Society for the Neural Control of Movement

NCM

SATELLITE MEETING
April 17, 2023

ANNUAL MEETING
April 18 – 21, 2023

32nd Annual Meeting

2023

Victoria, Canada

Victoria Conference Centre

@ncm-soc #NCMVic23

Program at a Glance

Schedule is subject to change

Time	Monday 17-Apr	Tuesday 18-Apr	Wednesday 19-Apr	Thursday 20-Apr	Friday 21-Apr
08:00	Registration /Information Desk Open	Registration / Information Desk Open Posters on Display Exhibits on Display ***Session 1*** ***Panel I*** Smoulder (08:00 - 10:00)	Registration / Information Desk Open Posters on Display Exhibits on Display ***Session 5*** ***Panel III*** Cisek (08:00 - 10:00)	Registration / Information Desk Open Posters on Display Exhibits on Display ***Session 9*** ***Panel V*** Orban de xivry (08:00 - 10:00)	Registration / Information Desk Open Posters on Display ***Session 12*** ***Panel VI*** Rizzoglio (08:00 - 10:00)
08:15					
08:30	**Satellite Meeting**				
08:45					
09:00					
09:15					
09:30					
09:45					
10:00		**Break** (10:00 - 10:30)	**Break** (10:00 - 10:30)	**Break** (10:00 - 10:30)	**Break** (10:00 - 10:30)
10:15					
10:30		***Session 2*** ***Individual I*** (10:30 - 12:30)	***Session 6*** ***Panel IV*** Carey (10:30 - 12:30)	***Early Career Talk*** Juan Alvaro Gallego (10:30 - 11:05)	***Session 13*** ***Individual III*** (10:30 - 12:30)
10:45					
11:00				***Session 10*** ***Perspective*** Seáñez (11:05 - 12:45)	
11:15					
11:30					
11:45					
12:00					
12:15					
12:30		***Session 3*** **Posters, Exhibitors & Lunch** (12:30 - 15:00)	***Session 7*** **Posters, Exhibitors & Lunch** (12:30 - 15:00)		***Session 14*** **Posters & Lunch** (12:30 - 15:00)
12:45				***Session 11*** **Posters, Exhibitors & Lunch** (12:45 - 15:15)	
13:00					
13:15					
13:30					
13:45					
14:00					
14:15					
14:30					
14:45					
15:00		***Session 4*** ***Panel II*** Batista (15:00 - 17:00)	***Session 8*** ***Individual II*** (15:00 - 17:00)		***Session 15*** ***Panel VII*** Kita (15:00 - 17:00)
15:15					
15:30				**Free Time and/or Excursions**	
15:45					
16:00					
16:15					
16:30					
16:45					
17:00			**Members' Meeting** (17:00 - 17:30)		***Distinguished Career Award*** Chris Miall (17:00 - 18:00)
17:15					
17:30		**NCM Board Meeting** (17:30 - 20:30)			
17:45					
18:00					**Closing Drinks Reception** (18:00 - 19:00)
18:15					
18:30					
18:45					
19:00					
19:15					
19:30	**Opening Reception** *CRAFT Beer Market* (19:30 - 21:30)				
19:45					
20:00		**Nightly Pub Meet up**	**Nightly Pub Meet up**		
20:15					
20:30					
20:45					
21:00					
21:15					
21:30					
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22:00					
22:15					
22:30					

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 32ND ANNUAL MEETING OF THE SOCIETY FOR THE NEURAL CONTROL OF MOVEMENT!

I am pleased to welcome all to the 32nd annual meeting of the Society for the Neural Control of Movement. Last year the etymology of Dublin's River Liffey had us, quite appropriately, "fording hurdles." This year, despite our long history of strong Canadian involvement in the society, being in Victoria puts us in Canada for the first time in 33 years. It puts us, in fact, in the backyard of Marischal De Armond, Michelle Smith, and Podium Conference Specialists, who have continued to work overtime to get us beyond hurdles to "Victorious", a delightful turn of events!

In that frame of mind, I'd like to highlight a couple exciting program points – first is the satellite on *"Computations and neural code underlying the control of posture"* which opens our annual meeting week. This year we have the added bonus that the organizers, Jean-Sébastien Blouin and Mark Carpenter, from the University of British Columbia, are both local. We will also have two keynote addresses again this year. The first, on Thursday, is from Juan Gallego, of Imperial College London, winner of the Early Career Award. His talk is entitled *"Understanding how the brain controls movement through neural manifolds"*. We close the annual meeting with Chris Miall, the Distinguished Career Award Winner, whose topic is, *"The cerebellum – prediction in motor control and cognition"*.

The difficult part of this letter this year is the announcement of officer turnover. I've reached the end of what has been a wonderful two terms as president. In that time, we've effectively refocused efforts of both the Development and Secretary / Treasurer roles, received substantial meeting support funding from NIH, made real strides in trainee involvement, diversity and inclusiveness, and welcomed large numbers of new members. Along the way we also managed to overcome some pretty substantial hurdles. Although it is a bit painful to think about moving on from this position, I am very pleased that the role will be capably filled by Kathy Cullen, former VP and program chair. I look forward to watching the further evolution of NCM under her guidance.

Rachael Seidler will also be moving on from the Secretary / Treasurer position she has filled for two terms, to be replaced by Alaa Ahmed. Among the changes in this position has been a transition from concerns largely about NCM accounting, to managing financial support for a broad range of individuals who would otherwise not have been able to attend the annual meeting. This is but one of the important ways in which we have increased the diversity of our membership and meeting attendance.

This push for diversity is one of several goals identified by the board that are of particular importance to NCM, for which we have now established several working committees. In addition to a Diversity committee, we have Social Media and Community Conduct committees, each composed of several society members with a board member liaison. In the latter context, we have several new board members to welcome following a strong turnout for elections that included a full slate of seven candidates. Juan Gallego will return for a second term, while Joshua Cashaback, Julie Duque, and Tarkeshwar Singh are all newly elected to the board, with terms to begin following this meeting. Feel free to reach out to any board member if you are interested in contributing to the society's endeavors.

I look forward to joining all of you in the meeting room, posters, and at the resurrected pub crawl as we move from surmounting hurdles to Victorious!

Cordially,

Lee Miller
President

Society Information

EElected 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
Adrian Haith

Treasurer & Secretary
Rachael Seidler

Development Officer
Kazuhiko Seki

BOARD MEMBERS

NAME	INSTITUTION	COUNTRYACT	TERM
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
Wilsaan Joiner[1]	*University of California Davis*	USA	2021 - 2024
Jennifer Semrau[1]	*University of Delaware*	USA	2021 - 2024

Megan Carey[2]	*Champalimaud Center of the Unknown*	Portugal	2022 - 2025
Susan Coltman*	*UUniversity of Colorado, Denver*	USA	2022 - 2024
Freidl De Groote[1]	*KU Leuven*	Belgium	2022 - 2024
Sam McDougle[1]	*Yale University*	USA	2022 - 2025
Hans Scherberger[1]	*German Primate Center*	Germany	2022 - 2025
Aaron Wong[1]	*Moss Rehabilitation Research Institute*	USA	2022 - 2025

[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 conclusion of the 2023 Annual Meeting:

NAME	INSTITUTION	COUNTRY	TERM
Juan Alvaro Gallego	*Imperial College London*	GBR	2023 - 2026
Joshua Cashaback	*University of Delaware*	USA	2023 - 2026
Julie Duque	*Université catholique Louvain*	BEL	2023 - 2026
Tarkeshwar Singh	*Pennsylvania State University*	USA	2023 - 2026

NCM ADMINISTRATION

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

Podium Conference Services

- Michelle Smith
- Marischal De Armond
- Rachel Waller
- Sebastien Lavoie

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
31st Annual Meeting	July 25 – 29, 2022	Dublin	Ireland	The Clayton Hotel Burlington Road
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

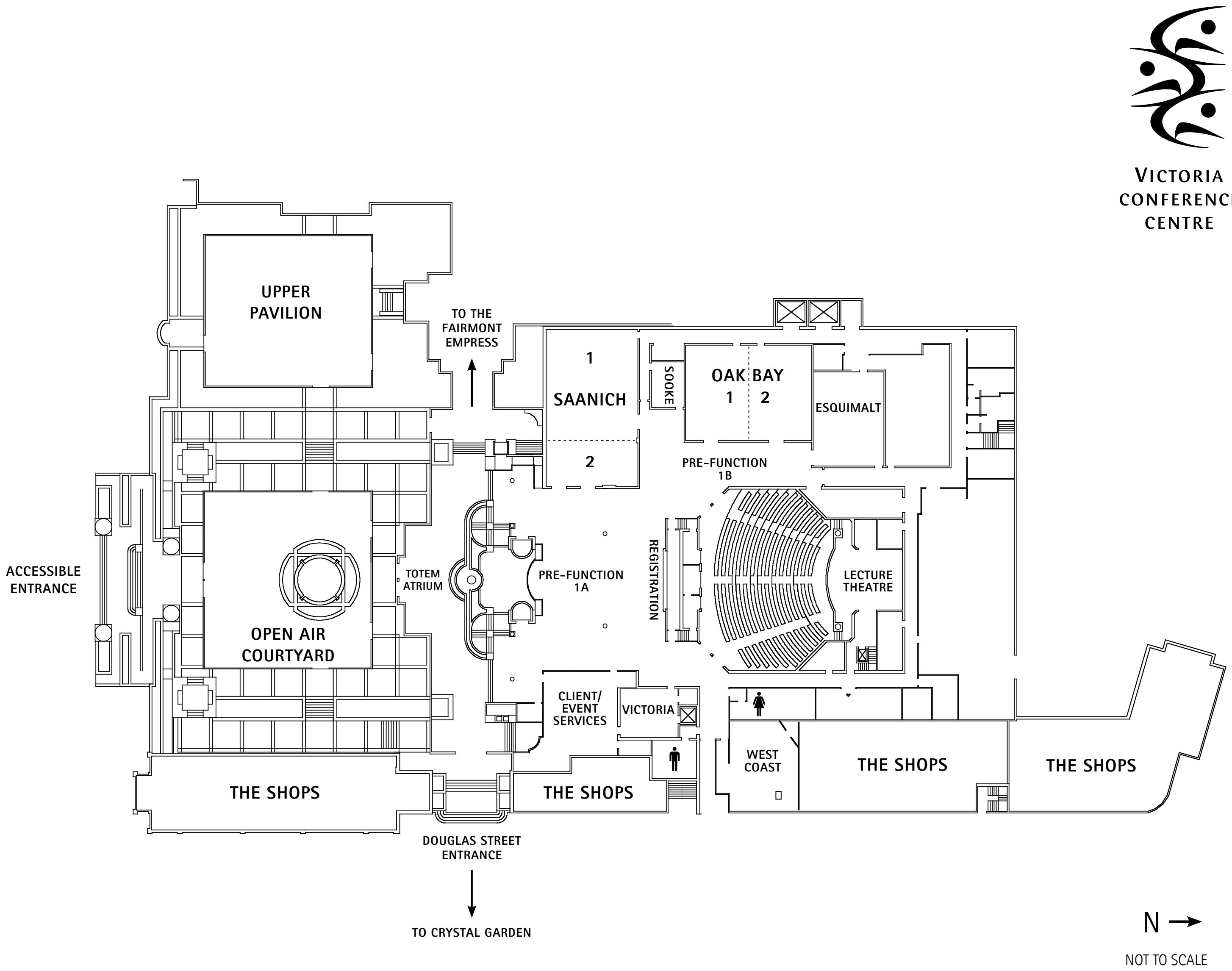
General Conference Information

CONFERENCE VENUE

Victoria Conference Centre

720 Douglas Street
Victoria, BC V8W 3M7
Canada

All conference sessions will take place in this location. The Opening Reception will be off-site at CRAFT Beer Market, a short walk from the Victoria Conference Centre.



REGISTRATION

SATELLITE MEETING

Satellite Meeting registration fees include access to the full day meeting with refreshment breaks and a buffet lunch on Monday April 17th.

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 CRAFT Beer Market, 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 always wear it. 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 green 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 of the first floor of the Victoria Conference Centre, outside the Lecture Theatre, will be open during the following dates and times:

Monday, April 17	07:30 – 18:00
Tuesday, April 18	07:30 – 17:00
Wednesday, April 19	07:30 – 17:00
Thursday, April 20	07:30 – 15:30
Friday, April 21	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, April 18, between 07:30 and 10:00

Remove:
Tuesday, April 18, no later than 17:15

POSTER SESSION 2

Set-up:
Wednesday, April 19, between 07:30 and 10:00

Remove:
Wednesday, April 19, no later than 17:45

POSTER SESSION 3

Set-up:
Thursday, April 20, between 07:30 and 10:00

Remove:
Thursday, April 20, no later than 15:15

POSTER SESSION 4

Set-up:
Friday, April 21, between 07:30 and 10:00

Remove:
Friday, April 21, 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 **VictoriaConference** *WiFi network*, Select **Complimentary** and agree to the terms and conditions, then select **Connect Me**. 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 *#NCMVic23 @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 Victoria Conference Centre is a completely non-smoking facility. There is a designated outdoor smoking area in the south end of the main building's courtyard.

CODE OF CONDUCT

As a representative of your institution the professional standards and code of conduct of your institution are in effect while at the NCM Annual Meeting, Satellite Meeting and all social events.

The Society for the Neural Control of Movement (NCM) encourages open and honest intellectual debate within a welcoming and inclusive atmosphere at the Annual Meeting and through official NCM social media channels. To help maintain an open and respectful community of scientists, NCM does not tolerate illegal or inappropriate behavior at any annual meeting, including violations of applicable laws of the country in which the meeting is taking place. NCM condemns inappropriate or suggestive acts or comments that demean or harass another person by reason of gender, gender identity or expression, sexual orientation, physical appearance, ethnicity/race, religion (or lack thereof), or that are generally unwelcome or offensive to other members of the community. Sexual language and imagery, unless related to specific scientific discussions, is not appropriate for any conference venue, including talks, workshops, parties, Twitter and other online media. As the NCM Annual Meeting is attended by a wide spectrum of delegates, please be aware of the power dynamic between PIs, post doctoral fellows and students and how that dynamic may affect interactions amongst delegates.

Special Meetings & Events

GENERAL INFO

Monday, April 17 17:00 – 18:30

SATELLITE POSTER RECEPTION

Location: **Victoria Conference Centre, First floor**

Monday, April 17 19:30 – 21:30

OPENING RECEPTION

Location: **CRAFT Beer Market 450 Swift Street**

Wednesday, April 19 17:00 – 17:30

NCM MEMBERS MEETING

Location: **Lecture Theatre**

Friday, April 21 18:00 – 19:00

CLOSING DRINKS RECEPTION

Location: **Victoria Conference Centre, First floor**

Directions to **Opening Reception at CRAFT Beer Market**

Exit out the front of the Fairmont Empress

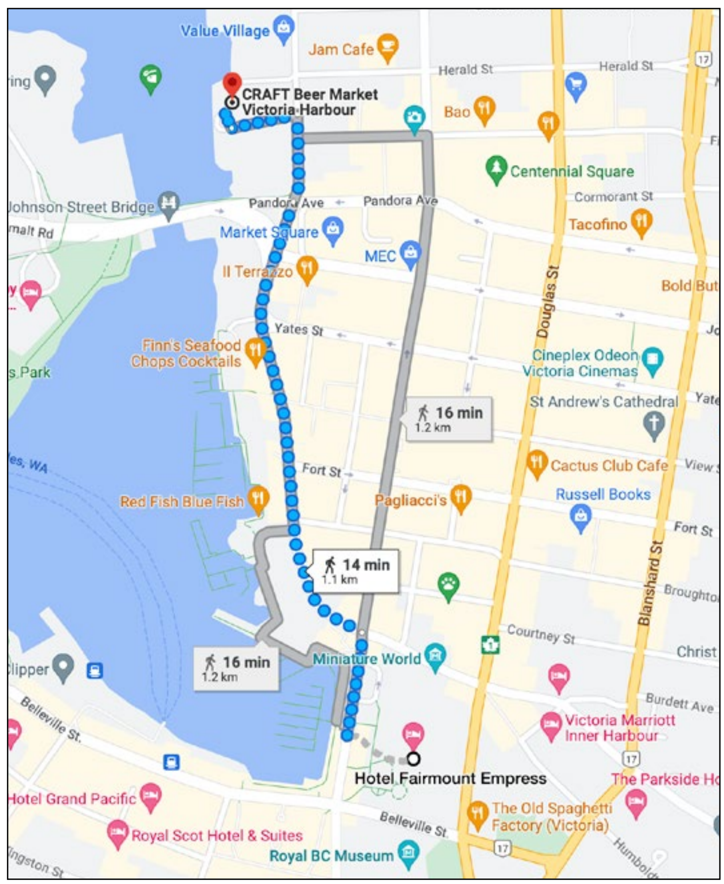
***Turn right** along Government Street*

*At the lights, **veer to the left** and stay on Wharf Street to walk along the waterfront*

Continue straight

Go straight through the lights at Johnson Street/Pandora Avenue, the bridge will be on the left hand side. The road name changes to Store Street

Turn left on Swift Street, walk down the hill and CRAFT Beer Market will be on the right side



NCM Excursions

NCM invites you to take advantage of your visit to Victoria by exploring this wonderful city by the sea and its surroundings! Excursions can be added by visiting the registration desk. Please note there are limits to maximum capacity of delegates per tour.

THURSDAY APRIL 20, 2023

WHALE WATCHING

$105 per person USD
16:00 – 19:00 (approximately)

Join us aboard a comfortable double hulled catamaran for a fast, smooth and stable ride on the Salish Sea, one of the world's largest and biologically rich inland seas. The wildlife that can be found here includes Resident (fish-eating) Orcas, Transient (Marine mammal eating) Orcas, Humpback Whales, Gray Whales, Minke Whales, Harbor & Dall's Porpoise, Pacific White-sided Dolphins, Steller & California Sea Lions, Harbor Seals, Northern Elephant Seals and both River & Sea Otters. The tour will depart from the registration desk of the Victoria Conference Centre and will last approximately three hours.

WALKING CITY TOUR

$20 per person USD
15:45 – 17:15 (approximately)

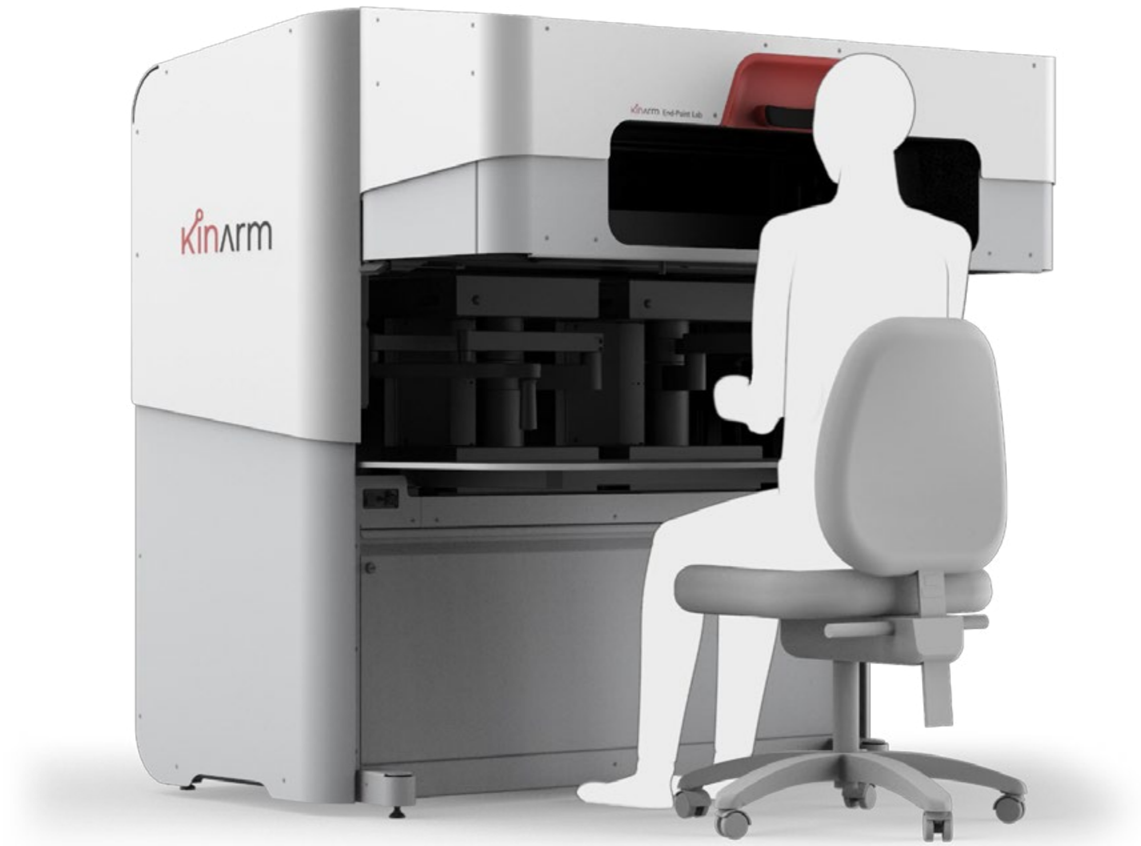
The walking city tour is a leisurely 90-minute walk through Downtown Victoria and will depart from the Victoria Conference Centre. The professional guides are passionate about Victoria's history and breathe life into the stories. Iconic architecture, fascinating details about local events that link to world themes, famous and colorful people from the past are all included. By the end of the tour, delegates will know why Victoria is here, how it became the capital city and what the current civic issues are. Find out about the city's First Nations origins, its fur trade and gold rush periods and how it has evolved over time.

