loss after traumatic brain injury predicts vestibular dysfunction***

Mohammad Mahmud[1], Zaeem Hadi[1], Rebecca Smith[2], Yuscah Pondeca[2], Barry Seemungal[1]

[1]Imperial College London, [2]Imperial College

SP1.10 ***Remote assessment of stroke in acute vertigo: Preliminary results of a feasibility study***

Abdel Rahman Saad[1], Alice Miller[1], Abdel Rahman Saad[1], Matteo Ciocca[1], Barry Seemungal[1]

[1]Imperial College London

SP1.11 ***Assessing human pedunculopontine nucleus activity & link to postural control***

Matteo Ciocca[1], Zaeem Hadi[1], Yuscah Pondeca[1], Mohammad Mahmud[1], Yen Tai[1], Barry Seemungal[1]

[1]Imperial College London

SP1.12 ***The effects of subclinical neck pain on cerebellar processing as measured by the cervico-ocular and vestibulo-ocular reflexes***

Devonte Campbell[1], Bernadette Murphy[1], James Burkitt[2], Nicholas LaDelfa[1], Praveen Sanmuganathan[1], Paul Yielder[1]

[1]Ontario Tech University, [2]McMaster University

SP1.13 ***Effect of post-training sensory input on systems consolidation of a motor skill***

Trace Stay, Eunice Chan, Solmih Kim, Victoria Xin, Alex Somera, Dong Cheol Jang, Jennifer Raymond

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Scholarship Winners

New investigators and faculty are essential for the future of any field of scientific inquiry. NCM has historically encouraged conference participation by graduate students and post-doctoral fellows. The scholarship program is designed to provide partial support for them to participate in the conference and is open to student and post-doc members in good standing. Our scholarship program is funded through the support of our sponsors.

Antimo Buonocore, *University of Tuebingen*

Antimo Buonocore recently accepted an Assistant Professorship at Suor Orsola Benincasa University, Naples, Italy. His main research focus is the control of eye movements in response to visual stimulation. By combining psychophysical experiments with neurophysiological recordings, he is addressing questions about response inhibition and decision processes within the oculomotor system.

Chen Avraham, *Ben Gurion University of Negev*

Chen Avraham received her B.Sc. (magna cum laude) in biomedical engineering in 2016 from Ben-Gurion University. She started her Ph.D. studies in the direct track under the supervision of Prof. Ilana Nisky at the Biomedical Robotics Lab at Ben-Gurion University. Her research interests include human motor control and multisensory feedback.

Andrew Byun, *Harvard University*

Andrew Byun is a Bioengineering PhD candidate at Harvard University, studying under the mentorship of Maurice Smith and John Torous. Andrew received his BSE in Mechanical Engineering and Computer Science from Duke University. His research focuses on understanding the functional architectures of implicit and explicit motor learning from reinforcement signals.

Jared Cregg, *University of Copenhagen*

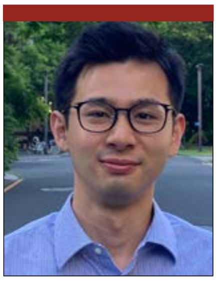
Jared Cregg is a postdoctoral researcher with Dr. Ole Kiehn at the University of Copenhagen. Jared is working to uncover how brainstem circuits control spinal locomotor networks. Jared received his PhD from Case Western Reserve University in 2018 under the mentorship of Drs. Jerry Silver and Lynn Landmesser

Catia Fortunato, *University College London*

Cátia Fortunato is a 3rd year PhD student in the Be.Neuro Lab, at Imperial College London, under the supervision of Dr. Juan A. Gallego. Her research focuses on cortical and subcortical motor regions and how they interact to generate skilled behaviour.

Matthias Franken, *McGill University*

Matthias Franken is a postdoctoral researcher with prof. David Ostry at McGill University. His work focuses on speech motor learning and speech perception, which he studies using psychophysics, electrophysiology, and non-invasive brain stimulation. He earned his PhD at Radboud University (the Netherlands), studying the interactions between speech production and perception.