BUTCHART GARDENS

$60 per person USD
15:45 – 18:30 (approximately)

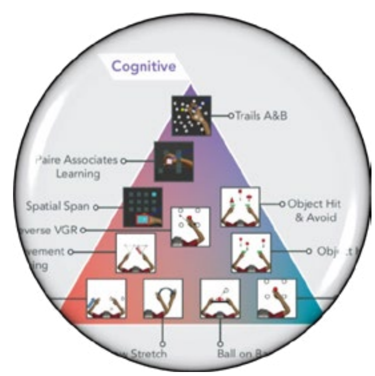
Travel from downtown Victoria aboard a charter bus to the majestic and world famous Butchart Gardens! World famous Butchart Gardens is a wonderland containing spectacular theme gardens, exotic plants, streams and ponds. Ross Fountain, the famous Sunken Garden, the Rose and Japanese gardens and so much more are sure to create a lasting impression. The cost includes admission to the gardens as well as return bus transportation

The evolution of Kinarm.
Bringing precision assessment to precision medicine.



Fits tall and small

Gaze-tracker compatible



Built to clinical standards

Computations and neural code underlying the control of posture

Sponsored by:

THE UNIVERSITY OF BRITISH COLUMBIA
School of Kinesiology

UBC
Origins of Balance Deficits & Falls

NCM SATELLITE MEETING, VICTORIA, CANADA

APRIL 17, 2023

All sessions will be held at the Victoria Conference Centre

Whether it is for maintaining the position of a limb, whole-body stability or the foundation to generate goal-directed movements, postural control is central to our ability to move. Postural control, however, is often studied in silos, with researchers focusing on arm movements rarely interacting with researchers characterizing the control of upright balance (and vice-versa). A primary aim of this satellite meeting is to highlight emerging postural control research related to single joint, multi-joint and whole-body movements as well as the interactions between movement and postures. We invite all researchers with expertise in distinct subfields of postural control addressing their research questions from a modeling and/or physiological perspective, with an objective to foster discussions between attendees and potentially identify commonalities or emerging questions that may lead to a unified understanding of postural control across contexts (including arm, neck and whole-body postural control). We intend to create a forum to challenge established ideas and promote a broad vision of postural control and its understanding within the general field of sensorimotor control of movement. To do so, the satellite meeting will provide a venue for diverse trainees, junior and senior scientists to present their recent work, and have opportunities to interact, share ideas and provide/receive feedback and discuss emerging models of postural control.

The satellite is organized by **Jean-Sébastien Blouin** and **Mark Carpenter**, *University of British Columbia*

MONDAY APRIL 17

07:30 – 08:00 **REGISTRATION**

08:00 - 08:15 **WELCOME/INTRODUCTION FROM MARK CARPENTER AND JEAN-SÉBASTIEN BLOUIN**

8:15 – 9:55 **SESSION 1**

Risk, error, and uncertainty in the control of reaching and posture

Alaa A. Ahmed, *University of Colorado Boulder*

Somatosensory signals for feedforward and feedback control of arm movement and posture: a human deafferentation approach

Fabrice Sarlegna, *Aix-Marseilles University*

Cortical activity during reactive balance reflect perceptual, cognitive, and motor function in health, aging, and disease

Lena H. Ting, *Emory University & Georgia Tech*

Sensorimotor recalibration of balance control through standing with unexpected sensorimotor delays

Brandon Rasman[1], Jean-Sébastien Blouin[2], Patrick Forbes[1]

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

Interaction between movement control and abnormal resting posture after stroke

Alkis Hadjiosif[1], Kahori Kita[2], Scott Albert[3], Robert Scheidt[4], Reza Shadmehr[2], John Krakauer[2]

[1]*Harvard University,* [2]*Johns Hopkins University,* [3]*University of North Carolina,* [4]*Marquette University*

Adaptation, learning, retention: Using canes significantly improves balance but with no aftereffects or longer-term persistence

Sabra Sisler[1], Marta Russo[2], Dagmar Sternad[1]

[1]*Northeastern University,* [2]*Tor Vergata University*

10:00 – 10:15 **COFFEE BREAK**

10:15 – 12:05 **SESSION 2**

Predictive vestibular processing: An essential computation for postural control

Kathleen E. Cullen, *Johns Hopkins University*

Trunk control in posture and upper limb function: tools, fundamental insights, and clinical translation

Albert H. Vette, *University of Alberta* and **Kei Masani**, *University of Toronto*

Computational study on the relationship between margin-of-stability and the probability of falling during the lean-and-release test

Jonguk Lee[1], Nili Upadhyay[1], Kei Masani[2]

[1]*University of Toronto,* [2]*University Health Network*

Cortical encoding of full-body posture and movement in freely behaving mice

Kyle Severson[1], Jinghao Lu[1], Wenxi Xiao[2], Helen Jiang[1], Fan Wang[1]

[1]*Massachusetts Institute of Technology,* [2]*Duke University*

Encoding of active and passive translations in the primate posterior cerebellum for postural control

Robyn Mildren[1], Kathleen Cullen[1]
[1]*Johns Hopkins University*

Task-level feedback during combined translational and rotational perturbations of standing balance is impaired in children with cerebral palsy

Jente Willaert[1], Kaat Desloovere[1], Anja Van Campenhout[1], Lena Ting[2], Friedl De Groote[1]
[1]*Katholieke Universiteit Leuven,* [2]*Emory University & Georgia Institute of Technology*

The loss of the α9/10 Nicotinic Acetylcholine Receptor Subunit Impairs Postural Stability in Mutant Mice

Tobias Niebur[1], Brandie Morris Verdone[2], Kathleen Cullen[1]
[1]*Johns Hopkins University School of Medicine,* [2]*Johns Hopkins University Whiting School of Engineering*

Whole-body and neck postural responses linked to saccadic eye movement

Emma Reiter[1], Solenne Villemer[1], Romeo Chua[1], J. Timothy Inglis[1], Mark Carpenter[1]
[1]*University of British Columbia*

12:05 – 12:45 LUNCH AND SATELLITE MEETING POSTER SESSION

12:45 – 14:30 SESSION 3

Differential vestibular influence on the perception and control of postural self-motion

Patrick A. Forbes, *Erasmus University Medical Centre*

Tapping into our skin: can we customize balance control?

Leah R. Bent, *University of Guelph*

Flexible control of sensory feedback in upper limb reaching movements

Tyler Cluff, *University of Calgary*

Real-time haptic feedback for balance

Raymond Reynolds[1], Craig Smith[1], Lorenz Assländer[2]
[1]*University of Birmingham,* [2]*University of Konstanz*

Vestibular contributions to dynamic balance in freely moving rhesus monkeys

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

Human Foot Force Informs Neural Control Strategies of Quiet Balance

Kaymie Shiozawa[1], Marta Russo[2], Jongwoo Lee[1], Neville Hogan[1], Dagmar Sternad[3]
[1]*MIT,* [2]*Tor Vergata Polyclinc, IRCCS Santa Lucia Foundation,* [3]*Northeastern University*

14:30 – 14:45 COFFEE BREAK

14:45 – 16:30 SESSION 4

Noisy tendon stimulation for probing human muscle spindles and stretch reflexes

Ryan M. Peters, *University of Calgary*

Insights in standing and walking balance control gained from stochastic optimal control simulations

Friedl De Groote[1], Tom Van Wouwe[2], Lena Ting[3]
[1]*KU Leuven,* [2]*Stanford University,* [3]*Emory University and Georgia Institute of Technology*

Brownian processes in human motor tasks: behavioral evidence of velocity-level planning

Federico Tessari[1], James Hermus[1], Rika Sugimoto Dimitrova[1], Neville Hogan[1]
[1]*Massachusetts Institute of Technology*

Contralateral monosynaptic reflexes in the axial motor system of mammals

Kendall Schmidt[1], Andrey Borisyuk[1], Sebastian Atoche Jovacho[1], Simon Giszter[1]
[1]*Drexel University*

Vestibular contributions to primate head and body stability during active locomotion

Ruihan Wei[1], Oliver Stanley[1], Kathleen Cullen[1]
[1]*Johns Hopkins University*

Locally applied heating enhances cutaneous reflexes in the human foot sole

Erika Howe[1], Tushar Sharma[1], Laura Marrelli[1], Leah Bent[1]
[1]*University of Guelph*

Modeling and quantifying dynamics of emerging of postural control

Patricia Mellodge[1], Sandra Saavedra[2]
[1]*University of Hartford,* [2]*Western University of Health Sciences*

Scaling of response times under feedforward and feedback control with sensorimotor delays in terrestrial mammals

Sayed Naseel Mohamed Thangal[1], Heather More[1], C. David Remy[2], Max Donelan[1]
[1]*Simon Fraser University,* [2]*University of Stuttgart*

16:30 – 17:00 PANEL DISCUSSION

17:00 – 18:30 SATELLITE POSTER AND NETWORKING SESSION

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.

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Annual Conference Schedule

All sessions will be held in the Lecture Theatre of the Victoria Conference Centre

DAY 1 MONDAY APRIL 17, 2023

19:30 – 21:30 **OPENING RECEPTION**

Off Site at the **CRAFT Beer Market**

Join us at CRAFT Beer Market for an informal opening reception. Complete with ample food and opportunities to try over 100 mostly local beer on tap, it will be a great time to catch up with old colleagues, meet new friends, and start off the conference!

DAY 2 TUESDAY APRIL 18, 2023

08:00 - 10:00 **SESSION 1, PANEL I**

Motivated movement: how reward shapes neural activity and behavior

Organizer: **Adam Smoulder**

Discussant: **Paul Cisek,** *University of Montreal*

Hee Jae Jang[1], Alaa Ahmed[2], Adam Smoulder[3], Becket Ebitz[4]

[1]*New York University,* [2]*University of Colorado Boulder,* [3]*Carnegie Mellon University,* [4]*University of Montreal*

10:00 – 10:30 **BREAK**

10:30 - 12:30 **SESSION 2, INDIVIDUAL I**

Compositionality and high-dimensionality of motor cortex activity

Elom Amematsro[1], Eric Trautmann[1], Najja Marshall[2], Larry Abbott[1], Mark Churchland[1]

[1]*Columbia University,* [2]*CTRL Labs*

Presenting Author: **Elom Amematsro**

Direct neural perturbations reveal a dynamical mechanism for robust cortical movement generation

Daniel O'Shea[1], Lea Duncker[1], Maneesh Sahani[2], Krishna Shenoy[1]

[1]*Stanford University,* [2]*Gatsby Computational Neuroscience Unit*

Presenting Author: **Daniel O'Shea**

Self-generated vestibular prosthetic input updates forward internal model of self-motion

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

[1]*Johns Hopkins University*

Presenting Author: **Kantapon Pum Wiboonsaksakul**

Descending control of turning during walking in Drosophila

Helen Yang[1], Quinn Vanderbeck[1], Laia Serratosa Capdevila[1], Anna Li[1], Jasper Phelps[2], Brandon Mark[3], Zetta AI LLC[4], John Tuthill[3], Wei-Chung Lee[5], Rachel Wilson[1]

[1]Harvard Medical School, [2]EPFL, [3]University of Washington, [4]Zetta AI LLC, [5]Boston Children's Hospital, Harvard Medical School

Presenting Author: **Helen Yang**

Dynamical mechanisms of flexible pattern generation in spinal neural populations

Lahiru Wimalasena[1], Chethan Pandarinath[1], Nicholas Au Yong[2]

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

Presenting Author: **Lahiru Wimalasena**

A novel neural framework to assess movement control at the spinal motor neuron level

Francois Hug[1], Simon Avrillon[2], Dario Farina[2]

[1]Universite Cote d'Azur, [2]Imperial College London

Presenting Author: **Francois Hug**

12:30 – 15:00 SESSION 3, POSTER 1, EXHIBITORS, & LUNCH

15:00 – 17:00 SESSION 4, PANEL II

Are memories active?

Organizer & Discussant: **Aaron Batista**

Aaron Batista[1],Dagmar Sternad[2], Steve Chase[3], Se-Woong Park[4], Rachel Swanson[5], Jon Wolpaw[6]

[1]University of Pittsburgh, [2]Northeastern University, [3]Carnegie Mellon University, [4]University of Texas at San Antonio, [5]New York University, [6]National Center for Adaptive Neurotechnologies

20:00 IRISH TIMES PUB

1200 Government Street

Join us at the Irish Times pub for casual networking. *Please note:* space is based on availability. The pub has food, drinks and a lively atmosphere.

DAY 3 WEDNESDAY APRIL 19, 2023

08:00 - 10:00 **SESSION 5, PANEL III**

The neural control of movement through the lens of evolution

Organizer: **Paul Cisek**

Discussant: **Megan Carey**, *Champalimaud Centre for the Unknown*

Terence Sanger[1], Andreas Kardamakis[2], Leah Krubitzer[3], Paul Cisek[4]

[1]*University of California, Irvine,* [2]*Universitas Miguel Hernandez,* [3]*University of California, Davis,* [4]*University of Montreal*

10:00 – 10:30 **BREAK**

10:30 - 12:30 **SESSION 6, PANEL IV**

Internal models: From systems to circuits

Organizer: **Megan Carey**

Discussant: **Kathleen Cullen**, *Johns Hopkins University*

Megan Carey[1], Andrew Pruszynski[2], Abigail Person[3], Javier Medina[4]

[1]*Champalimaud Center for the Unknown,* [2]*Western University,* [3]*University of Colorado,* [4]*Baylor College of Medicine*

12:30 - 15:00 **SESSION 7, POSTER 2, EXHIBITORS, & LUNCH**

15:00 - 17:00 **SESSION 8, INDIVIDUAL II**

Dynamic synchronization between hippocampal spatial representations and the stepping rhythm

Abhilasha Joshi[1], Eric Denovellis[1], Abhijith Mankili[1], Yagiz Meneksedag[2], Thomas Davidson[1], Anna Gillespie[1], Jennifer Guidera[1], Demetris Roumis[1], Loren Frank[1]

[1]*University of California, San Francisco,* [2]*Hacettepe University*

Presenting Author: **Abhilasha Joshi**

Neural basis of skilled behaviors

Adam Hantman[1]

[1]*University of North Carolina, Chapel Hill*

Presenting Author: **Adam Hantman**

Slower cortical responses during balance recovery associated with nonparetic postural compensation and stiffer biomechanical reactions in people post stroke

Jacqueline Palmer[1], Aiden Payne[2], Jasmine Mirdamadi[3], Lena Ting[3], Michael Borich[3]

[1]*University of Kansas Medical Center,* [2]*Florida State University,* [3]*Emory University*

Presenting Author: **Jacqueline Palmer**

Characterization of locomotor adaptation and generalization dynamics from high-dimensional neuromuscular data

Dulce Mariscal[1], Krista Fjeld[1], Gelsy Torres-Oviedo[1]

[1]*University of Pittsburgh*

Presenting Author: **Dulce Mariscal**

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*

Presenting Author: **Bence Bagi**

Cerebellar granule cells and climbing fibers jointly acquire signals to learn reward timing

Mark Wagner[1], Martha Garcia Garcia[1], Lina Takemaru[1], Akash Kapoor[1], Oluwatobi Akinwale[1], Tony Hyun Kim[2], Casey Paton[3], Mark Schnitzer[2], Liqun Luo[2], Ashok Litwin-Kumar[4]

[1]*National Institutes of Health,* [2]*Stanford University,* [3]*Cornell University,* [4]*Columbia University*

Presenting Author: **Mark Wagner**

17:00 – 17:30 NCM MEMBERS MEETING

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

20:00 STICKY WICKET PUB

919 Douglas Street

Join us at an iconic Victoria location for casual networking! The pub and restaurant has food, drinks, a games room and lively atmosphere.

DAY 4 THURSDAY APRIL 20, 2023

8:00 – 10:00 **SESSION 9, PANEL V**

Age- and disease-related changes in the cerebellum impact motor function

Organizer: **Jean-Jacques Orban de xivry**

Discussant: **Richard Ivry,** *University of California, Berkeley*

Jean-Jacques Orban de xivry[1], Di Cao[2], Jovin Jacobs[3], Alanna Watt[4]

[1]KU Leuven, [2]Johns Hopkins University, [3]Champalimaud Centre for the Unknown, [4]McGill University

10:00 – 10:30 **BREAK**

10:30 – 11:05 **EARLY CAREER AWARD PRESENTATION AND TALK**

Understanding how the brain controls movement through neural manifolds

Juan Alvaro Gallego, *Imperial College London*

11:05 – 12:45 **SESSION 10, PERSPECTIVE**

Combining electrical stimulation and behavioral training to restore motor control after injury: Finally a reason for optimism?

Organizer: **Ismaél Seanez**

Discussant: **John Krakauer**

Ismaél Seanez[4], Elvira Pirondini[1], Monica Perez[2], John Krakauer[3]

[1]University of Pittsburgh, [2]Shirley Ryan AbilityLab, [3]Johns Hopkins University and The Santa Fe Institute, [4]Washington University

12:45 – 15:15 **SESSION 11, POSTER 3, EXHIBITORS, & LUNCH**

15:15 – onwards **FREE TIME AND TICKETED EXCURSIONS**

DAY 5 FRIDAY APRIL 21, 2023

08:00 – 10:00 **SESSION 12, PANEL VI**

Aligned neural population dynamics provide a stable window onto motor intent

Organizer & Discussant: **Fabio Rizzoglio**

Fabio Rizzoglio[1], Xuan Ma[1], Carlos Vargas-Irwin[2], Joanna Chang[3]

[1]Northwestern University, [2]Brown University, [3]Imperial College London

10:00 – 10:30 **BREAK**

10:30 – 12:30 **SESSION 13, INDIVIDUAL III**

How does the cortical hand representation change following amputation? A pre- and post-amputation fMRI study

Hunter Schone[1], Mathew Kollamkulam[2], Craig Gerrand[3], Norbert Kang[4], Alexander Woollard[4], Imad Sedki[3], Roni Maimon Mor[2], Chris Baker[1], Tamar Makin[5]

[1]National Institutes of Health, [2]University College London, [3]The Royal National Orthopaedic Hospital NHS Trust, [4]Royal Free Hospital NHS Trust, [5]University of Cambridge

Presenting Author: **Hunter Schone**

The role of sensory variability in closed-loop sensorimotor control

Kassia Love[1], Marissa Rosenberg[2], Raquel Galvan-Garza[3], Torin Clark[4], Faisal Karmali[1]

[1]Mass Eye and Ear, [2]Space X, [3]Lockheed Martin, [4]University of Colorado - Boulder

Presenting Author: **Kassia Love**

Is implicit reward-based motor learning possible?

Nina van Mastrigt[1], Jonathan Tsay[2], Tianhe Wang[2], Guy Avraham[2], Sabrina Abram[2], Katinka van der Kooij[1], Jeroen B.J. Smeets[1], Rich Ivry[2]

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

Presenting Author: **Nina M. van Mastrigt**

Autonomic correlate of human motor learning and contextual inference

Atsushi Yokoi[1]

[1]National Institute of Information and Communications Technology

Presenting Author: **Atsushi Yokoi**

Neural mechanisms of eye-head coordination during active gaze redirection in mice

Brandie Verdone[1], Hui Ho Chang[1], Dale Roberts[1], Kathleen Cullen[1]

[1]Johns Hopkins University

Presenting Author: **Brandie Morris Verdone**

Neural correlates of online movement preparation

Mahdiyar Shahbazi[1], Giacomo Ariani[2], Andrew Pruszynski[1], Jörn Diedrichsen[1]
[1]University of Western Ontario, [2]Nature Human Behaviour

Presenting Author: **Mahdiyar Shahbazi**

12:30 – 15:00 SESSION 14, POSTER 4 & LUNCH

15:00 – 17:00 SESSION 15, PANEL VII

Novel perspectives on de novo learning

Organizer: **Kahori Kita**

Discussant: **Dagmar Sternad**

Kahori Kita[1], Lucas Dal'Bello[2], Amy Orsborn[3], Andrea d'Avella[4]
[1]Johns Hopkins University, [2]University of Tsukuba, [3]University of Washington, [4]IRCCS Fondazione Santa Lucia / University of Messina

17:00 - 18:00 SESSION 16, DISTINGUISHED CAREER AWARD TALK

The cerebellum – prediction in motor control and cognition

Chris Miall, *University of Birmingham*

18:00 – 19:00 CLOSING DRINKS RECEPTION

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TUESDAY APRIL 18, 2023

08:00 – 10:00 **SESSION 1, PANEL I**

Motivated movement: how reward shapes neural activity and behavior

Hee Jae Jang[1], Alaa Ahmed[2], Adam Smoulder[3], Becket Ebitz[4]

[1]New York University, [2]University of Colorado Boulder, [3]Carnegie Mellon University, [4]University of Montreal

Movements are often driven by the goal of garnering rewards. It is perhaps unsurprising then that the brain's pathways for reward processing and motor control are tightly intertwined. In subcortical structures, dopamine (DA) neurons both control movements and encode value and reward-prediction errors (RPEs). Reward signals are also found widely across the brain, including in frontal cortex regions involved in action selection and motor planning/execution (i.e. prefrontal, premotor, and primary motor cortex). This brain-wide entanglement of reward and movement processing is also evident in behavior, where reward invigorates movements and drives decisions. How does the brain integrate reward information into the movements it generates, and how and why does this process fail? In this panel, we will explore these questions in multiple brain areas (striatum, prefrontal and motor cortex) across multiple model organisms (rats, humans, monkeys). First, Hee Jae Jang will discuss how DA release in the striatum balances encoding of movement, reward value, and RPE at distinct timepoints. Using fiber photometry and chemogenetic manipulation in rats, Hee Jae's data suggest that the heterogeneous DA signals in dorsomedial striatum support value-based decision-making by promoting movement and learning at distinct timepoints for action policies. Second, Alaa Ahmed will detail the relationship between RPEs and movement vigor. Given DA's association with value representation as well as movements, DA signaling may be the brain's bridge linking greater rewards with more vigorous movements. Alaa's work uses human reaching experiments to logically extend this hypothesis by demonstrating that RPEs often encoded by subcortical DA cells influence movement vigor as well. Third, Adam Smoulder will explore how increased rewards can aid-then-interfere with motor planning. While performance typically improves with greater incentives, we sometimes "choke under pressure", failing when the stakes are highest. Using motor cortex recordings from rhesus macaques performing a reaching task, Adam will present evidence that reward interfering with motor planning is a potential neural mechanism of choking under pressure. Continuing in this theme, Becket Ebitz will consider how the brain generates mistakes: decisions that fail to maximize reward. Becket's work in the prefrontal cortex of nonhuman primates suggests that mistakes are the result of fundamental nonlinearities in reward processing that may offer advantages for behavior over long timescales, even when they cause failures in the moment. We will conclude with a 20 minute discussion on the influence of reward on motor behavior, decision making, and upstream neural activity, led by Paul Cisek.

10:30 – 12:30 SESSION 2, INDIVIDUAL I

Compositionality and high-dimensionality of motor cortex activity

Elom Amematsro[1], Eric Trautmann[1], Najja Marshall[2], Larry Abbott[1], Mark Churchland[1]
[1]Columbia University, [2]CTRL Labs
Presenting Author: **Elom Amematsro**

Neurons in M1 are anatomically closer to the muscles than those in V1 are to the photoreceptors. V1 neurons have a straightforward relationship to photoreceptor activation. A natural assumption is that M1 activity should have a similarly straightforward relationship with muscle force. Traditionally, 'straightforward' implied that individual-neuron responses should directly resemble muscle activity. Alternatively, 'straightforward' could imply a simple network strategy for generating muscle force. These views differ in their explanation of the fact that individual-neuron responses are complex and heterogeneous, and rarely mirror externally measured force (or its consequence, limb acceleration). In the force-encoding view, response complexity results from complexity of limb dynamics, sensory feedback, or encoding of additional task-relevant variables. In the network view, response complexity is a natural consequence of recurrent-network strategies that leverage a large null space; population-level signals that encode muscle force are dwarfed by null-space signals that don't. These views make very different predictions regarding what should occur if the task were simplified such that force becomes unambiguously central. To test these predictions, we employed a force-tracking task where essentially all task-relevant variables are tightly coupled with force. To intercept a scrolling dot path with a cursor, monkeys generated force, isometrically in a single direction. Thus, cursor position and velocity directly reflect force and its derivative. Because the arm doesn't move, limb dynamics are simple, muscle activity and force should be nearly identical (confirmed via motor unit recordings). The dominant source of proprioceptive feedback - muscle stretch - is proportional to force. Thus, under the traditional force-encoding perspective, neural activity should be particularly simple in this task, primarily reflecting force and its derivative. In contrast, under the network perspective this task is far from simple; it involves generating forces across a range of frequencies, possibly using multiple feedback-control strategies. We found that force was reliably encoded, but was a small signal, contributing ~10% of response structure. Motor unit responses were simple, yet M1 responses were complex, heterogeneous, and high-dimensional. Unexpectedly, we found that the null-space signals (those not resembling force) occupied different neural subspaces for different motor 'syllables'. For example, neural activity switched from one subspace to another as force switched from low to high frequency, even within a single trial. These results argue that M1 response complexity is not simply a consequence of physical complexity, but reflects network computations that employ a large null space. Furthermore, these results provide some of the first evidence that even seemingly unified movements may be composed from multiple distinct internal computational strategies.

Direct neural perturbations reveal a dynamical mechanism for robust cortical movement generation

Daniel O'Shea[1], Lea Duncker[1], Maneesh Sahani[2], Krishna Shenoy[1]
[1]Stanford University, [2]Gatsby Computational Neuroscience Unit
Presenting Author: **Daniel O'Shea**

The rich repertoire of skilled mammalian behavior is the product of neural circuits that generate robust and flexible patterns of activity distributed across populations of neurons. Decades of associative studies have linked many behaviors to specific patterns of population activity, but association alone cannot reveal the dynamical mechanisms that shape those patterns. Are local neural circuits high-dimensional dynamical reservoirs able to generate arbitrary superpositions of patterns with appropriate excitation? Or might circuit dynamics be shaped in response to behavioral context so as to generate only the low-dimensional patterns needed for the task at hand? Here, we addressed these questions within primate motor cortex by delivering optogenetic and electrical microstimulation (ICMS) perturbations during reaching behavior, while concomitantly recording local neural population responses. To accurately recover spiking activity during ICMS, we developed a signal processing algorithm to remove electrical artifacts on a nearby Neuropixel probe and validated its accuracy using synthetic ground truth datasets. We developed a novel analytic approach that relates measured activity to theoretically tractable, dynamical models of excitatory and inhibitory neurons. This computational model captured the dynamical effects of these perturbations and demonstrates that motor cortical activity during reaching is shaped by a self-contained, low-dimensional dynamical system. The subspace containing task-relevant dynamics proved to be oriented so as to be robust to strong non-normal amplification within cortical circuits. This task dynamics space exhibited a privileged causal relationship with behavior, in that stimulation in motor cortex perturbed reach kinematics only to the extent that it altered neural states within this subspace. Our results resolve long-standing questions about the dynamical structure of cortical activity associated with movement, and illuminate the dynamical perturbation experiments needed to understand how neural circuits throughout the brain generate complex behavior.

Self-generated vestibular prosthetic input updates forward internal model of self-motion

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

[1]*Johns Hopkins University*

Presenting Author: **Kantapon Pum Wiboonsaksakul**

The brain must differentiate between externally-generated and self-generated sensory inputs to build stable perception and generate appropriate behavior. Despite recent advances in neuroprostheses, little is known about how the brain interprets prosthetic sensory input, especially when self-generated. Here, we asked: How does the brain learn to distinguish self-generated prosthetic stimulation? To do this, we leveraged the well-understood neural pathways and behavior readouts of the vestibular system. In a monkey with bilateral vestibular deficits, we implanted a vestibular prosthesis that senses head rotation and transforms this movement into vestibular nerve stimulation, substituting for the damaged periphery. The monkey was trained to make eye-head coordinated gaze shifts between horizontal targets while the head, eye, and gaze positions were recorded. Each session comprised a three-block learning paradigm: baseline gaze-shifts, gaze-shifts with prosthetic stimulation, and washout without stimulation. We hypothesized that 1) prosthetic stimulation would first engage vestibular reflex pathways, resulting in impeded head movements and truncated gaze-shifts but also that 2) the brain would then update its internal model to account for this new sensory input and no longer engage the reflex when it is counterproductive. Consistent with our predictions, gaze position error initially increased after stimulation onset. Furthermore, this error then exponentially decayed within ~60 trials, with early washout trials showing oppositely-directed gaze position error, indicating a central adaptation rather than simply reflex suppression. We next asked whether the observed adaptation was due to updating a forward internal model (i.e., the brain's prediction of self-generated prosthetic sensory input) or instead was simply the result of updating the gaze controller's inverse model (i.e., the required motor command). To do this, we tested learning in a gaze adaptation paradigm where the target was jumped forward 5 deg. This learning, which requires mainly the updating of inverse model, demonstrated substantially slower adaptation (~300 trials), suggesting that the rapid learning seen during the stimulation paradigm was more likely due to the updating of forward internal model. Together, these results show that the brain can quickly learn to recognize self-generated prosthetic input to improve behavioral performance, likely by updating its forward internal model to predict and cancel out expected incoming sensory stimulation. Importantly, these findings provide new insights on how the brain interprets prosthetic sensory inputs to generate accurate behavior.

Descending control of turning during walking in Drosophila

Helen Yang[1], Quinn Vanderbeck[1], Laia Serratosa Capdevila[1], Anna Li[1], Jasper Phelps[2], Brandon Mark[3], Zetta AI LLC[4], John Tuthill[3], Wei-Chung Lee[5], Rachel Wilson[1]

[1]Harvard Medical School, [2]EPFL, [3]University of Washington, [4]Zetta AI LLC, [5]Boston Children's Hospital, Harvard Medical School

Presenting Author: **Helen Yang**

To understand how the brain controls behavior, we need to understand the neural code for movement. Descending neurons (DNs), which connect the brain to the nerve cord, represent a key bottleneck for motor control signals, and so provide an opportunity to study neural coding in a compact form. This is particularly the case in Drosophila, where the entire DN population consists of approximately 400 pairs of neurons. Most of these DNs are uniquely identifiable in the connectome of the central nervous system and are targetable with specific genetic drivers, allowing us to study their connectivity and physiology in parallel. Previous studies in Drosophila have concluded that DNs generate high-level motor commands, such as "stop" or "turn", leaving the detailed implementation to the circuitry of the ventral nerve cord. Here, we challenge this conclusion. First, we used two-photon calcium imaging to show that there are many DNs whose activity correlates with turning during walking. To understand their potential specializations, we focused on two of these cells, DNa02 and DNg13. We found that they have distinct synaptic inputs in the brain connectome and also distinct synaptic outputs in the ventral nerve cord connectome; this implies they can be recruited independently and that they drive different features of movement. We found that directly activating DNa02 shortens the stride on the inside of a turn, while activating DNg13 lengthens the stride on the outside of a turn. Using electrophysiological recordings in walking flies, we found that these neurons' spike rates are also correlated with these changes in stride, implying that DNa02 and DNg13 drive these leg movements during natural walking. Furthermore, we observed that DNa02 is mainly active during fast turns that arrest forward movement, whereas DNg13 is more broadly active, spiking during fast and slow turns regardless of forward movement. DNa02 is also recruited abruptly, whereas DNg13 is recruited gradually. Together, these results clearly show that DNs specify limb movements, rather than merely issuing high-level commands, and that different DNs are specialized to independently control different limb movement features. Our work illustrates how DNs can be recruited to execute a complex motor output with flexible kinematics and vigor.

Dynamical mechanisms of flexible pattern generation in spinal neural populations

Lahiru Wimalasena[1], Chethan Pandarinath[1], Nicholas Au Yong[2]

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

Presenting Author: **Lahiru Wimalasena**

Recent investigations into the coordinated activity of neuronal populations in motor circuits have revealed low-dimensional dynamical features hypothesized to support the generation of patterned motor output. However, such studies have typically relied heavily on simplifications-including trial-averaging and temporal smoothing-and are often analyzing cortical neural activity far removed from motoneuronal activity, the ultimate output of the motor system. Thus, it is not clear whether the uncovered dynamical descriptions are only useful for intuition-building, or whether they accurately capture the underlying mechanisms that allow motor circuits to achieve the temporal precision of motor control. Here, we investigate spinal interneuronal activity-the neural population in closest proximity to motoneuronal output-to determine the degree and precision with which spinal population dynamics shape muscle activity. We analyzed lumbar intermediate zone interneuronal population recordings along with simultaneous bilateral, intramuscular EMG recordings from two decerebrated T9 spinalized cats performing air-stepping. We computed firing rates of lumber interneurons in 10-ms bins and applied AutoLFADS, an unsupervised deep learning method to infer latent dynamics, for data from multiple sessions (cat1: 382 units, cat2: 295 units). AutoLFADS provided de-noised firing rate estimates for sorted single-unit activity, allowing us to analyze the relationship between spinal population dynamics and muscle activity on a single gait-cycle basis. Spinal population dynamics were highly predictive of multi-muscle activity on a moment-by-moment basis for individual gait cycles. However, the reverse was not true: the spinal activity could not be completely predicted from muscle activity, suggesting that spinal activity contained additional features not directly related to muscle output. We hypothesized that these additional features may contain timing mechanisms that handle the precise alternation of flexor and extensor muscle activations to generate stable gait. Specifically, we investigated the relation between the spinal population activity and the ipsilateral extensor muscle (biceps femoris anterior) burst duration, which ranged from 200- to 900-ms for individual steps and varied in correspondence with the length of the gait cycle. We discovered oscillatory dynamics within the spinal population activity that occur during extensor bursts, and found that the amount of time that the spinal population state oscillated was highly predictive of single-gait cycle variations in extensor burst duration (cat1: 492 cycles, $r = 0.95$; cat2: 446 cycles, $r = 0.81$), precise to within tens of milliseconds (linear model prediction error, mean /- SEM: cat1: 30 /- 1 ms, cat2: 51 /- 2 ms). These results reveal low-dimensional dynamical features in spinal interneuron activity that may be integral in enabling flexible pattern generation and controlling timing variations in motor output.

A novel neural framework to assess movement control at the spinal motor neuron level

Francois Hug[1], Simon Avrillon[2], Dario Farina[2]
[1]Universite Cote d'Azur, [2]Imperial College London
Presenting Author: **Francois Hug**

To simplify the production of movement, it has been proposed that the number of controlled variables is reduced through the combination of muscle synergies. The fact that synergies are classically identified from interference electromyographic signals implies that the smallest unit of analysis is the muscle. However, each muscle is composed of hundreds of fibers gathered in small groups (motor units), each group is innervated by a single spinal motor neuron. Thus, it is evident that the muscle is not at the lowest level of movement control. Rather, the spinal motor neurons, as the "final common pathways" of the neuromuscular system, are the quanta of the neural control signals to muscles. We will present a series of recent work where we changed the scale at which we observe and interpret the control of movement, i.e. from the muscles to the spinal (alpha) motor neurons. Specifically, we propose a new conceptual framework of the neural control of movement, which merges the concept of common input to motor neurons and modular control, together with the constraints imposed by recruitment order. This framework is based on the following assumptions: (1) motor neurons are grouped into functional clusters (motor neuron synergies) based on the common inputs they receive; (2) clusters may significantly differ from the classical definition of motor neuron pools, such that they may span across muscles and/or involve only a portion of a muscle; (3) clusters represent functional modules used by the central nervous system to reduce the dimensionality of the control; and (4) selective volitional control of single motor neurons within a cluster receiving common inputs cannot be achieved. We will present an approach based on graph theory to identify these motor neuron synergies during single-joint and multi-joint isometric tasks. This approach involves the recording of high-density surface electromyography from multiple muscles, and the decomposition of these signals into motor neurons spiking activity. These activities are then analyzed by identifying their common low-frequency components, from which networks of correlated activity to the motor neurons are derived and interpreted as motor neuron synergies. This approach can identify the number of 'common' inputs to motor neurons and their respective synaptic weights. We will present the validation of this approach on a model of 100 motor neurons driven by a known number of common inputs with fixed synaptic weights for each motor neuron. Furthermore, we will present a series of experimental data, which support the predictions made by our novel neural framework.

15:00 – 17:00 SESSION 4, PANEL II

Are memories active?

Aaron Batista[1],Dagmar Sternad[2], Steve Chase[3], Se-Woong Park[4], Rachel Swanson[5], Jon Wolpaw[6]

[1]University of Pittsburgh, [2]Northeastern University, [3]Carnegie Mellon University, [4]University of Texas at San Antonio, [5]New York University, [6]National Center for Adaptive Neurotechnologies

How do memories endure over time? Consider riding a bike. If you go for decades without riding, you do not lose the skill. Does this mean that the neural substrate encoding this skill remains unchanged? Or, has it changed, due to time and intervening experiences, but in a manner that still preserves skilled performance? This panel presents evidence, drawn from across brain regions, analysis scales, and skill types, that memories are active. The traditional concept of memory as a passive entity that is accessed when needed was suitable for the 1970s conception of a mostly hardwired CNS. By this view, memories were thought to be stored in special sites, specifically in a supposedly small number of modifiable synapses. Since then, new insights have made this concept obsolete. First, it is now clear that the CNS, from cortex to spinal cord, remains ubiquitously plastic through life. Driven largely by activity, neuronal properties change at every level - synapses, dendrites, axons, and hormones; glia change and vasculature changes; in some regions, new neurons can appear. Second, skill substrates are not sequestered to special sites; the plasticity comprising them is widely distributed through the CNS. What are the implications of these insights? How does bike-riding survive for decades in a continually changing CNS? A possible solution is that memories are active - their neural substrates can change, even when their corresponding behaviors are not being performed. The four talks consider, from different perspectives, the premise that memories are active. - Aaron Batista offers a brief overview before the talks, and moderates a panel discussion afterward. - Dagmar Sternad and Se-Woong Park examine the long-term practice and retention of motor skills from a behavioral perspective. They show evidence for stable 'memories' in a bimanual polyrhythmic task. What is retained and what is lost over long practice and what can adapt to other task demands? - Steve Chase presents evidence that the representation of a movement in motor cortex is altered by later learning, indicating that memories might be changing their neural substrates to accommodate newly learned skills. - Rachel Swanson considers the active maintenance of memories in the hippocampus and discusses the relation between systems consolidation during sleep and representational drift. Her talk extends the evidence that memories can be active beyond the motor system. - Jon Wolpaw's message is that such insights invite a new paradigm for considering how skills are preserved. By introducing the concepts of "heksors" and the "negotiated equilibrium" of CNS properties that heksors create, he offers a new paradigm in which heksor plasticity ensures skill stability through life. - The panel concludes with a discussion focused on the themes emerging across the talks.

08:00 – 10:00 SESSION 5, PANEL III

The neural control of movement through the lens of evolution

Terence Sanger[1], Andreas Kardamakis[2], Leah Krubitzer[3], Paul Cisek[4]
[1]University of California, Irvine, [2]Universitas Miguel Hernandez, [3]University of California, Davis, [4]University of Montreal

Like all biological entities, nervous systems are products of evolution. They were constructed through a long process of gradual modifications, each defined within the developmental constraints of a given ancestral population and sculpted by the demands of survival in a particular niche. Consequently, the resulting circuits and mechanisms are not always readily interpretable in terms of their functional roles in modern animals or in terms of normative theories of how the nervous system should be organized. Nevertheless, a growing body of comparative and developmental data makes it increasingly possible to reconstruct the sequence of modifications that took place in our evolutionary history, providing valuable insights that can constrain theory development and, we believe, help to make better sense of data that might otherwise appear inexplicable. In this panel, we will discuss some of the potential insights that considerations of evolutionary history offer for theories and studies of the neural control of movement. Terry Sanger will begin with a computational perspective, describing how simple control systems set the stage for more complex ones. This will start from basic reflexes to state-dependent control and to multi-step autonomous behaviors based on reward prediction, discussing corresponding innovations in biological circuits. Andreas Kardamakis will take a closer look at some of the specific innovations. In particular, he will describe recent work in his lab comparing the retino-colliculo-spinal circuits involved in visually guided orientation behavior in mice to homologous circuits previously identified in lamprey. Leah Krubitzer will describe how the cerebral cortex was elaborated from early mammals to modern species, including primates. In particular, she will discuss how sensorimotor maps have adapted to species-typical behavioral capacities along different lineages. Paul Cisek will return to computational questions in the context of a summary of the evolutionary history of the lineage that produced primates. He will suggest how the expansion of the behavioral repertoire led to an architecture consisting of parallel and nested behavioral control circuits, including specialized cortical action maps as well as cortico-striatal circuits that arbitrate among them. Finally, Megan Carey will moderate a discussion among members of the panel and the audience, focusing on the implications of evolutionary perspectives for current theories of the neural control of movement and new approaches for studying it.