Toshiki Kobayashi, *The University of Tokyo*

Toshiki Kobayashi is a project researcher in the Graduate School of Education at the University of Tokyo, where he has been since 2022. His research focuses on how the brain achieves movement control in a redundant motor task.

Rebecca Kozak, *University of Western Ontario*

Rebecca Kozak is a PhD Candidate in the lab of Dr. Brian D. Corneil at the university of Western Ontario. Her research focuses on investigating the underlying neural circuits which mediate rapid visuomotor transformations during visually guided reaching in both healthy and clinical populations.

Clara Kuper, *Humboldt University Berlin*

Clara Kuper studies how human perception supports, and is supported by, interaction with the environment. During her PhD at Humboldt-Universität zu Berlin (advisor: Martin Rolfs), she investigates how surprising visual information informs ongoing motor plans for hand and eye movements. She develops online psychophysical experiments for mobile devices.

Patrick Marino, *University of Pittsburgh*

Patrick Marino is a PhD candidate at the University of Pittsburgh working with Aaron Batista, Byron Yu, and Steven Chase. His current work leverages intracortical brain-computer interfaces (BCI's) to investigate the organization of sensory and motor signals in motor cortex. Previously, he worked on improving decoding algorithms for electrocorticography-based BCI's.

Heather McGregor, *Univeristy of Florida*

My research uses a combination of brain imaging and behavioural techniques to explore how the brain reweights sensory inputs to maintain motor performance when faced with sensory loss or dysfunction. Ultimately, I aim to use this knowledge to inform behavioural and neuromodulatory therapeutic interventions.

Robyn Mildren, *Johns Hopkins University*

Robyn is a post-doctoral fellow in Dr. Cullen's lab at Johns Hopkins University where she studies pathways in the vestibular cerebellum that process information about our motion through the world.

Jasmine Mirdamadi, *Emory University*

Jasmine is a postdoctoral fellow at Emory University mentored by Michael Borich and Lena Ting. She investigates how the brain processes sensory information during balance perturbations in adults with and without stroke. She seeks to understand neural mechanisms of sensorimotor function to develop objective assessments and targeted rehabilitation interventions.

Dollyane Muret, *University College London*

Dollyane Muret is a postdoctoral researcher, currently working at NeuroSpin (Paris, France), former postdoctoral researcher at the Institute of Cognitive Neuroscience (UCL, London) with Prof. Tamar R. Makin. Her research aims at understanding human sensorimotor organisation and plasticity, considering the role of body usage and compensatory behaviours.

Rashida Nayeem, *Northeastern University*

Rashida is PhD Candidate in Electrical Engineering at Northeastern University, Boston. She studies human interaction with objects with internal dynamics on multiple scales. This includes experiments with able-bodied individuals in virtual environments, to testing control of real-objects in those after stroke. Her approach includes kinematic data analysis and computational modeling.

Elizaveta Okorokova, *University of Chicago*

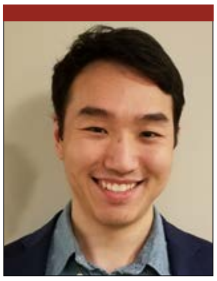
Elizaveta is a PhD student at the University of Chicago.

Jonathan Tsay, *University of California Berkeley*

JT is a 4th year psychology PhD student at UC Berkeley. His dissertation centers on re-examining the computational and neural mechanisms that support motor adaptation. Before arriving in Berkeley, JT studied math and physical therapy at Northwestern University. Outside the lab, JT loves to take long walks in nature.

Taniel Winner, *Georgia Institute of Technology and Emory University*

Taniel is a 4th year PhD candidate in the joint Biomedical Engineering Department between Georgia Institute of Technology and Emory University. Her research focuses on developing data-driven, dynamical characterizations of healthy and impaired gait to inform the development of tailored gait rehabilitation strategies.



Christopher Yang, *Johns Hopkins University*

Christopher is a postdoctoral fellow with Dr. Adrian Haith and Dr. John Krakauer at Johns Hopkins University, and previously earned a PhD in the same lab. Christopher's research focuses on understanding how people learn new motor skills and how the performance of these skills becomes habitual.

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