10:30 – 12:30 SESSION 6, PANEL IV

Internal models: From systems to circuits

Megan Carey[1], Andrew Pruszynski[2], Abigail Person[3], Javier Medina[4]
[1]Champalimaud Center for the Unknown, [2]Western University, [3]University of Colorado, [4]Baylor College of Medicine

The concept of internal models has been extremely influential for the study of motor control. This panel will bring together research from a variety of behaviors and brain systems, including control of reaching movements, locomotion, and associative learning, to discuss recent progress in our understanding of how internal models are implemented by the brain. First, Andrew Pruszynski and Abigail Person will discuss internal models for the control of reaching movements in humans, monkeys, and mice. They will present recent results that suggest how internal models are represented in cerebral cortex and cerebellum and how they contribute to voluntary, reflexive, and adaptive control. Next, Megan Carey will present recent evidence that individual cerebellar Purkinje cells simultaneously encode movements of multiple limbs and body parts and discuss how this information could be used within an internal model framework to achieve precise coordination of whole-body movement during locomotion. Finally, Javier Medina will describe associative learning experiments in mice that reveal how recurrent cerebellar circuits can form distinct modules to implement inverse and forward models, allowing the cerebellum to rapidly generate accurate motor commands.

15:00 – 17:00 SESSION 8, INDIVIDUAL II

Dynamic synchronization between hippocampal spatial representations and the stepping rhythm

Abhilasha Joshi[1], Eric Denovellis[1], Abhijith Mankili[1], Yagiz Meneksedag[2], Thomas Davidson[1], Anna Gillespie[1], Jennifer Guidera[1], Demetris Roumis[1], Loren Frank[1]

[1]University of California, San Francisco, [2]Hacettepe University

Presenting Author: **Abhilasha Joshi**

The hippocampus is a mammalian brain structure that expresses spatial representations and is critical for navigation. Navigation in turn intricately depends on locomotion; however, current accounts suggest a dissociation between hippocampal spatial representations and the details of locomotor processes. Specifically, the hippocampus is thought to primarily represent higher-order cognitive and locomotor variables like position, speed, and direction of movement, while the limb movements that propel the animal are thought to be computed and represented primarily in subcortical circuits, including the spinal cord, brainstem, and cerebellum. Whether hippocampal representations are actually decoupled from the detailed structure of locomotor processes remains unknown. To address this question, we simultaneously monitored hippocampal spatial representations and ongoing limb movements underlying locomotion at fast timescales. We found that the forelimb stepping cycle in freely behaving rats is rhythmic and peaks at ~8 Hz during movement, matching the ~8 Hz organization of information processing in the hippocampus during locomotion. We also discovered precisely timed coordination between the time at which the forelimbs touch the ground ('plant' times of the stepping cycle) and the hippocampal representation of space. Notably, plant times coincide with hippocampal representations closest to the actual position of the animal, while in-between these plant times, the hippocampal representation progresses towards possible future locations. This synchronization was specifically detectable when animals approached upcoming spatial decisions. Taken together, our results reveal profound and dynamic coordination on a timescale of tens of milliseconds between central cognitive representations and peripheral motor processes. This coordination engages and disengages rapidly in association with cognitive demands and is well suited to support rapid information exchange between cognitive and sensory-motor circuits.

Neural basis of skilled behaviors

Adam Hantman[1]

[1]University of North Carolina-Chapel Hill

Presenting Author: **Adam Hantman**

Skillful movements contribute to the major functions of the brain, including perception and manipulation of the world. Skill involves understanding the world, developing appropriate plans, converting those plans into appropriate motor commands, and adaptively reacting to feedback. Considering the range of possible actions and the complexity of musculoskeletal arrangements, skilled motor control is an amazing achievement of the nervous system. The underlying operations for skill are likely performed by the collaboration of a diverse set of neural circuits. By combining anatomy, multi-site physiology, and specific (genetic and temporal) manipulations, we attempt to identify and understand the neural elements responsible for skillful motor control. We study a reach to grab to eat task in rodents. We have shown that the initiation and the continued execution of this behavior depends on motor cortex. However, cortex does not operate as an autonomous dynamical system, rather cortical dynamics depend on external inputs from the thalamus. By dissecting the role of inputs from each subdivision of motor thalamus, we attempt to identify how subcortical systems provide critical inputs for constructing the cortical dynamics. Additionally, we follow cortical activity to downstream targets in effort to understand how each of these outputs contributes to the generation of behavior. Thus, my lab strives to achieve a brain-wide understanding of the neural dynamics underlying skilled behaviors.

Slower cortical responses during balance recovery associated with nonparetic postural compensation and stiffer biomechanical reactions in people post stroke

Jacqueline Palmer[1], Aiden Payne[2], Jasmine Mirdamadi[3], Lena Ting[3], Michael Borich[3]
[1]*University of Kansas Medical Center,* [2]*Florida State University,* [3]*Emory University*
Presenting Author: **Jacqueline Palmer**

Balance impairments after stroke are common but poorly understood. An impaired ability to utilize the paretic leg rapidly and effectively after stroke may bias compensatory utilization of the nonparetic leg for balance control. Stiffer biomechanical strategies for balance control are also common after stroke, contributing to lower resilience to postural perturbations and increased fall risk. Measuring evoked cortical responses with electroencephalography (EEG) during standing balance reactions, we recently found that older adults with lower balance function elicited greater cortical activity during balance recovery (Palmer et al., 2021), suggesting increased reliance on the cerebral cortex for postural stability. Thus, the inability of older individuals to engage the cerebral cortex during balance recovery could contribute to balance deficits in the presence of a brain lesion affecting cortical and subcortical brain regions, such as stroke. However, the role of the cerebral cortex in post-stroke balance control is poorly understood. We hypothesized that the ability to engage the cerebral cortex rapidly and effectively during balance reactions plays a functional role during post-stroke balance-correcting behavior, particularly when the paretic leg is necessary to recover balance. We recorded brain activity using EEG and concurrent kinetics and kinematics in older adults with (n=18) and without (n=16) chronic (>6mo) stroke during balance recovery from standing postural perturbations. To test differences in evoked cortical activity when balance recovery was more reliant on the paretic vs. nonparetic legs, we presented posterolateral support surface translations that preferentially biased either the paretic leg, the nonparetic leg, or equal legs for balance recovery. We identified cortical activity metrics of onset latency, the peak amplitude, and peak latency of the first (100-400ms) robust negative cortical evoked potential over the midline sensorimotor region (Cz) post perturbation. Consistent with our hypotheses, our results revealed slowed and attenuated perturbation-evoked cortical responses to balance destabilization after stroke, regardless of perturbation condition. Compared to the paretic bias and equal limb conditions, the fastest onset of evoked cortical activity occurred during biased nonparetic leg balance recovery. Individuals with slower evoked cortical responses during the biased paretic leg condition had greater weight-bearing reliance on the nonparetic limb for standing posture immediately prior to perturbation onset and demonstrated stiffer biomechanical strategies (i.e., wider margins of stability) for balance recovery. These findings reveal electrophysiologic biomarkers of post-stroke balance-correcting behavior that are linked to nonparetic postural compensation and impaired biomechanical strategies for balance recovery and have important clinical implications for rehabilitation of balance and fall prevention.

Characterization of locomotor adaptation and generalization dynamics from high-dimensional neuromuscular data

Dulce Mariscal[1], Krista Fjeld[1], Gelsy Torres-Oviedo[1]
[1]*University of Pittsburgh*
Presenting Author: **Dulce Mariscal**

Humans can adapt their gait to compensate for changes in environmental demands and generalize learned movements from one situation to another. One way to study the process that underlays locomotor adaptation is by exposing participants to split-belt treadmill walking; this paradigm induces robust changes in gait parameters. Additionally, we can study generalization by contrasting the adaptation effects (i.e., aftereffects) that participants exhibit in the same (treadmill) or different (overground) contexts from the adaptation. Here we propose a novel approach for characterizing locomotor adaptation by analyzing muscle activation patterns. We ask what processes underly the adaptation of neuromuscular patterns and what aspects are observed during post-adaptation (treadmill) and generalization (overground). This information helps identify transient vs. longer-lasting and generalizable motor patterns following split-belt walking. We hypothesize that at least two processes with distinct dynamics underly the changes in neuromuscular patterns during locomotor adaptation and de-adaptation. Specifically, we posit that a fast reactive process will recruit a neuromuscular pattern to maintain balance at every transition between walking environments. Whereas a slow adaptive process will forge a contextual pattern meeting the demands of the novel split environment, this pattern will be slowly disengaged during post-adaptation (tied walking) on the treadmill and will not be used during overground post-adaptation due to environmental changes. Twenty-four young adults (<40 yrs. old) experienced split-belt walking during their adaptation, and their de-adaptation was measured on either the treadmill (n=12) or overground (n=12) walking. We used a data-driven approach to measure the reactive and contextual patterns to reproduce the evolution of muscle activity during the split-belt walking paradigm. Our analysis showed that during adaptation, the reactive component emerges quickly upon introducing the split-belt perturbation but is rapidly mitigated as individuals adapt their gait. In contrast, the contextual pattern slowly develops during the adaptation period. During treadmill de-adaptation, the reactive patterns are quickly recruited to maintain their balance, whereas the contextual pattern gradually disengages. Conversely, during overground de-adaptation, the reactive and the contextual patterns are recruited to a lesser extent. Our results suggest that reactive and contextual patterns contribute to the evolution of neuromuscular patterns during split-belt walking. However, the generalization of these patterns to walking without the training device is much smaller, contributing to the smaller kinematic aftereffects previously reported during walking overground. These findings provide insights into locomotor adaptation features beyond those drawn from traditional kinetic or kinematic analyses.

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

Presenting Author: **Bence Bagi**

Precise movement execution often relies on adequately planning the upcoming action, a process that is largely mediated by the dorsal premotor (PMd) and primary motor (M1) cortices. Due to their anatomical and functional similarities, PMd and M1 are commonly assumed to contain similar planning-related information and are often analyzed together. Here we show that when planning movements under uncertainty, the activity of PMd and M1 neural populations show distinct features, suggestive of area-specific functions. We analyzed simultaneous single-unit recordings from populations of PMd and M1 neurons from monkeys performing both a standard center-out reaching task, and a task requiring them to plan reaches based on uncertain visual information about the target's location (Dekleva et al. eLife 2016). We investigated how uncertainty shaped planning activity by computing area-specific "latent dynamics" using principal component analysis during the instructed delay epoch. First, we asked whether having uncertain information about the targets' location compared to being presented with explicit, veridical targets led to detectable changes in neural population activity. Even though monkeys had to produce similar movements and the subspaces spanning the preparatory activity were well aligned between the uncertainty and standard center-out reaching tasks, different cue types might make monkeys identify different tasks as different contexts. Indeed, the latent dynamics for these two tasks occupied separate parts of neural state space, allowing linear classifiers to identify task identity based on inter-trial activity --- especially in M1. In the uncertainty task, both PMd and M1 latent dynamics contained information about reach direction, as well as the uncertainty level associated with the visual cues. However, the relative importance of these two signals varied across areas: M1 activity was mainly organized by reach direction, while in PMd uncertainty was dominant. Yet, for both regions, the axes needed to linearly decode uncertainty and reach direction were orthogonal to each other, supporting the view that orthogonal subspaces may enable separate computations. Another intriguing difference between PMd and M1 was that their activity contained qualitatively different information about the intended movement: decoding performance using PMd activity integrated through time resembled that of instantaneous decoding from M1 latent dynamics, even after subsampling neurons to match firing rate statistics between areas. This result suggests that, in agreement with their relative position along the neuraxis, M1 might integrate PMd activity to formulate a final motor plan. Thus, despite their apparent similarities, when target information is not clearly specified, PMd and M1 may become primarily involved in different aspects of planning an upcoming movement.

Cerebellar granule cells and climbing fibers jointly acquire signals to learn reward timing

Mark Wagner[1], Martha Garcia Garcia[1], Lina Takemaru[1], Akash Kapoor[1], Oluwatobi Akinwale[1], Tony Hyun Kim[2], Casey Paton[3], Mark Schnitzer[2], Liqun Luo[2], Ashok Litwin-Kumar[4]

[1]National Institutes of Health, [2]Stanford University, [3]Cornell University, [4]Columbia University

Presenting Author: **Mark Wagner**

The cerebellum is widely viewed as a structure for generalized learning of predictions from its inputs, which range from body sensory organs to neocortical cognitive zones. Decades-old cerebellar learning theory posits that when a Purkinje (Pkj) cell receives a climbing fiber (CF) input spike, any of its 100,000 granule cell (GrC) synaptic inputs that were active immediately prior are weakened. Thus, the Pkj cell acts as an adaptive filter of its GrC inputs, with plasticity directed by the CF covariance learning rule. However, recent discoveries of cerebellar reward expectation signals separately in the GrC pathway and the CF pathway have been difficult to reconcile with classical covariance learning theory: GrCs are densely active for sustained periods of time; the CF signals can be difficult to interpret as "errors," and some signals only emerge as animals learn reward-driven skills. As a result, it remains unclear how reward signals in GrCs and CFs relate to one another, and what learning they might direct in Pkj cells. Decrypting cerebellar computations thus plainly requires understanding joint GrC-CF dynamics. Yet surprisingly, GrC and CF activity have yet to observed simultaneously or related to learning and behavior. To investigate this, we devised the first simultaneous recordings from populations of GrCs and CFs, using dual-color two-depth two photon $Ca2+$ imaging over days of learning of reward-driven operant behavior. Learning yielded reciprocal GrC-CF reward signaling: in anticipation of expected reward, there was widespread GrC activation coinciding with CF spike suppression, whereas reward delivery triggered GrC de-activation and a large-scale CF spike burst--and the latter did not abate with learning, contrary to an "error signal." We show that this learned pattern of GrC anticipatory activation yields more accurate reward timing information. To determine whether CFs make this timing information available to Pkj cells, we used known GrC-CF plasticity rules to predict GrC-Pkj LTD from our data. This resolved two key nonclassical phenomena into a new reward timing computation. Specifically, widespread GrCs with pre-reward spiking sustained over a range of timescales, combined with a constant, reward-evoked CF burst, can produce a graded distribution of synaptic strengths across the GrC ensemble: GrCs with earlier anticipatory activity will undergo LTD less often than those with activity sustained closer to the reward. Downstream Purkinje cells can therefore decode time to reward over an entire second-long delay period--despite CF-plasticity acting over only the prior ~150 ms. We thus provide a specific and mechanistic cerebellar reward timing computation. Moreover, whereas classical theory stipulated cerebellar involvement only in short-timescale association learning, our data suggests a mechanism for learning predictions over longer timescales, which are likely to be important in more volitional or cognitive movement contexts.

08:00 – 10:00 SESSION 9, PANEL V

Age- and disease-related changes in the cerebellum impact motor function

Jean-Jacques Orban de xivry[1], Di Cao[2], Jovin Jacobs[3], Alanna Watt[4]
[1]KU Leuven, [2]Johns Hopkins University, [3]Champalimaud Centre for the Unknown, [4]McGill University

The cerebellum plays multiple roles in skilled motor function, including maintaining calibrated movement, error correction, prediction of target motion, and internal model simulation. These functions are not specific to a particular movement or limb. Given its importance, cerebellar injury or degeneration can have devastating consequences. Cerebellar dysfunction leads to a range of motor symptoms including impaired inter-joint coordination, inaccurate movements, balance problems, and inability to perform repeated movements. Yet, we are missing a link between the structural changes in the cerebellum that are caused by age and disease (mostly in animal models) and the changes in function (mostly in human studies). The goal of this panel is to bridge this gap by providing an overview of the links between age- or disease-related changes in the cerebellum and their impact on motor function. This overview will be based on animal models and human data on both healthy aging and cerebellar degeneration. It will span different tasks (reaching, locomotion, etc.) and different techniques (electrophysiology, pharmacological manipulation, mathematical modeling). Jean-Jacques Orban de Xivry will present new results on the effect of aging on cerebellar motor tasks. He will suggest the existence of a motor reserve, similar to the idea of a cognitive reserve. Di Cao will present data she collected during COVID using a "ship-to-home" VR system. Her data reveal the structure of computational deficits in feedforward and feedback control pathways for individuals with cerebellar ataxia. Using a control-theoretic experimental approach, we found that damage to the cerebellum does cause two computational deficits: cerebellar damage increases time delay on both pathways and reduces the ability to extract useful information from time-lead (preview) information. Alanna Watt will discuss recent work from her lab demonstrating that similar cellular changes occur in Purkinje cells in the mouse cerebellum in both aging and ataxia. Jovin Jacobs will present recent work on how loss of Purkinje cell/granule cells in adult mice affects locomotion and locomotor learning. He will show that; 1) the behavioral effects largely overlap with that seen in Purkinje cell degeneration mice, 2) that the effects scale as a function of cell death magnitude and 3) that the data suggests locomotion is more resilient to loss of Purkinje cells than granule cells. Together, this panel will aim at highlighting how much change in cerebellar structure leads to actual changes in motor function and what are the key components for understanding the link between cerebellar structure and function. It will also provide the opportunity to discuss how understanding how age- and disease-related changes in cerebellum can teach us about cerebellar function.

10:30 – 11:05 EARLY CAREER AWARD PRESENTATION AND TALK

Understanding how the brain controls movement through neural manifolds

Juan Alvaro Gallego, *Imperial College London*

The activity of populations of single neurons underlying behavior is well captured by relatively few population-wide patterns. Intriguingly, the study of these activity patterns—the “latent dynamics”—has shed light into questions about cognition, motor control, and learning that had remained elusive when focusing on the activity of individual neurons.

In this talk, I will give an overview of our work to understand the neural basis of motor control and learning from this perspective. This research is based on the hypothesis that the latent dynamics arise from “neural manifolds” that reflect fundamental biophysical constraints on circuit function. Under this assumption, first I will show that animals generate the same latent dynamics as they perform the same covert or overt behavior on different days, which we can uncover even when we record from different neurons. Second, I will show how adopting this framework reveals large similarities in neural manifolds underlying a variety of reaching and wrist manipulation tasks, even if the properties of single neurons change dramatically across them. Third, I will provide evidence that adopting this framework helps identify region-specific contributions to motor adaptation. Finally, I will present recent results showing that even if each animal has a brain that is unique, individuals from the same species that are engaged in the same behavior share preserved latent dynamics.

Thus, the study of neural manifolds and their associated latent dynamics provides insights into how individual animals both consistently and flexibly perform a variety of behaviors, and may enable principled studies across groups of individuals, and even comparative studies across different species.

11:05 – 12:45 SESSION 10, PERSPECTIVE

Combining electrical stimulation and behavioral training to restore motor control after injury: Finally a reason for optimism?

Ismaél Seanez[4], Elvira Pirondini[1], Monica Perez[2], John Krakauer[3]

[1]University of Pittsburgh, [2]Shirley Ryan AbilityLab, [3]Johns Hopkins University and The Santa Fe Institute, [4]Washington University

Decades of basic research in animals and humans provided evidence that changes in the CNS can lead to behavioral improvements after damage to the motor system after either stroke or spinal cord injury. However, despite this knowledge, we still lack a therapeutic approach that achieves much beyond what can be expected from spontaneous biological recovery. As a result, most rehabilitation approaches emphasize compensatory strategies rather than true restoration. In exciting parallel advancements in neuro-technologies for animal and human research offered new tools to investigate and manipulate the neural activity of specific populations of neurons across the entire nervous system. In consequence, against this somewhat pessimistic backdrop, we will suggest that recent results from new studies in humans and non-human primates using these tools and combining intense behavioral training and electrical stimulation provide reason for optimism. Dr. Elvira Pirondini will open the panel with discussing the neural changes that occur both at single cell and a neural population level in non-human primate after a sub-cortical stroke and showing how the investigation of these changes led to the development of a novel deep brain stimulation approach to treat post-stroke motor deficits. Dr. Ismael Seáñez, will then shift toward human applications of electrical spinal cord stimulation. Specifically, he will discuss the neural mechanisms behind improvements in muscle recruitment selectivity by non-invasive technologies, and why understanding these is crucial for translation into effective rehabilitation strategies. Dr. Monica Perez will then show that electrical and magnetic stimulation can be used to tap into ancestral mechanisms of synaptic plasticity to boost functional recovery in people with spinal cord injury highlighting the relevance of working on protocol optimization. Finally, Dr. John Krakauer will close the panel, by summarizing the evidence accumulated so far and discussing the very concept of recovery, compensation and plasticity after injury. The open discussion will revolve around an important question: are we ready now to design technologies that can really improve the life of people with motor deficits?

08:00 – 10:00 **SESSION 12, PANEL VI**

Aligned neural population dynamics provide a stable window onto motor intent

Fabio Rizzoglio[1], Xuan Ma[1], Carlos Vargas-Irwin[2], Joanna Chang[3]
[1]Northwestern University, [2]Brown University, [3]Imperial College London

The interconnected networks of neurons generate coordinated activity that plans and executes our highly varied motor behaviors. Within this varied movement repertoire are many stereotypic behaviors that tend to be preserved across individuals, despite the idiosyncratic neural circuitry of any given individual's brain. An obvious question is whether there may be a shared neural representation of these preserved behaviors, or that each individual has found a unique solution to a shared problem. Experimental work has shown that the space of observed neural activity patterns is constrained to a low-dimensional manifold. Perhaps the signals within this latent space might contain a stable representation across individuals. However, as the manifold is embedded in a space with ever-changing neurons over time, comparisons of population activity across individuals seem impossible. Recently, though, it has been shown that a consistent image of motor intent over time can be recovered, at least for highly stereotypical tasks, if one performs a change of basis and "aligns" the manifolds from a given day to that of another day. This has enabled fixed decoders to make accurate predictions over periods as long as two years. Might similar alignment methods allow us to address the question of how motor intent for shared behaviors is represented across individuals? Our work addresses this question across several species and types of motor behaviors. We have discovered that latent spaces are preserved not only across time, but also across individuals of several species and different brain areas, extending even across human and non-human primates performing (or attempting to perform) the same behavior. A similar phenomenon is also observed in the same individual but for the case of different behaviors, with a significant portion of neural covariance pattern preserved across quite varied movements. Carlos Vargas-Irwin will introduce the cross-individual analysis and show that neural population patterns in primary motor cortex (M1) and ventral premotor cortex are preserved across monkeys performing reach and grasp. Joanna Chang will expand on these concepts by showing preserved latent dynamics across the dorsolateral striatum of mice grasping and pulling a joystick, as well as across M1 of monkeys performing a reach task under both overt and covert conditions. Fabio Rizzoglio will discuss how the consistency of task representation extends across species, showing that the latent dynamics in the neural manifold of a monkey can be aligned to those of a human with a paralyzed arm attempting to do the same task and that such aligned latent dynamics allowed to make EMG predictions without computing a new decoder. Xuan Ma will expand the topic of the panel to the cases of different motor tasks, showing that neural manifolds in monkey M1 are partially preserved across multiple unconstrained grasping movements, even though the limb states and contexts vary greatly.

How does the cortical hand representation change following amputation? A pre- and post-amputation fMRI study

Hunter Schone[1], Mathew Kollamkulam[2], Craig Gerrand[3], Norbert Kang[4], Alexander Woollard[4], Imad Sedki[3], Roni Maimon Mor[2], Chris Baker[1], Tamar Makin[5]

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Sensorimotor experiences throughout our lifespan are thought to shape the neural representation of the body. What happens to the adult brain when it loses a key source of input, for example, following the amputation of an arm? Recent research has demonstrated that despite decades of input loss, and presumed mechanisms for cortical plasticity, the sensorimotor system of amputees preserves the representation of a missing hand. Does this persistent hand representation reflect a canonical representational structure, e.g. due to local network homeostatic constraints, which is stable independently of experience (e.g. innate)? Or does the preserved representational structure reflect a lifetime of sensorimotor experiences with the missing hand? Prior cross-sectional designs addressing this question conflate within- and between-subject variability with respect to the missing hand representation. Here, we longitudinally investigated the stability of the hand representation, before and after hand amputation. Using functional MRI, we interrogated the representational structure underlying activity elicited by real hand movements (pre-amputation) and phantom hand movements (post-amputation). Over a 7-year period and across 10 UK clinic sites, we recruited 10 patients preparing to undergo hand amputations. Due to a multitude of factors (e.g., complications during surgery, MRI safety contraindications, no hand motor control, poor physical mobility etc.), we successfully managed to complete testing on 1 patient with a planned unilateral hand amputation to remove a soft-tissue sarcoma on the right forearm. The patient was scanned twice pre-amputation surgery and at two separate time-points post-amputation: 3 months and 6 months. Additionally, we scanned 15 age-matched able-bodied control participants across the same timescale (60 scans in total). Using both mapping of digit topography and representational similarity analysis, we show a remarkably consistent inter-digit representational structure of the pre-amputation hand and the post-amputation phantom (missing) hand. Overall, this work provides the first pre- and post-amputation longitudinal evidence for preserved representation of the phantom (missing) hand following amputation.

The role of sensory variability in closed-loop sensorimotor control

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Neural noise (i.e., variability [1]) affects various sensory and motor processes. In closed-loop motor control tasks like postural control, where motor outputs are sensed by sensory organs and used to plan new motor commands, it is thought that performance is degraded due to neural noise in sensory and motor systems. However, understanding the role of noise in closed-loop control is complicated because variability in the motor output is fed back into the sensory inputs, and thus the problem has been studied using both computational models and experiments. For example, closed-loop postural models posit that postural sway arises from neural noise [2, 3]. Likewise, perceptual thresholds, which are thought to assay sensory noise, are correlated with postural sway. To further support the hypothesis that sensory noise degrades performance in

closed-loop orientation control, we combined: 1) closed-loop computational models; 2) vestibular perceptual threshold from individual subjects as assays of individual sensory noise; 3) experimental performance in a closed-loop task. We modeled a task for which we have published experimental results [4]. Subjects sat in the dark on a motorized chair that could be roll-tilted using a joystick. Subjects used the joystick to align themselves with their perceived upright while they experienced a random disturbance. Behavioral variability was quantified by the standard deviation of chair tilt angle over time. Performance in different gravity environments was also studied using a centrifuge. In the closed-loop model, sensed tilt orientation was used to determine joystick commands. Consistent with decision-making theory, we assumed that subjects would only move the joystick when they had reliable vestibular information - i.e., the sensed tilt exceeded their sensory noise. Each subject also had an individual "effort" that determined how intensely they reacted to an error. Model predictions closely followed experimental [4] behavior, and had similar frequency-domain responses. We found lower behavioral variability (i.e., better performance) in subjects with lower vestibular thresholds (i.e., less neural noise); modeling and experimental results had a similar slope for the relationship between behavioral variability and thresholds. This strongly supports the hypothesis that vestibular noise worsens behavioral variability in closed-loop control. To ensure robustness, we tested variations of the model elements and found little difference in results. Finally, in both model and experimental [4] results, we found lower behavioral variability (i.e., better performance) in higher G levels, supporting the hypothesis that higher G level increases the vestibular signal-to-noise ratio, resulting in better performance. 1. Diaz-Artiles & Karmali. Neuroscience, 2021. 468: p. 282. 2. Kuo. J Neural Eng, 2005. 2(3): p. S235. 3. van der Kooij & Peterka. J Comput Neurosci, 2011. 30(3): p. 759. 4. Rosenberg. J Neurophysiol, 2018. 120(6): p. 3187

Is implicit reward-based motor learning possible?

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People can modify the way they move based on information whether they failed or succeeded on previous attempts. This has been shown in paradigms that gradually shift rewarded center-out reaches to study learning to compensate for this shift ('visuomotor rotation'). Usually, rotations are relatively large (15-25°) and learning is considered largely explicit. Here, we test whether binary feedback about success or failure can also elicit implicit learning in response to a visuomotor rotation, and if so, whether use-dependent learning drives this learning. Participants made fast, center-out reaching movements, trying to make their invisible hand pass through a visual target. Feedback was limited to a tone indicating whether they succeeded or failed in crossing a reward zone. We shifted the reward zone incrementally away from the target to induce learning. In the "Small" perturbation group (n=20), the reward zone was shifted 7.5°. In the "Large" perturbation group (n=28), the shift was 25°. After finishing the learning phase, we measured aftereffects to quantify implicit adaptation. We told participants that the feedback might have been perturbed. For the subsequent trials without feedback, we instructed them to reach straight to the target to encourage participants to stop using a possible aiming strategy that they might have developed. In these no-feedback trials, participants also reached to probe targets flanking the training target. This was done to test whether the trained movement attracted future movements, a signature of use-dependent learning. The results showed that both groups compensated for about 95% of the perturbation. The Small group showed a clear sign of implicit learning: an aftereffect of 45% of the perturbation, but this was less clear for the Large group (only 9%). Biases to the flanking targets were in the same direction as the aftereffect (both groups 83% of the aftereffect), without any sign of attraction to the learned movement. Since use-dependent learning would predict the latter, our results argue against use-dependent learning as the mechanism underlying the implicit learning. Rather, binary feedback might implicitly calibrate a sensorimotor mapping or action-outcome mapping. In conclusion, binary feedback can induce implicit learning and this is probably not driven by use-dependent learning.

Autonomic correlate of human motor learning and contextual inference

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Autonomic measures, such as heart rate and pupil diameter, have been known to reflect a wide variety of individuals' internal states. Recent studies also highlight autonomic arousal as indices of subjective uncertainty and surprise, which play a significant role in the formation of contexts for memory (Clewett et al., Nat Comm, 2020). However, it remains largely unexplored whether/how these autonomic measures are informative about motor learning processes. Here we report the results from a series of experiments in which we simultaneously measured pupil diameter alone, or pupil diameter, electrodermal activity, and heart rate during the reach adaptation paradigm. Based on the results, we suggest the potential connection between autonomic responses and the contextual inference process. In all experiments, participants made center-out reaching movements to a target while they maintained fixation on the target throughout the trial. We analyzed pre-movement pupil diameter (baseline pupil diameter) and in-movement pupil dilation velocity (pupil dilation), as well as instantaneous heartbeat interval (RRI) and skin conductance response (SCR) when available. In the first set of experiments, we asked how autonomic responses and error sensitivity are related by using the single-trial adaptation paradigm with mechanical perturbations of different sizes. Consistent with our recent work (Yokoi & Weiler, JNP, 2022), pupil dilation, SCR, and RRI specifically responded to large errors. Interestingly, such autonomic responses to errors accompanied the reduction in error sensitivity. The results thus imply a certain association between increased autonomic arousal (e.g., surprise/uncertainty) and reduced error sensitivity. In the second set of experiments, we asked how temporal forgetting of motor memory and subjective uncertainty are related by controlling the inter-trial intervals (3~240 sec) and the duration of set breaks (60 or 180 sec) after participants adapted to the force field. The baseline pupil diameter and reaction/movement time showed an exponential increase as a function of time, indicating an increase in subjective uncertainty. Motor memory showed clear forgetting as a function of time. Interestingly, the participants showed recovery of motor memory when they repeated the movement in the force channel with no additional learning trial after the delay/break. The result suggests that the observed forgetting of motor memory does not reflect true memory loss, implying the contribution of contextual inference. A simulation by the recently proposed model of contextual inference (Healds et al., Nature, 2021) reproduced the above behavioral features. Furthermore, the model's internal variables (surprise and entropy derived using predicted sensory feedback) showed similar patterns to the autonomic responses to errors and time-lapse. These results suggest the involvement of autonomic arousal in the contextual inference process.

Neural mechanisms of eye-head coordination during active gaze redirection in mice

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Animals can generate head and eye movements to reorient their axis of visual gaze relative to space. It is understood that animals lacking the high-acuity visual center known as the fovea (afoveates) perform head-directed gaze shifts, while foveate animals use their eyes to redirect gaze with compensatory head movement. Though mice are an afoveate model used in the study of vision, little is known about the neural mechanisms that underlie their natural gaze reorientation strategy, though much of the neural connectivity underlying directed saccades in foveate vertebrates is in fact conserved in mice. The prevailing view is that voluntary gaze shifts in mice are generated by active head movements with corresponding passive eye movements. Alternatively, mice may generate both voluntary eye and head movements to redirect their gaze much like afoveate vertebrates. In this study, we assess the dynamics of mouse gaze during active movements to define their natural gaze behaviors and distinguish between these two possibilities. To investigate gaze during active head movements, adult male mice (n=6) were trained to perform horizontal, goal-directed head rotations of varying sizes to orient between two waterspouts for reward. Eye position relative to the head was tracked using a miniature camera system; head position relative to space was measured using a high-resolution potentiometer; and gaze was calculated as the sum of head and eye position. We found that a significant portion of gaze redirections displayed rapid saccade-like eye movements in the same direction as the head with an extremely small latency (~10 ms) relative to head motion onset. The propensity towards eye-leading gaze shifts increased with the size of the gaze shift (31% for small vs. 62% for large). Active eye-head gaze shifts were stereotyped with main-sequence relationships (frequency vs. amplitude) maintained. Furthermore, the starting position of the eye influenced the relative contribution of head vs. eye to the overall gaze shift amplitude. For comparison, we recorded eye movements evoked in response to comparable passively-applied head movements. As expected, passive head movements initially resulted in gaze stabilizing eye movements that were opposite in direction, consistent with the vestibulo-ocular reflex (VOR). Quick-phases were generated but always followed the initial compensatory VOR eye movement. Finally, using Neuropixel recording technology, we have leveraged our active gaze paradigm to record from brainstem oculomotor pathways while tracking both eye and head movements to probe the mechanisms underlying the control of these active eye-head shifts in mice. Taken together, our results contrast with the prevailing view and suggest that mice generate both voluntary eye and head movements to redirect gaze. We propose that although mice lack a fovea, they can reorient gaze using a combined eye-head strategy that has more in common with primates than is commonly assumed.

Neural correlates of online movement preparation

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Many complex real-world activities demand preparing the next action while the current movement is still unfolding. Recent evidence suggests that when movement preparation and execution are separated in time, brain activity patterns underlying the preparation of single movements are highly correlated with those underlying execution. But what happens when the brain needs to prepare and execute movements at the same time, as in the context of rapid movement sequences? One possibility is that the coordination of simultaneous preparation and execution might require additional brain resources (either additional areas or extra activation). Alternatively, the brain may have a mechanism to afford concurrent preparation and execution effortlessly. To test these hypotheses, we designed a high-field (7T) functional neuroimaging (fMRI) experiment (N=22) consisting of two main conditions. In one condition, preparation for the upcoming movement overlapped with the execution of the ongoing movement (overlap). In the other, movement preparation and execution happened sequentially (non-overlap). Because we matched both conditions in all other basic perceptual and motor processes, any difference would reveal areas that are more engaged during online preparation. To be able to differentiate whether extra activation relates to motor planning and perceptual action selection, we varied the complexity of the movement: participants were either required to produce a single-finger press or a chord of three simultaneous finger presses. In a behavioral pilot experiment (N=11), we showed that chords require longer planning time than single-finger movement, even if the complexity of action selection was the same. In the main fMRI experiment, we scanned participants on overlapping and non-overlapping conditions, both for single-finger presses and chords. We observed significantly higher activations in parietal (IPS, OPJ) and occipital regions (TOS, LOT, vOT) for the overlap condition compared to the non-overlap condition, for both single-finger presses and chords. The complexity of the motor response did not affect the size of the overlap/non-overlap contrast, suggesting that the extra activity was due to the overlap between concurrent execution with action selection but not movement planning. In line with this view, we did not find significant differences between conditions in the dorsal premotor cortex (PMd), a region traditionally associated with motor planning. This is despite the fact that PMd was substantially more activated during the chord as compared to the single-finger condition, suggesting that it was heavily engaged during motor planning. Our results, therefore, support the hypothesis that motor planning, but not action selection, can run in parallel to ongoing execution with very little need for extra brain activity.

15:00 – 17:00 SESSION 15, PANEL VII

Novel perspectives on de novo learning

Kahori Kita[1], Lucas Dal'Bello[2], Amy Orsborn[3], Andrea d'Avella[4]

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How can people learn new skills? De novo learning is a topic of increasing interest in the motor control field. In the real world, we often face situations where we have to learn unfamiliar and arbitrary relationships between our actions and their consequences from scratch, for instance, driving a car or controlling a drone. New control policy is acquired typically through multiple hours of practice. One long-standing paradigm used in motor learning research is adaptation which challenges participants to learn rather minor perturbations to their existing controllers of motion. Despites its importance, de novo learning has received less attention than adaptation and mechanisms of de novo learning are still unclear. In this panel, four speakers, using a range of physiological, behavioral, and computational methods, will present different perspectives to provide new insights into de novo learning. Amy Osborn will present work exploring de novo learning in brain-computer interfaces (BCIs). BCIs define novel sensorimotor mappings from neural activity to behavior that engage learning with marked parallels to natural motor skill learning. She will present analysis of experimental data and neural network models that explore how the "decoder" that maps neural activity to movement influences learning computations in the brain. Andrea d'Avella will address de novo learning in the context of muscle synergies. In a synergy-based controller, de novo learning may require learning of new synergies. Virtual tendon-transfer surgeries, i.e. remapping of muscle forces simulated in virtual reality using myoelectric control, allow to investigate learning of new control policies with or without learning of new synergies. He will present recent results on adaptation to virtual surgeries across multiple days. Kahori Kita will present her work about de novo learning from a behavioral perspective. In everyday life, we need to learn novel motor skills through "de novo" learning and frequently switch between those skills. For instance, picking up and using different tools or getting on or off a bike. It's unclear whether analogous switch costs exist in the context of switching between entirely different motor skills. She will introduce her latest results of learning two de novo policies and switching between them. Lucas Rebelo Dal'Bello will present a computational model that elucidates the role of motor exploration on error-based de novo learning. In his computational model, motor exploration is used to learn an internal model responsible for correcting movement errors, which is then used to guide the error-based learning of a new control policy for the task. He will then show how his model can replicate the results from multiple behavioral studies. Lastly, Dagmar Sternad will energize a 20-minutes discussion on key aspects of de novo learning, possible universal principles across domains.

17:00 – 18:00 DISTINGUISHED CAREER AWARD TALK

The cerebellum – prediction in motor control and cognition

Chris Miall, *University of Birmingham*

The role(s) of the cerebellum are still uncertain. A prominent theory is that the cerebellum holds a predictive internal model of the sensory-motor system. This is a crucial component in the process of state estimation, combining information from descending motor commands and ascending sensory afferent signals to predict the outcome of actions, helping determine the current state of the motor system. Without state estimation, feedback delays in sensory pathways would degrade performance. State estimate is also likely to underpin coordinated actions, again overcoming feedback delays to allow synchronicity of different effectors. This role would explain the contribution the cerebellum makes to control action, as well as its obvious importance for and dependence on learning and adaptation. Inaccuracy in state estimates would lead to hypometria and dyscoordination like that observed in cerebellar ataxia. The fundamental role of prediction in state estimation also suggests a wider role for the cerebellum in non-motor domains.

In this lecture I describe studies from my laboratory that support this theory, using laboratory-based motor tasks to explore movement control and coordination. Our motor studies have included testing the effects of artificially extending visual feedback delays, adaptation tasks, and recording, inactivating, and imaging cerebellar activity. We have also used transcranial magnetic and electrical stimulation to disrupt its operations, in movement and in cognitive tasks. I will end with some recent experiments testing novel “event related” methods of TDCS to enhance motor adaptation.

Poster Author Index

Name	Poster Numbers
Cagnan, Hayriye	1-E-36
Cai, Yiyang	1-D-23
Caie, Brandon J	4-A-2
Cakici, Andre	4-E-36
Calabres Quintanilla, Jesus D	4-F-51
Campbell, Kristin L	4-F-40
Canaveral, Cesar A	1-B-6
Canfield, Ryan A	1-B-7
Cao, Di	3-G-54
Cardinaux, Annie	1-E-31
Carlsen, Anthony N	4-B-18
Carpenter, Mark G	2-C-22
Carter, Eugene	4-G-58
Carter, Luke	4-B-6
Carter, Russell E	3-D-29
Cecala, Aaron L	1-B-5
Cesanek, Evan A	1-F-38
Chan, Rosa	4-F-46
Chan, Rosa Ho Man	3-B-12
Chan, Zoe	4-F-46
Chandy, Anisha	4-E-34, 4-E-34
Chaput, Meredith	1-F-39, 2-F-50
Chase, Steven M	3-B-2, 3-D-25, 3-D-28, 4-B-10
Chavet, Pascale	1-D-26
Chen, Chao-Ying	4-F-46
Chen, Chih-Yang	4-A-3
Chen, Yun	2-G-59
Chester, Victoria	2-B-6
Cheung, Roy	4-F-46
Cheung, Vincent Chi Kwan	2-G-56, 3-B-12, 4-F-46
Cho, Wanhee	4-D-28
Chou, Amber Hsiao-Yang	4-G-56
Chowdhury, Raeed H	2-D-28, 4-B-10
Chua, Romeo	1-C-16, 2-F-41, 4-E-34, 4-F-52
Chun, Emily E	3-G-53
Cisek, Paul	1-B-6
Cisneros, Elizabeth	1-F-40
Cler, Gabriel	4-F-53
Cluff, Tyler	3-B-6
Cohen, Jeremy D	2-D-29

Name	Poster Numbers
Cole, Jonathan	4-E-34
Collinger, Jennifer L	3-B-2, 4-B-10
Coltman, Susan K	1-B-8
Conforto, Silvia	2-E-37
Cope, Timothy C	4-G-60
Corneil, Brian D	1-B-12, 1-B-5, 3-B-4
Cortina, Karen	1-D-29
Cote, Roland	3-F-48
Cowan, Noah J	3-G-54
Cowley, Kristine	1-E-35
Crawford, John D	1-A-4
Cressman, Erin K	3-F-51
Cross, Kevin P	2-D-29
Crozier, Dena	1-E-31
Cui, Anja X	3-D-23
Cui, He	1-G-58, 2-G-59
Cullen, Kathleen E	1-C-21, 1-G-54, 2-C-21, 2-C-23, 3-C-14, 4-A-5
Cuthbert, Benjamin	1-G-55
Dachy, Bernard	3-E-33
Daley, Monica A	4-B-19
Damewood, Bridgette	4-C-22, 4-C-22
Dancause, Numa	2-B-10
Danion, Frederic R	4-F-41
d'Avella, Andrea	2-B-14, 2-E-37
De Dios, Yiri E	1-F-50
De Groote, Friedl	4-E-38
De La Fontaine, Élisa	2-F-39
de Nobile, Alessia	2-E-37
De Pasquale, Paolo	2-B-14, 2-E-37
De Schrijver, Sofie	3-D-21
de Witte, Anda C	1-B-11, 2-B-8, 2-B-8
De, Sayan D	4-B-9
Dean, Jesse C	3-C-18
Decramer, Thomas	2-D-27, 3-D-21
Defebvre, Luc	2-E-35
Degenhart, Alan	3-D-25
Deisseroth, Karl	4-G-58
Deistung, Andreas	1-E-33
Dekleva, Brian M	2-D-28, 3-B-2, 4-B-10

Name	Poster Numbers
Del Vecchio, Alessandro	4-E-36
Delivet-Mongrain, Hugo	2-B-10
Dellenbach, Blair	3-F-48
Delval, Arnaud	2-E-35
Deng, Xueqian	2-G-53
Denyer, Ronan	4-B-11, 4-F-40
Desabhotla, Krishna Sarvani	2-G-54
Desloovere, Kaat	4-E-38
Di Ruggiero, Giorgia	2-D-30
Diedrichsen, Jörn	2-B-9, 2-B-12
Diekfuss, Jed A	4-B-15
Diomedi, Stefano E	3-D-30
Dlugaiczyk, Julia	2-D-30
Donelan, Max	1-G-56, 2-C-19, 3-G-57
Donoghue, John P	1-G-57, 4-D-33
Dougherty, Kim	3-E-34
Draganova, Rossitza	1-E-33
Du, Yue	2-G-55
Duan, Xiaojie	2-G-56
Dukelow, Sean P	1-A-1, 1-A-3, 2-C-25
Durandau, Guillaume	3-G-55
Easthope, Eric	3-C-17
Ebitz, Becket	4-A-4
Ebner, Timothy J	2-D-32, 3-D-29
Elemans, Coen P. H.	2-B-16
Endres, Dominik	1-G-55
Eng, Janice J	2-C-25, 3-C-19, 4-E-35
Er, Carol	4-C-27
Er, Jie Kai	4-C-27
Escalante, Yori	1-F-42, 2-F-40, 2-F-40
Eschelmuller, Gregg L	2-F-41, 4-F-52
Eskofier, Bjoern	4-E-36
Fabre, Marie	1-C-15, 3-F-44
Faisal, Aldo A	1-G-59, 2-F-42, 4-F-47
Falaki, Ali	2-B-10
Faraji, Amir H	2-C-24
Farajzadeh, Ata	2-B-11
Farajzadeh, Ataallah	2-B-11

Name	Poster Numbers
Farina, Dario	1-B-9, 2-D-26
Farmer, Simon F	1-E-36
Farne, Alessandro	4-E-34
Farraye, Byrnadeen T	1-F-39, 2-F-50
Fattori, Patrizia	3-D-20, 3-D-30
Fellows, Lesley K	2-F-48
Fels, Sidney	3-C-17, 4-C-25
Fernandez Fisac, Carmen	3-D-25
Ferris, Daniel P	2-F-46, 4-C-23
Ferris, Jennifer	4-F-40
Filippini, Matteo	3-D-20, 3-D-30
Fitzgerald, Justin	1-E-32, 3-E-32
Fitzgerald, Zachary	1-G-54
Flash, Tamar	1-C-18
Flessner, Tjalda	1-E-36
Forbes, Patrick A	1-D-24, 4-C-24, 4-F-50
Forrence, Alexander D	4-B-14
Foulger, Liam H	1-C-16
Foxe, John J	3-F-42
Franklin, David W	3-B-3, 4-B-12, 4-B-8
Franklin, Sae W	3-B-3
Freedman, Edward G	3-F-42
Freiwald, Winrich	4-D-30
Freudenberg, James S	3-G-54
Friedman, Jason	3-E-35
Fukunaga, Masaki	1-D-28
Fukuyama, Hiroyuki	1-D-28
Funato, Tetsuro	4-F-48
Furuya, Shinichi	1-F-49
Gach, Mary	4-D-31
Gale, John	1-G-54
Galea, Joseph	2-F-44
Garcia Ramirez, Jesus	3-D-21
Gastrock, Raphael Q	1-F-41
Gaunet, Florence	1-D-26
Gaunt, Robert A	3-B-2
Gerhart, Morgan L	2-D-32
Germine, Laura	3-F-49
Gholami, Soheil	2-C-18
Gianferrara, Pierre G	4-D-29
Gick, Bryan	3-C-17, 4-C-25

Name	Poster Numbers
Gilmer, Jesse I	1-B-8
Giszter, Simon F	2-B-17, 3-E-34, 4-B-13
Gonzalez-Martinez, Jorge A	1-G-54, 3-B-2
Goodale, Mel A	1-B-12
Goodman, James	3-B-8
Göricke, Sophia L	1-E-33
Goubran, Miriam	2-B-11
Graef, Cosima	1-B-9
Greeley, Brian	4-F-40
Green, Andrea M	1-B-6
Greene, Patrick	3-G-58
Greenhouse, Ian	4-D-31
Grigsby, Erinn	3-D-25
Grison, Agnese	2-D-26
Grogan, Max D	2-F-42
Grooms, Dustin R	1-F-39, 2-F-50, 4-B-15
Grunbaum, Sigal	3-E-35
Günter, Clara	4-B-12
Guo, Jian-Zhong	2-D-29
Guo, Xiaoyu	4-F-46
Gusbin, Valentine	3-E-33
Ha, Sophia	4-F-46
Haar, Shlomi	1-B-9, 2-F-42, 4-F-47
Hadjidimitrakis, Kostas	3-D-30
Hadjiosif, Alkis M	4-F-42
Hagura, Nobuhiro	3-F-39
Haith, Adrian M	2-G-53, 2-G-55
Hall, Kristina G	2-F-46
Hamada, Tsukasa	4-C-26
Hamano, Yuki H	1-D-28
Hantman, Adam	1-D-29, 2-D-29
Hara, Yuki	4-F-48
He, Borong	2-G-56
He, Dorothy	1-F-52
Hegele, Mathias C	2-F-43, 2-F-43
Henriques, Denise P	1-F-41, 4-F-43, 4-F-43
Hermus, James	3-B-11
Herron, Jeffrey	4-F-53
Hillman, Hanna K	4-B-14, 4-B-14

Name	Poster Numbers
Hinneberg, Britta M	2-F-43
Hirano, Masato	1-F-49
Hirashima, Masaya	3-F-39
Ho, Kuan-Ting	4-A-3
Hockeimer, William D	4-B-10
Hoekstra, Hopi E	1-D-29
Hoffmann, Sven	2-F-43
Hogan, Neville	1-B-13, 3-B-11
Homer, Von M	2-G-57
Hosli, Sarah	2-D-30
Howard, Ian S	3-B-3, 4-B-8
Hsu, Sarah	3-B-5
Huang, Helen J	1-C-17
Huang, Subing	3-B-12
Hupfeld, Kathleen	1-F-50
Huynh, Angelina T	1-F-42, 4-F-44
Hynes, Jacqueline	4-D-33
Ianni, Geena	4-D-30
Ingber, Moria	3-E-35
Inglis, J. Timothy	2-F-41, 4-F-52
Isa, Tadashi	4-A-3
Ito, Takayuki	3-D-22
Iversen, John	4-D-28
Ivry, Richard B	1-F-40, 1-F-48, 3-F-49, 3-F-50, 3-G-53, 4-E-34, 4-F-52
Jacob, Joshua D	3-E-36
Jacobsen, Noelle A	4-C-23
James, Michelle	1-E-32, 3-E-32
James, Reshma	3-F-40
James, Shirley A	1-F-52
Janssen, Peter	2-D-27, 3-D-21
Javadzadeh No, Sina	2-B-1
Jenkinson, Ned	2-F-44
Jing, Amy	2-B-9
Joiner, Wilsaan	1-E-32, 3-D-25, 3-E-32
Jones, Christina B	3-D-23, 4-F-40
Jones, Christy	3-D-23
Kagawa, Takahiro	4-D-28
Kambara, Hiroyuki	4-D-28
Kamibayashi, Kiyotaka	1-F-43, 4-C-26
Kantak, Shailesh S	3-E-36

Name	Poster Numbers
Karney, Sheer	1-F-40
Karolitsky, Tanya	3-E-35
Karpowicz, Brianna M	2-B-13
Kashefi, Mehrdad	2-B-12
Kasiri, Maral	2-E-4
Kearsley, Sarah L	3-B-4
Kechabia, Yann-Romain	4-A-1
Keirse, Elina	2-D-27
Kerr, Kennedy G	1-G-53, 3-C-15
Kesar, Trisha M	2-C-20
Khan, Najeeb	4-C-25
Khul, Lydia M	1-A-2
Kikuta, Satomi	3-D-24
Kim, Hakjoo	1-F-37, 4-F-44
Kim, HoWon	2-F-50, 4-B-15
Kim, Hyeonseok	4-D-28
Kim, Hyosub E	4-F-52
Kim, Olivia A	3-F-41
Kim, Taegyo	2-B-17, 4-B-13
Kinfe, Thomas	4-E-36
Kitamura, Masaya	1-F-43, 4-C-26
Klein, Christine	2-E-36
Ko, Andrew L	4-F-53
Kobayashi, Makoto	4-D-28
Kocer, Muhammet Berkan	1-E-35, 3-C-13
Koch, Giacomo	2-E-37
Kodandaramaiah, Suhasa	3-D-29
Koh, Natalie	3-B-5
Konczak, Jürgen	1-E-33
Kong, Amy H.S.	3-B-12
Kosuri, Likhita M	3-D-23
Kottke, Benjamin W	3-D-29
Kpankpa, John	3-F-38
Krausz, Nili	1-C-18
Kristl, Amy C	3-B-5, 3-B-5
Krook-Magnuson, Esther	3-D-29
Krotov, Aleksei D	4-G-57, 4-G-57
Kuah, Christopher Wee Keong	1-E-34
Kubota, Shinji	3-D-24
Kucukahmetler, Deniz	1-E-36
Kudou, Moeko	3-D-24
Kudzia, Pawel	2-C-19
Kuhl, Lydia M	1-A-1, 1-A-3
Kühn, Simone	1-D-23
Kumar, Neeraj	3-F-46
Kumar, Vikash	3-G-55
Kundu, Aritra	2-D-26
Kunigk, Nicolas C	4-B-10
Kuo, Calvin	1-C-16
Kuper, Clara	4-B-16
Kuruganti, Usha	2-B-6
Kwong, Wai Hang Patrick	4-C-27
L Tellini, Tamires	2-E-34
Lacquaniti, Francesco	2-B-14, 2-E-37
Lametti, Daniel R	2-F-45
Lang, Anthony	2-E-36
Lapole, Thomas	1-C-15, 3-F-44, 3-F-52
Larssen, Beverley	4-F-40
Lata, William	1-B-6
Latash, Mark	4-B-9
Lau, Kelvin Lau Yat	3-B-12
Lavoisier, Florian	1-C-15
Leavitt, Olivia M	3-C-14
Lee, Wei-Chung A	1-B-10
Lee, WeiHsien	2-B-13, 3-B-9
Leeuwis, Matto	4-C-24
Lehmann, Sebastian J	1-B-5, 3-B-4
Lei, Yuming	1-F-37, 1-F-42, 1-F-44, 2-F-38, 2-F-40, 4-F-44
Leib, Raz	4-B-12
Lepage, Jean-François	2-F-39
Lesser, Ellen	1-B-10
Levin, Moran	3-E-35
Lewis, Allison	3-F-48
Li, Chenyang	1-G-58
Li, Jinfeng	1-C-17
Li, Si Jia	1-F-45, 4-F-45
Lim, Lek Syn	4-C-27
Lim, Shannon	3-C-19, 4-E-35
Lim, Yu Chin	1-E-34, 4-C-27
Lin, Biyang	1-F-44
Lin, Jiayin	4-F-46
Liu, Yadong	3-C-17, 4-C-25
Liu, Yiming	4-B-12
Loh, Yong Joo	1-E-34
Loughlin, Patrick	2-D-28
Luneau, Davy	3-F-52
Ma, Zhengyu	3-B-5
MacRae, Fraser A	4-E-35
Madarshahian, Shirin	1-D-27
Madduri, Maneeshika M	1-F-45, 4-F-45
Magnani, Ivan	4-A-1
Magosso, Elisa	3-D-20
Mahaki, Mohammadreza	1-C-19
Mahdi, Ghadeer	3-B-6
Makeig, Scott	4-D-28
Makino, Yuto	3-G-56
Makwana, Mukesh	4-D-33
Mang, Cameron	4-E-37
Marina, De Vitis	3-D-30
Marino, Patrick	3-D-25, 3-D-25, 3-D-28
Martino, Giovanni	1-G-53
Maselli, Antonella	2-B-14, 2-E-37
Maslovat, Dana	4-B-18
Mason, Catherine F	2-C-20
Masuda, Nao	3-G-56
Matrov, Denis	4-A-3
Matthijs, Anouck	1-B-11, 2-B-8
Maurer, Heiko	2-F-43
Maurer, Lisa K	2-F-43
Maurus, Philipp	3-B-6
Max, Ludo	4-F-53
McCurdy, Justin R	3-D-26
McDougle, Samuel D	3-G-53, 3-G-59, 4-B-14, 4-F-39
McGregor, Heather	1-F-50, 2-F-46, 2-F-46
McIlroy, Bill	2-C-25
McIntyre, Joseph	3-E-33
Mehdizadeh, Sina	1-G-56
Mekhaiel, David Y	1-B-12
Menon, Vilas	1-D-29
Mensink, Lucas	1-D-24

Name	Poster Numbers
Mercier, Catherine	1-A-2, 1-A-3
Miall, R. Chris	2-F-44, 4-E-34
Mildren, Robyn L	2-C-21
Miller, Lee E	4-B-10
Millevolte, Augusto X	1-F-45, 4-F-45
Milner, Theodore	2-F-47
Mimouni-Bloch, Aviva	3-E-35
Mirdamadi, Jasmine L	1-G-53, 3-C-15
Miri, Andrew	3-B-5
Missen, Kyle J	2-C-22
Mitchell, Jude	4-D-32
Miyakoshi, Makoto	4-D-28
Mohamed Thangal, Sayed Naseel	3-G-57
Monfort, Scott M	1-F-39
Monrose, Aaron B	1-F-52
Mon-Williams, Mark	1-F-51
More, Heather	3-G-57
Morehead, Ryan	1-F-51
Moslemi, Zahra	4-E-37
Motiwala, Asma	3-D-25
Mousavi, Alireza S	2-E-4
Müller, Hermann	2-F-43
Muller, Lyle E	3-B-4
Münchau, Alexander	2-E-36
Munier, Louis	2-C-18
Mushahwar, Vivian	3-D-27
Mushtaq, Faisal	1-F-51
Myer, Gregory D	4-B-15
Nakayama, Ken B	3-F-49
Nakayama, Yoshihisa	1-D-28
Nardelli, Paul	4-G-60
Nardi, Federico	4-F-47
Nardon, Mauro	3-F-37, 3-F-38, 4-B-9
Nataraj, Jaya	2-B-2, 2-E-3
Nayeem, Rashida	2-G-54
Nettekoven, Caroline R	1-E-33
Neu, Isabelle	3-E-33
Neufeld, Esra	3-B-4
Neva, Jason L	4-F-40
Nguyen, Tri	2-D-31
Nicklas, Paige	3-F-42, 3-F-42

Name	Poster Numbers
Niebur, Tobias	2-C-23
Nishimura, Yukio	1-D-28
Niziolek, Caroline A	1-F-47
Nordin, Andrew D	1-C-20
Nozaki, Daichi Nozaki	3-G-56
Nuijten, Puk L	1-B-5
Oby, Emily R	2-D-28, 3-D-25, 3-D-28
Ody, Edward	1-F-41
Ohta, Naohito	4-F-48
Onoe, Hirotaka	4-A-3
Orban de Xivry, Jean-Jacques	1-B-11, 2-B-8, 3-D-31
Orsborn, Amy L	1-B-7, 1-F-45, 3-B-7, 3-F-43, 4-F-45, 4-F-49, 4-F-51
Ortiz, Oscar	2-B-6
Oshima, Atsushi	1-F-43, 4-C-26
Osswald, Marius	4-E-36
Ostry, David J	3-F-46
Ouchi, Tomohiro	3-B-7
Oya, Tomomichi	3-D-24
Ozawa, Yusuke	2-B-15
Pack, Andrea R	2-B-16
Pages, Thomas	3-E-33
Paine, Morgan L	1-D-27
Palidis, Dimitrios J	2-F-48
Pandarinath, Chethan	2-B-13
Pangan, Wylianne	1-D-25
Papavasileiou, Anastasia	1-C-15
Parhizi, Behdad	3-D-27
Park, Se-Woong	1-E-31, 1-F-46
Parrell, Ben	1-F-47
Parrell, Benjamin	1-F-47
Pascual Valdunciel, Alejandro	1-B-9
Patikas, Dimitrios	1-C-15
Pauly, Martje	2-E-36
Pavlovsky, Nick P	3-D-28
Payne, Aiden M	1-G-53
Pedrosa, David	1-E-36
Penido, Isabella	1-G-57
Perich, Matthew G	4-G-58

Name	Poster Numbers
Perks, Katherine M	3-F-43
Perrasse, Camille	1-C-15
Perrier, Pascal	3-D-22
Person, Abigail L	1-B-8
Peters, Ryan M	1-C-14
Peters, Sue	4-E-35
Pfenninger, Clara	3-F-44
Phelps, Jasper S	1-B-10
Philipp, Roland	4-F-48
Phillips, Mitchell	2-B-7
Phipps, Alan M	3-C-16
Piscitelli, Francesco	3-F-37
Poitras, Isabelle	1-A-1, 1-A-2, 1-A-3
Pollock, Courtney	2-C-25, 3-C-19
Ponfick, Matthias	4-E-36
Potts, Cory A	3-E-36
Pruszynski, J. Andrew	1-B-5, 1-D-25, 2-B-12
Prut, Yifat	4-D-30
Puygrenier, Alice	4-F-41
Quessy, Stephan	2-B-10
Quinlan, Shannah	2-B-7
Rai, Richa	4-G-55
Rajan, Kanaka	4-G-58
Rajendran, Anjana	4-B-11
Rajendran, Vijay	3-D-29
Rajeswaran, Pavithra	1-B-7, 3-B-7, 4-F-49, 4-F-51
Rasman, Brandon G	1-D-24, 4-F-50
Rastogi, Rishabh	2-C-20
Refai, Hazem	4-G-59
Remy, C. David	3-G-57
Reschechtko, Sasha	1-D-25
Reuter-Lorenz, Patricia	1-F-50
Rhee, Joohyun	4-F-44
Ricotta, Joseph	4-B-9
Rinat, Shie	3-D-23, 4-F-40
Robinovich, Stephen	2-C-19
Rolfs, Martin	4-B-16
Roques, Axel	3-F-45
Rouse, Adam G	2-B-13, 3-B-9, 4-D-30
Rubino, Cristina	4-F-40

Name	Poster Numbers
Ruopp, Rubi	4-D-31
Russo, Marta	1-E-31, 2-E-37, 3-F-47
Ruszala, Brandon M	2-F-49
Sacre, Pierre	1-G-54
Sadato, Norihiro	1-D-28
Sadeghi, Mohsen	2-D-28, 2-G-54, 4-G-57
Sadler, Christin M	4-B-18
Sahinis, Chrysosthomos	1-C-15
Salmas, Paola	2-G-56
Sanger, Terence D	2-B-1, 2-B-17, 2-B-2, 2-E-3, 2-E-4, 2-F-5
Santangelo, Cassandra M	4-B-18
Saranza, Gerard	2-E-36
Sarlegna, Fabrice R	1-D-26, 4-E-34
Sarma, Sridevi	1-G-54, 3-G-58
Sartori, Massimo	3-G-55
Sato, Makoto	4-D-28
Saxena, Shreya	4-G-54
Sayenko, Dimitry G	2-C-24
Schadan, Sydney M	2-C-24
Schaffelhofer, Stefan	3-B-8, 4-D-30
Scherberger, Hans	3-B-8
Schieber, Marc H	2-F-49, 3-G-58, 4-D-30
Schlink, Bryan	4-B-15
Schnittjer, Amber J	2-F-50
Schofield, Jonathon	1-E-32, 3-E-32
Scholl, Jamie	2-F-51
Scholl, Leo R	1-B-7, 3-B-7, 4-F-49, 4-F-51
Schuck, Lauren A	1-F-48
Schütz, Adrian	1-A-4
Schwartze, Kevin	3-B-9
Seethapathi, Nidhi	4-B-19
Seidler, Rachael	1-F-50, 2-F-46
Seki, Kazuhiko	2-B-15, 3-D-24, 4-F-48
Serre, Helene	2-D-31
Seth, Ajay	4-C-24
Seyyed Mousavi, Seyyed Alireza	2-B-1, 2-B-2, 2-E-3, 2-F-5

Name	Poster Numbers
Shahbazi, Mahdiyar	2-B-9
Shaklai, Sharon	3-E-35
Shamei, Arian	3-C-17, 4-C-25
Sharif Razavian, Reza	1-D-22, 2-D-28, 4-G-57
Sharps, Jason Q	1-F-52
Shaw, Luke	4-D-32
Shenoy, Aishwarya	2-C-25
Shepherd, Stephen	4-D-30
Shi, Ben	1-A-1
Shih, Pei-Cheng	1-F-49
Shiller, Douglas M	2-F-45
Shiraki, Kenichi	3-F-39
Shirazi, Seyed Yahya	1-C-17
Sidarta, Ananda	1-E-34, 3-F-46, 4-C-27
Sidorov, Evgeny V	1-F-52
Simon, Janet E	1-F-39, 2-F-50, 4-B-15
Singh, Tarkeshwar	1-D-27, 3-F-37, 3-F-38
Singhal, Rishabh	4-A-4
Sinha, Oindrila	1-D-27, 3-F-38
Sinha, Pawan	1-E-31
Sirpal, Parikshat	4-G-59
Sisler, Sabra N	3-F-47, 3-F-47
Slutsky-Ganesh, Alexis B	4-B-15
Smeets, Jeroen B.J.	3-B-10
Smith, Chelsea	3-F-46
Smith, Lydia I	1-B-7, 3-B-7, 3-F-43, 4-F-49, 4-F-51
Smith, Maurice A	4-F-42
Smith, Trevor S	2-B-17, 4-B-13
Smoulder, Adam L	3-D-25, 3-D-28
Snyder, Sam E	3-D-28
Sober, Samuel J	2-B-16
Soliman, Jolene	4-C-21
Song, Joo-Hyun	1-F-46, 2-D-31
Song, Seongmi	1-C-20
Soroushmojdehi, Rahil	2-B-2, 2-E-3, 2-F-5
Souza de Oliveira, Daniela	4-E-36
Spedden, Meaghan	1-E-36

Name	Poster Numbers
Stam, Marielle J	1-E-36
Stanley, Oliver R	1-C-21, 1-C-21, 4-A-5
Stecina, Katinka	1-E-35, 3-C-13
Steele, Alexander G	2-C-24
Steidel, Kenan	1-E-36
Steiner, Katharina	1-E-33
Steiner, Melanie	3-B-4
Steinmeier, Annika	2-E-36
Stephens, Jacob	4-G-60, 4-G-60
Sternad, Dagmar	1-D-22, 1-E-31, 2-D-28, 2-D-31, 2-G-54, 3-F-47, 4-G-57
Straumann, Dominik	2-D-30
Streng, Martha L	3-D-29
Sugawara, Sho K	1-D-28
Sugimoto Dimitrova, Rika	3-B-11
Sun, Yun	2-E-4
Szarka, Annika M	2-F-41, 4-F-52
't Hart, Bernard M	1-F-41, 4-F-43
Tadic, Vera	2-E-36
Tai, Yen	1-B-9
Takeda, Masaki	4-C-26
Tanaka, Hirokazu	4-D-28
Tang, Ding-lan	1-F-47
Taylor, Jordan A	3-F-41
Tays, Grant	1-F-50
Tessari, Federico	3-B-11
Theodosiadou, Anastasia	1-C-15
Therrien, Amanda S	4-B-6, 4-F-7
Theys, Tom	2-D-27, 3-D-21
Thompson, Aiko K	3-C-16, 3-F-48, 4-C-22
Timmann, Dagmar	1-E-33
Timms, Ryan	1-E-36
Ting, Lena H	1-G-53, 2-C-20, 3-C-15, 4-E-38, 4-G-60
Togneri, Kayla	3-D-29
Toledo-Aldana, Eduardo A	4-E-37
Tolley, Nicholas	4-D-33
Torres, Elizabeth B	4-G-55

Name	Poster Numbers
Townsend, Max B	1-F-51
Trach, Juliana E	3-G-59
Tsay, Jonathan S	1-F-40, 1-F-48, 3-F-49, 3-G-53, 4-E-34
Tuthill, John C	1-B-10
Tyssowski, Kelsey	1-D-29, 1-D-29
Uehara, Kazumasa	2-B-15
Ursino, Mauro	3-D-20
Ushiyama, Junichi	2-D-33
Usuda, Noboru	1-D-28
Vaccari, Francesco E	3-D-30
Vahdat, Shahabeddin	2-F-47
Vaidyanathan, Ravi	1-B-9
Van Campenhout, Anja	4-E-38
Van De Plas, Stien	3-D-31
Van Der Velde, Nathalie	1-C-19
Van Dieen, Jaap	1-C-19
Van Hoylandt, Anaïs	2-D-27
van Leeuwen, Moira	1-C-19, 3-C-18
Van Ooteghem, Karen	2-C-25
Vargas-Irwin, Carlos E	1-G-57, 4-D-33
Vasaghi, Attiyeh	1-E-35, 3-C-13
Vázquez, Yuriria	4-D-30
Verdone, Brandie Morris	2-C-23
Vette, Albert H	2-C-24
Vidal, Pierre-Paul	3-F-45
Voloshina, Alexandra S	4-B-19
Wakeling, James M	2-C-19
Wang, Hantao	4-F-53
Wang, Hongying	1-A-4
Wang, Huawei	3-G-55
Wang, Jinsung	3-F-40
Wang, Kuan H	4-D-32
Wang, Qifan	1-G-58
Wang, Tianhe	3-F-50, 3-G-53
Wang, Tianwei	1-G-58, 2-G-59
Wang, Wei-Chen	4-B-19
Wang, Yiyu	1-F-44
Wannawas, Nat	1-G-59
Warren, Shayla	4-B-15
Wasserman, Emma	3-D-29

Name	Poster Numbers
Watakabe, Akiya	4-A-3
Weber, Kyle	2-C-25
Wei, Kunlin	1-D-23, 2-F-52
Wei, Ruihan	1-C-21, 4-A-5
Weightman, Matthew	2-F-44
Weissbach, Anne	2-E-36
West Jr., A. Michael	1-B-13
West, Sarah L	2-D-32
West, Timothy O	1-E-36
Wijeyaratnam, Darrin O	3-F-51
Willaert, Jente	4-E-38
Williamson, Adam	3-B-4
Williamson, Jordan N	1-F-52
Williamson, Rand A	3-E-36
Wilmer, Jeremy	3-F-49
Wilson, Adam	2-B-6
Wolpert, Daniel M	1-F-38
Wong, Aaron L	4-B-6, 4-F-7
Woo, Peter Yat Ming	3-B-12
Wood, Scott	1-F-50
Wright, David	1-F-42, 4-F-44
Wu, Wencheng	2-F-52
Wu, Yufei	2-F-42
Xie, Jodie Jingping	3-B-12
Xiong, Ziyi	1-D-23
Yamagami, Momona	1-F-45, 4-F-45, 4-G-56
Yamamori, Tetsuo	4-A-3
Yamazaki, Ryoichiro	2-D-33
Yan, Xiaogang	1-A-4
Yanagi, Takashi	3-F-39
Yang, Chieh-Ling	4-E-35
Yang, Huichao	1-D-23
Yang, Yuan	1-F-52, 4-G-59
Yin, Chenshuo	2-G-53
Yoshida, Junichiro	3-D-24
Yoshida, Kaya J	3-C-19, 3-C-19
Yoshimura, Natsue	2-B-15, 4-D-28
Yu, Byron M	3-B-2, 3-D-25, 3-D-28
Zangakis, Dylan	4-F-7, 4-F-7
Zeghoudi, Narimane	3-F-44, 3-F-52
Zhang, Janet	4-F-46

Name	Poster Numbers
Zhang, Jing	2-G-56
Zhang, Xiaoyue	2-F-52
Zhang, Yiheng	1-G-58, 2-G-59
Zheng, Cong	1-G-58
Zicher, Blanka	2-D-26
Zuleger, Taylor M	4-B-15

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, April 18, 2023 08:00 – 18:00

SESSION 2
Wednesday, April 19, 2023 08:00 – 17:30

SESSION 3
Thursday, April 20, 2023 08:00 – 14:00

SESSION 4
Friday, April 21, 2023 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, APRIL 18, 2023

A – CONTROL OF EYE & HEAD MOVEMENT

Poster Cluster (1-A-1 to 1-A-3): ***Oculomotor behavior during upper limb sensorimotor tasks in children and adults with a brain lesion***

1-A-1 ***Examining saccades to visual and proprioceptive targets in the subacute phase of stroke***
Lydia Kuhl[1], Ben Shi[1], Isabelle Poitras[2], Sean Dukelow[1]
[1]University of Calgary, [2]Université Laval

1-A-2 ***Coupling between eye and hand movements during reaching in typically developing children and children living with hemiplegic cerebral palsy***
Isabelle Poitras[1], Lydia Khul[2], Catherine Mercier[1]
[1]Université Laval, [2]University of Calgary

1-A-3 ***Oculomotor behavior during a visually guided reaching task after stroke - a pilot study***
Isabelle Poitras[1], Lydia Kuhl[2], Sean Dukelow[2], Catherine Mercier[1]
[1]Université Laval, [2]University of Calgary

1-A-4 ***Prediction of future gaze errors in the monkey prefrontal neurons***
Vishal Bharmauria[1], Adrian Schütz[2], Xiaogang Yan[1], Hongying Wang[1], Frank Bremmer[2], John Crawford[1]
[1]York University, [2]Philipps-Universität Marburg

B – FUNDAMENTALS OF MOTOR CONTROL

1-B-5 ***Responding when time is of the essence: An analysis of signal timing in the macaque superior colliculus during reflexive visually-guided reaching***
Amirhossein Asadian[1], Aaron Cecala[1], Puk Nuijten[2], Sebastian Lehmann[1], Andrew Pruszynski[1], Brian Corneil[1]
[1]Western University, [2]University of Amsterdam

1-B-6 ***The brain can take biomechanical costs into account during decide-while-acting paradigms***
Cesar Canaveral[1], William Lata[1], Andrea Green[1], Paul Cisek[1]
[1]Université de Montréal

1-B-7 ***Neural population dynamics in large-scale electrocorticography (ECoG) during reaching***

Ryan Canfield[1], Leo Scholl[1], Pavithra Rajeswaran[1], Lydia Smith[1], Amy Orsborn[1]

[1]*University of Washington*

1-B-8 ***Characterizing the kinematic and motor correlates of skilled reaching in mice***

Susan Coltman[1], Jesse Gilmer[1], Abigail Person[1]

[1]*University of Colorado Anschutz Medical Campus*

1-B-9 ***Reading cortical beta bursts from forearm motor unit spiking activity***

Cosima Graef[1], Alejandro Pascual Valdunciel[1], Dario Farina[1], Ravi Vaidyanathan[1], Yen Tai[1], Shlomi Haar[1]

[1]*Imperial College London*

1-B-10 ***Specialized neural network architectures for motor control of the Drosophila leg and wing***

Ellen Lesser[1], Anthony Azevedo[1], Jasper Phelps[2], Wei-Chung Allen Lee[2], John Tuthill[1]

[1]*University of Washington,* [2]*Harvard University*

1-B-11 ***Can physical resilience explain the variability in age-related changes in motor function?***

Anouck Matthijs[1], Anda de Witte[1], Jean-Jacques Orban de Xivry[1]

[1]*KU Leuven*

1-B-12 ***The express visuomotor response facilitates arm movement in response to faces within 80ms***

David Mekhaiel[1], Mel Goodale[1], Brian Corneil[1]

[1]*Western University*

1-B-13 ***Kinematic hand synergies differ during tool-use and functional object manipulation***

A. Michael West Jr.[1], Neville Hogan[1]

[1]*Massachusetts Institute of Technology*

C – POSTURE AND GAIT

1-C-14 ***EVS sway recruitment thresholds: Monopolar vs Bipolar***

Christopher Banman[1], Ryan Peters[1]

[1]*University of Calgary*

1-C-15 ***The use of proprioceptive stimulation through vibration and electrical stimulation to better understand balance control***

Marie Fabre[1], Florian Lavoisier[1], Camille Perrasse[1], Anastasia Papavasileiou[2], Chrysosthomos Sahinis[2], Anastasia Theodosiadou[3], Ioannis Amiridis[2], Dimitrios Patikas[2], Stéphane Baudry[3], Thomas Lapole[1]

[1]*Université Jean Monnet Saint-Etienne, Lyon 1, Université Savoie Mont-Blanc, Laboratoire Interunivers,* [2]*Laboratory of Neuromechanics, School of Physical Education and Sports Sciences at Serres, Aristotle ,* [3]*Laboratory of Applied Biology and Research Unit*

1-C-16 ***Vestibular control of locomotion during real-world gait transitions***

Liam Foulger[1], Calvin Kuo[1], Romeo Chua[1], Jean-Sébastien Blouin[1]

[1]*University of British Columbia*

1-C-17 ***Perturbation unexpectedness enhances anterior cingulate responses in locomotor tasks***

Helen Huang[1], Jinfeng Li[1], Seyed Yahya Shirazi[2]

[1]*University of Central Florida,* [2]*University of California San Diego*

1-C-18 ***Intersegmental coordination asymmetries for K2 and K3 level transfemoral amputees walking on microprocessor knee-ankle prostheses***

Nili Krausz[1], Tamar Flash[1]

[1]*Weizmann Institute of Science*

1-C-19 ***Foot placement control can be trained: Older adults learn to walk more stable, when ankle moments are constrained***

Mohammadreza Mahaki[1], Moira van Leeuwen[1], Sjoerd Bruijn[1], Nathalie van der Velde[2], Jaap van Dieen[1]

[1]*Vrije Universiteit Amsterdam,* [2]*Amsterdam UMC*

1-C-20 ***Mechanical bodyweight support during gait increases human sensorimotor electrocortical alpha and beta band spectral power***

Seongmi Song[1], Andrew Nordin[1]

[1]*Texas A&M University*

1-C-21 ***Vestibular loss increases kinematic variability and alters gaze control strategy in locomoting primates***

Oliver Stanley[1], Ruihan Wei[1], Kathleen Cullen[1]

[1]*Johns Hopkins University*

D – INTEGRATIVE CONTROL OF MOVEMENT

1-D-22 ***Ringing a bell: Human control strategies for handling objects with internal collisions***

Sidharth Annapragada[1], Reza Sharif Razavian[2], Salah Bazzi[1], Dagmar Sternad[1]

[1]*Northeastern University,* [2]*Northern Arizona University*

1-D-23 ***Neural correlates of action feedback timing and sense of agency before and after controlling an avatar in virtual reality***

Yiyang Cai[1], Huichao Yang[2], Ziyi Xiong[2], Simone Kühn[3], Yanchao Bi[2], Kunlin Wei[1]

[1]*Peking University,* [2]*Beijing Normal University,* [3]*University Medical Center Hamburg-Eppendorf*

1-D-24 ***Variability and noise in the balance system***

Lucas Mensink[1], Brandon Rasman[1], Jean-Sébastien Blouin[2], Patrick Forbes[1]

[1]*Erasmus MC,* [2]*The University of British Columbia*

1-D-25 ***Finger choice and exploration strategies for single-shot tactile search***

Sasha Reschechtko[1], Wylianne Pangan[1], J. Andrew Pruszynski[2]

[1]*San Diego State University,* [2]*Western University*

1-D-26 ***Does visual experience influence proprioception? A comparison of passive arm matching between blind and sighted participants***

Najib Abi Chebel[1], Florence Gaunet[2], Pascale Chavet[1], Christine Assaiante[3], Christophe Bourdin[1], Fabrice Sarlegna[1]

[1]*ISM - UMR CNRS 7287,* [2]*CNRS - LPC,* [3]*CNRS - LNC*

1-D-27 ***The role of smooth pursuit eye movements in limb anticipatory posture stabilization***

Oindrila Sinha[1], Shirin Madarshahian[2], Morgan Paine[1], Tarkeshwar Singh[1]

[1]*Pennsylvania State University,* [2]*Thomas Jefferson University Hospitals*

1-D-28 ***Mesocortical system commonly contributes to short- and long-term fluctuations in motor performances***

Sho Sugawara[1], Noboru Usuda[2], Yuki Hamano[3], Yoshihisa Nakayama[2], Hiroyuki Fukuyama[4], Kiyomi Amemiya[4], Masaki Fukunaga[1], Norihiro Sadato[1], Yukio Nishimura[2]

[1]*National Institute for Physiological Sciences,* [2]*Tokyo Metropolitan Institute of Medical Science,* [3]*Waseda University,* [4]*Tokyo Metropolitan Matsuzawa Hospital*

1-D-29 ***Expansion of neural populations in the repeated evolution of skilled motor behaviors in deer mice***

Kelsey Tyssowski[1], Karen Cortina[1], Vilas Menon[2], Adam Hantman[3], Hopi Hoekstra[1]

[1]*Harvard University,* [2]*Columbia University,* [3]*University of North Carolina*

E – DISORDERS OF MOTOR CONTROL

1-E-30 ***Understanding the mechanisms of action observation as a rehabilitation intervention for stroke***

Layla Abdullatif[1]

[1]*Georgia Institute of Technology*

1-E-31 ***Use of naturalistic and virtual interception tasks to examine predictive ability in individuals with Autism Spectrum Disorder***

Se-Woong Park[1], Sabrina Bond[2], Annie Cardinaux[3], Marta Russo[4], Dena Crozier[5], Pawan Sinha[3], Dagmar Sternad[6]

[1]University of Texas San Antonio, [2]Stanford School of Medicine, [3]Massachusetts Institute of Technology, [4]Policlinico Tor Vergata & IRCCS Fondazione Santa Lucia, [5]Cleveland Clinic Lerner College of Medicine, [6]Northeastern University

1-E-32 ***Assessing motor control capabilities in children with congenital upper limb deficiencies***

Justin Fitzgerald[1], Anita Bagley[2], Jonathon Schofield[1], Michelle James[1], Wilsaan Joiner[1]

[1]University of California - Davis, [2]Shriners Hospitals for Children - Northern California

1-E-33 ***Training-related increase of cortico-cerebellar connectivity in cerebellar degeneration patients as a function of feedback***

Caroline Nettekoven[1], Rossitza Draganova[2], Katharina Steiner[2], Sophia Göricke[2], Andreas Deistung[3], Jürgen Konczak[4], Dagmar Timmann[2]

[1]Western University, [2]University of Duisburg-Essen, [3]University Hospital Halle (Saale), [4]University of Minnesota

1-E-34 ***Combined upper limb exercise for motor and proprioception post stroke: a preliminary finding***

Ananda Sidarta[1], Yu Chin Lim[2], Christopher Wee Keong Kuah[3], Yong Joo Loh[3], Wei Tech Ang[2]

[1]NTU, [2]Nanyang Technological University, [3]Tan Tock Seng Hospital

1-E-35 ***Comparison of two forms of non-invasive spinal cord stimulation***

Attiyeh Vasaghi[1], Muhammet Berkan Kocer[1], Katrina Armstrong[1], Katinka Stecina[1], Kristine Cowley[1]

[1]University of Manitoba

1-E-36 ***Reaching to understand the neural correlates of tremor variability during naturalistic movement: A high-density neuroimaging study in essential tremor patients***

Timothy West[1], Kenan Steidel[2], Tjalda Flessner[2], Marielle Stam[3], Deniz Kucukahmetler[1], Meaghan Spedden[4], Ryan Timms[4], Simon Farmer[4], Gareth Barnes[4], David Pedrosa[2], Hayriye Cagnan[1]

[1]University of Oxford, [2]University Hospital of Marburg, [3]University of Amsterdam, [4]University College London

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

1-F-37 ***The effect of continuous and intermittent theta-burst ultrasound stimulation over multiple depths of human motor cortex***

Shancheng Bao[1], Hakjoo Kim[1], Yuming Lei[1]

[1]Texas A&M University

1-F-38 ***Ouvrai: Opening access to remote VR studies of movement***

Evan Cesanek[1], Daniel Wolpert[1]

[1]Columbia University

1-F-39 ***Neural correlates of dual-task balance following experimentally induced knee joint deafferentation***

Meredith Chaput[1], Janet Simon[1], Scott Monfort[2], Byrnadeen Farraye[1], Dustin Grooms[1]

[1]Ohio University, [2]Montana State University

1-F-40 ***Differential effect of age on implicit and explicit motor learning processes***

Elizabeth Cisneros[1], Jonathan Tsay[1], Sheer Karney[1], Richard Ivry[1]

[1]University of California, Berkeley

1-F-41 ***Neural markers for movement preparation and error processing during motor adaptation and de novo learning***

Raphael Gastrock[1], Edward Ody[2], Denise Henriques[1], Bernard 't Hart[1]

[1]York University, [2]Philipps - Universität

1-F-42 ***Hyperstabilization of motor memory in adaptation***

Angelina Huynh[1], Yori Escalante[1], Shancheng Bao[1], Yuming Lei[1], David Wright[1]

[1]Texas A&M University

1-F-43 ***Changes in corticospinal excitability during motor imagery by training of force production task: effect of the rate of force development during training***

Masaya Kitamura[1], Atsushi Oshima[1], Kiyotaka Kamibayashi[1]

[1]Doshisha University

1-F-44 ***Cortical and subcortical stimulation affect memory consolidation and acquisition of sequence learning and motor adaptation***

Biyang Lin[1], Yiyu Wang[1], Shancheng Bao[1], Yuming Lei[1]

[1]Texas A&M University

1-F-45 ***Analyzing user learning across varying decoder parameters in co-adaptive myoelectric interfaces***

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

[1]University of Washington

1-F-46 ***Specificity of emergent timing in a polyrhythmic skill on time perception***

Se-Woong Park[1], Joo-Hyun Song[2]

[1]University of Texas at San Antonio, [2]Brown University

1-F-47 ***Sensory error sensitivity in speech production can be modulated by perturbations of perceived variability***

Ding-lan Tang[1], Caroline Niziolek[1], Benjamin Parrell[1]

[1]University of Wisconsin-Madison

1-F-48 ***Cerebellar degeneration impairs strategy discovery but not strategy recall***

Jonathan Tsay[1], Lauren Schuck[2], Richard Ivry[1]

[1]University of California, Berkeley, [2]Mount Sinai

1-F-49 ***Junction-specific training improves the stability of motor sequence execution in expert pianists***

Pei-Cheng Shih[1], Masato Hirano[1], Shinichi Furuya[1]

[1]Sony Computer Science Lab, Inc.

1-F-50 ***Sensorimotor adaptation in microgravity requires increased neural resources to maintain performance***

Grant Tays[1], Kathleen Hupfeld[1], Heather McGregor[1], Nichole Beltran[2], Yiri De Dios[2], Scott Wood[3], Patricia Reuter-Lorenz[4], Jacob Bloomberg[3], Rachael Seidler[1]

[1]University of Florida, [2]KBR, [3]NASA, [4]University of Michigan

1-F-51 ***Explicit aiming solutions are gained through insight***

Max Townsend[1], Faisal Mushtaq[1], Mark Mon-Williams[1], Ryan Morehead[1]

[1]University of Leeds

1-F-52 ***Transcranial magnetic stimulation induced motor evoked potentials as a measure of motor impairments and recovery post stroke***

Jordan Williamson[1], Shirley James[2], Justin Brixey[1], Blair Apple Hill[2], Jason Sharps[2], Aaron Monrose[2], Dorothy He[2], Evgeny Sidorov[2], Yuan Yang[1]

[1]University of Oklahoma, [2]University of Oklahoma Health Sciences Center

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

1-G-53 ***Identification of cortically mediated components of muscle activity in reactive balance***

Scott Boebinger[1], Aiden Payne[2], Giovanni Martino[3], Jasmine Mirdamadi[3], Kennedy Kerr[3], Michael Borich[3], Lena Ting[1]

[1]Georgia Institute of Technology & Emory University, [2]Florida State University, [3]Emory University

1-G-54 ***Internal states as a source of subject-dependent movement variability and their representation by large-scale networks***

Macauley Breault[1], Pierre Sacre[2], Zachary Fitzgerald[3], John Gale[4], Kathleen Cullen[5], Jorge Gonzalez-Martinez[6], Sridevi Sarma[5]

[1]Massachusetts Institute of Technology, [2]University of Liege, [3]Northwestern University, [4]DIXI Neurolab, Inc., [5]Johns Hopkins University, [6]University of Pittsburgh

1-G-55 *RNN dynamics are not conserved across different task implementations*

Benjamin Cuthbert[1], Dominik Endres[2], Gunnar Blohm[1]

[1]Queen's University, [2]Philipps-Universität Marburg

1-G-56 *Reinforcement learning of energy optimal gaits*

Sina Mehdizadeh[1], Max Donelan[1]

[1]Simon Fraser University

1-G-57 *A geometric framework for understanding neural computation: a single neuron perspective*

Isabella Penido[1], John Donoghue[1], Carlos Vargas-Irwin[1]

[1]Brown University

1-G-58 *Network analysis of population activity in macaque motor cortex during reach toward static and moving targets*

Qifan Wang[1], Yiheng Zhang[1], Chenyang Li[1], Tianwei Wang[1], Cong Zheng[1], He Cui[1]

[1]Chinese Institute of Brain Research

1-G-59 *Learning muscle activation pattern for FES cycling using reinforcement learning*

Nat Wannawas[1], Aldo Faisal[2]

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

POSTER SESSION 2

WEDNESEDAY, APRIL 19, 2023

B – FUNDAMENTALS OF MOTOR CONTROL

Poster Cluster (2-B-1 to 2-F-5)

2-B-1 *Basal Ganglia activity during directional hand reaching task*

Sina Javadzadeh No[1], Seyyed Alireza Seyyed Mousavi[1], Terence Sanger[1]

[1]University of California Irvine

2-B-2 *On the effects of deep brain stimulation on motor performance of the affected side of a hemidystonic child during a continuous motor task*

Seyyed Alireza Seyyed Mousavi[1], Jaya Nataraj[1], Rahil Soroushmojdehi[1], Terence Sanger[2]

[1]University of California Irvine, [2]Children's Health Orange County

2-E-3 *Pattern changes in task-related and task-unrelated frequency content in a dystonic adult receiving deep brain stimulation during a continuous motor task*

Jaya Nataraj[1], Rahil Soroushmojdehi[1], Seyyed Alireza Seyyed Mousavi[1], Terence Sanger[2]

[1]University of California, Irvine, [2]Children's Health of Orange County

2-E-4 *Comparison analysis of evoked potentials generated by peripheral median nerve stimulation (PNS) and by deep brain stimulation (DBS) in VIM and PPN*

Yun Sun[1], Maral Kasiri[1], Alireza Mousavi[1], Terence Sanger[1]

[1]University of California, Irvine

2-F-5 *Intracranial paired pulse stimulation shows inhibition at inter-stimulus intervals (ISI) less than 1 msec in patients with dystonia*

Rahil Soroushmojdehi[1], Seyyed Alireza Seyyed Mousavi[1], Terence Sanger[1]

[1]University of California, Irvine

2-B-6 *Changes in EEG alpha-band power during prehension indicate neural motor drive inhibition*

Oscar Ortiz[1], Usha Kuruganti[1], Victoria Chester[1], Adam Wilson[1], Dan Blustein[2]

[1]University of New Brunswick, [2]Acadia University

2-B-7 *Reaching performance under stress*

Liana Brown[1], Mitchell Phillips[1], Shannah Quinlan[1], Leia Bagesteiro[2]

[1]Trent University, [2]San Francisco State University

2-B-8 ***Evaluation of cerebellum-dependent movement predictions and adaptations in a healthy elderly population***

Anda de Witte[1], Anouck Matthijs[1], Jean-Jacques Orban de Xivry[1]

[1]*KU Leuven*

2-B-9 ***Using repetition effects to study the building blocks of motor sequence learning***

Joern Diedrichsen[1], Mahdiyar Shahbazi[1], Giacomo Ariani[1], Amy Jing[1]

[1]*Western University*

2-B-10 ***Local field potentials in the primary and premotor cortices during ipsilateral vs. contralateral reach and grasp in macaque monkeys***

Ali Falaki[1], Hugo Delivet-Mongrain[1], Stephan Quessy[1], Numa Dancause[1]

[1]*Université de Montréal*

2-B-11 ***Reaction time to neutral, physical activity, and sedentary stimuli across adulthood***

Ata Farajzadeh[1], Matthieu Boisgontier[1], Miriam Goubran[1]

[1]*University of Ottawa*

2-B-12 ***Is there more to sequence learning than better anticipation?***

Jörn Diedrichsen[1], Andrew Pruszynski[1]

[1]*Western University*

2-B-13 ***Different patterns in the neural space for the initial and corrective phases of precision reaching***

WeiHsien Lee[1], Brianna Karpowicz[2], Chethan Pandarinath[3], Adam Rouse[1]

[1]*University of Kansas Medical Center,* [2]*Emory University,* [3]*Emory University, Georgia Tech*

2-B-14 ***Interception of virtual throws reveals predictive skills based on the visual processing of throwing kinematics***

Antonella Maselli[1], Paolo De Pasquale[2], Francesco Lacquaniti[3], Andrea d'Avella[4]

[1]*Research Council of Italy,* [2]*University of Messina,* [3]*University of Rome Tor Vergata,* [4]*IRCCS Fondazione Santa Lucia / University of Messina*

2-B-15 ***Electroencephalographic whole brain analysis of sensory gating during active and passive movement***

Yusuke Ozawa[1], Kazumasa Uehara[2], Kazuhiko Seki[3], Natsue Yoshimura[1]

[1]*Tokyo Institute of Technology,* [2]*National Institute for Physiological Sciences,* [3]*National Center of Neurology and Psychiatry*

2-B-16 ***Millisecond-scale differences in muscle stimulation patterns modulate motor output.***

Andrea Pack[1], Iris Adam[2], Coen P. H. Elemans[2], Samuel Sober[1]

[1]*Emory University,* [2]*University of Southern Denmark*

2-B-17 ***Identifying stochastic relations among neurons and motor behavior- beyond spike triggered averaging: synergies and synergy control applications***

Trevor Smith[1], TaeGyo Kim[1], Terence Sanger[2], Simon Giszter[1]

[1]*Drexel University,* [2]*University of California, Irvine*

C – POSTURE AND GAIT

2-C-18 ***Four-arms manipulation: a new way to implement robotic surgery***

Soheil Gholami[1], Louis Munier[1], Cécile Cabasse[1], Mohamed Bouri[1], Aude Billard[1]

[1]*École Polytechnique Fédérale de Lausanne*

2-C-19 ***Neuromuscular fatigue reduces the nervous system's ability to control leg external forces***

Pawel Kudzia[1], James Wakeling[1], Stephen Robinovich[1], Max Donelan[1]

[1]*Simon Fraser University*

2-C-20 ***Modulation of corticospinal excitability with balance task difficulty and cognitive dual task performance***

Catherine Mason[1], Rishabh Rastogi[2], Michael Borich[2], Trisha Kesar[1], Lena Ting[2]

[1]*Emory University,* [2]*Georgia Institute of Technology and Emory University*

2-C-21 ***Encoding of active and passive translations in the primate posterior cerebellum for postural control***

Robyn Mildren[1], Kathleen Cullen[1]

[1]Johns Hopkins University

2-C-22 ***Velocity-dependent reweighting of proprioceptive information for human balance control***

Kyle Missen[1], Lorenz Assländer[2], Mark Carpenter[1]

[1]University of British Columbia, [2]Universität Konstanz

2-C-23 ***The loss of the α9/10 nicotinic acetylcholine receptor subunit impairs postural stability in α9/10 knockout mice***

Tobias Niebur[1], Brandie Morris Verdone[2], Kathleen Cullen[1]

[1]Johns Hopkins University School of Medicine, [2]Johns Hopkins University School of Engineering

2-C-24 ***Stimulation-dependent characterization of trunk muscle responses to single-pulse epidural spinal stimulation***

Sydney Schadan[1], Alexander Steele[2], Amir Faraji[2], Dimitry Sayenko[2], Albert Vette[1]

[1]University of Alberta, [2]Houston Methodist Hospital

2-C-25 ***Sensors for Exploring Novel Stroke Specific Outcome and Recovery measureS (SENSORS)***

Aishwarya Shenoy[1], Kyle Weber[2], Kit Beyer[2], Bill McIlroy[2], Karen Van Ooteghem[2], Sean Dukelow[3], Courtney Pollock[1], Janice Eng[1]

[1]University of British Columbia, [2]University of Waterloo, [3]University of Calgary

D – INTEGRATIVE CONTROL OF MOVEMENT

2-D-26 ***Coherent oscillations in an exhaustive sample of motor units revealed by arrays of surface and intramuscular EMG electrodes***

Simon Avrillon[1], Blanka Zicher[1], Agnese Grison[1], Aritra Kundu[1], Dario Farina[1]

[1]Imperial College London

2-D-27 ***Human intracranial recordings during action execution and action observation***

Vasiliki Bougou[1], Elina Keirse[1], Thomas Decramer[2], Anaïs Van Hoylandt[2], Peter Janssen[1], Tom Theys[2]

[1]KU Leuven, [2]UZ Leuven

2-D-28 ***Neural activity in motor cortex evolves differently for continuously feedback-driven movements compared to discrete reaches***

Raeed Chowdhury[1], Mohsen Sadeghi[2], Salah Bazzi[2], Reza Sharif Razavian[3], Brian Dekleva[1], Emily Oby[1], Dagmar Sternad[2], Patrick Loughlin[1], Aaron Batista[1]

[1]University of Pittsburgh, [2]Northeastern University, [3]Northern Arizona University

2-D-29 ***Differential roles of the ventral anterior and ventral lateral thalamic nuclei on motor cortical dynamics during dexterous movements***

Kevin Cross[1], Jeremy Cohen[1], Jian-Zhong Guo[1], Adam Hantman[1]

[1]University of North Carolina at Chapel Hill

2-D-30 ***Lost in translation: Exploring the effects of rotation and translation in real life horizontal plane movements in healthy subjects and patients with unilateral vestibular hypofunction***

Sarah Hosli[1], Christopher Bockisch[1], Giorgia Di Ruggiero[1], Julia Dlugaiczyk[2], Dominik Straumann[2]

[1]University of Zurich, [2]University Hospital Zurich

2-D-31 ***Emergent rhythmic motor timing enhances perception of periodic temporal patterns***

Helene Serre[1], Tri Nguyen[2], Joo-Hyun Song[2], Dagmar Sternad[1]

[1]Northeastern University, [2]Brown University

2-D-32 ***Wide-field calcium imaging of cortical activation and functional connectivity in externally- and internally-driven locomotion***

Sarah West[1], Morgan Gerhart[1], Timothy Ebner[1]

[1]University of Minnesota

2-D-33 ***Head movements improve the stability of sensorimotor synchronization of finger flexion to auditory rhythms***

Ryoichiro Yamazaki[1], Junichi Ushiyama[1]

[1]*Keio University*

E – DISORDERS OF MOTOR CONTROL

2-E-34 ***Reaching in children with cerebral palsy: a motor characteristics study***

Leia B Bagesteiro[1], Tamires L Tellini[2], Liana Brown[3]

[1]*San Francisco State University,* [2]*Universidade Federal do ABC,* [3]*Trent University*

2-E-35 ***Patients with Parkinson's Disease still have adaptive postural control to perform goal-directed visual tasks, but limited compared to age-matched controls***

Cédrick Bonnet[1], Cédrick Bonnet[1], Arnaud Delval[1], Luc Defebvre[1]

[1]*SCALab*

2-E-36 ***Short-latency afferent inhibition and somatosensory-motor inhibition in genetically confirmed dopa-responsive dystonia: A tale of time***

Matt Brown[1], Anne Weissbach[2], Annika Steinmeier[2], Martje Pauly[2], Duha Al-Shorafat[3], Gerard Saranza[4], Anthony Lang[5], Norbert Brüggemann[2], Vera Tadic[6], Christine Klein[2], Alexander Münchau[2], Tobias Bäumer[2]

[1]*California State University Sacramento,* [2]*University of Lübeck,* [3]*Jordan University of Science and Technology,* [4]*Chong Hua Hospital,* [5]*Toronto Western Hospital,* [6]*University Hospital Schleswig Holstein*

2-E-37 ***Sensorimotor indicators correlate with cognitive deficits in dementia***

Marta Russo[1], Alessia de Nobile[2], Ilaria Borghi[3], Denise Berger[3], Paolo De Pasquale[3], Antonella Maselli[4], Daniele Bibbo[2], Silvia Conforto[2], Francesco Lacquaniti[5], Giacomo Koch[3], Andrea d'Avella[6]

[1]*Policlinico Tor Vergata,* [2]*Roma Tre University,* [3]*IRCCS Fondazione Santa Lucia,* [4]*ISTC CNR,* [5]*Tor Vergata University,* [6]*University of Messina*

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

2-F-38 ***Modulating the discharge pattern of motor units through M1 and S1 stimulation***

Yuming Lei[1], Shancheng Bao[1]

[1]*Texas A&M University*

2-F-39 ***The effect of implicit visuomotor adaptation on beta band activity and subsequent adaptation capabilities***

Élisa De La Fontaine[1], Jean-François Lepage[1], Pierre-Michel Bernier[1]

[1]*Université de Sherbrooke*

2-F-40 ***Motor unit activity and neural drive to co-contracting muscles during motor adaptation to dynamic perturbations***

Yori Escalante[1], Yuming Lei[1]

[1]*Texas A&M University*

2-F-41 ***Exploring visuomotor adaptation in a bimanual aiming task***

Gregg Eschelmuller[1], Annika Szarka[1], J. Timothy Inglis[1], Romeo Chua[1]

[1]*University of British Columbia*

2-F-42 ***Reproducing human sensorimotor adaptation and deficits with spiking neural networks and known synaptic learning rules***

Max Grogan[1], Yufei Wu[1], Shlomi Haar[1], Aldo Faisal[2]

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

2-F-43 ***On the modulation of human motor learning by predictive reward and punishment***

Britta Hinneberg[1], Lisa Maurer[1], Heiko Maurer[1], Hermann Müller[1], Sven Hoffmann[2], Mathias Hegele[1]

[1]*Center for Mind, Brain & Behavior, Universities of Giessen and Marburg,* [2]*Hagen University*

2-F-44 ***Event-related transcranial direct current stimulation selectively enhances adaptation of coincident movements***

Ned Jenkinson[1], Matthew Weightman[1], Joseph Galea[1], Chris Miall[1]

[1]*University of Birmingham*

2-F-45 ***Sensorimotor planning and linguistic context in bilingual speech production***

Daniel Lametti[1], Douglas Shiller[2]

[1]Acadia University, [2]Université de Montréal

2-F-46 ***Can insole vibration speed up adaptation following gravity level changes?***

Heather McGregor[1], Kristina Hall[1], Daniel Ferris[1], Rachael Seidler[1]

[1]University of Florida

2-F-47 ***Brain network for sensorimotor recall***

Atousa Assadi[1], Shahabeddin Vahdat[2], Theodore Milner[1]

[1]McGill University, [2]University of Florida

2-F-48 ***Lesions affecting the dorsomedial frontal cortex impair error-based motor learning, but not reinforcement-based learning***

Dimitrios Palidis[1], Lesley Fellows[1]

[1]McGill University

2-F-49 ***Injecting arbitrary instructions into anterior intraparietal area with low-amplitude intracortical microstimulation***

Brandon Ruszala[1], Marc Schieber[1]

[1]University of Rochester

2-F-50 ***Quadriceps force control error is correlated with lesser bilateral sensorimotor cerebellar activation after knee anterior cruciate ligament reconstruction***

Amber Schnittjer[1], HoWon Kim[1], Byrnadeen Farraye[1], Meredith Chaput[1], Janet Simon[1], Dustin Grooms[1]

[1]Ohio University

2-F-51 ***Machine classification of electroencephalography during action observation and action performance during a real-world object lifting task is sensitive to previous experience***

Jamie Scholl[1], Lee Baugh[1]

[1]University of South Dakota

2-F-52 ***Both sensory prediction error and performance error contribute to implicit learning in visuomotor rotation adaptation***

Xiaoyue Zhang[1], Wencheng Wu[2], Kunlin Wei[1]

[1]Peking University, [2]Emory University

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

2-G-53 ***Information bottlenecks, use-dependent learning, and handedness in sensorimotor control***

Xueqian Deng[1], Chenshuo Yin[1], Adrian Haith[1]

[1]The Johns Hopkins University School of Medicine

2-G-54 ***Exploiting self-induced internal dynamics in the control of complex objects***

Krishna Sarvani Desabhotla[1], Rashida Nayeem[1], Mohsen Sadeghi[1], Dagmar Sternad[1]

[1]Northeastern University

2-G-55 ***Parallel processes of habit formation and response speed improvement***

Yue Du[1], Adrian Haith[1]

[1]Johns Hopkins University School of Medicine

2-G-56 ***Neural representation of hindlimb muscle synergies in the mouse spinal cord revealed by optogenetically elicited interneuronal activities recorded by soft carbon nanotube electrodes***

Borong He[1], Paola Salmas[1], Jing Zhang[2], Xiaojie Duan[3], Vincent Chi Kwan Cheung[1]

[1]The Chinese University of HongKong, [2]The University of Chicago, [3]Peking University

2-G-57 ***Characterization of a computational model of the tibialis anterior muscle using surface electromyography for the development of a lower extremity injury prediction neuromuscular algorithm***

Von Homer[1]

[1]Delaware State University

2-G-59 ***Gain modulation in preparatory activity for reaching sequence in macaque motor cortex***

Tianwei Wang[1], Yun Chen[1], Yiheng Zhang[1], He Cui[1]

[1]Chinese Institute for Brain Research, Beijing (CIBR)

POSTER SESSION 3

THURSDAY, APRIL 20, 2023

B – FUNDAMENTALS OF MOTOR CONTROL

3-B-1 ***The influence of transcranial direct current stimulation (tDCS) on the perception of actions following motor skill training***

Eryn Armstrong[1], Grace Bennett[1], John Buchanan[1]

[1]*Texas A&M Univeristy*

3-B-2 ***Distinct neural modes carry information about grasp timing and grip force in sensorimotor cortex***

Gary Blumenthal[1], Brian Dekleva[1], Jorge Gonzalez-Martinez[2], Byron Yu[3], Aaron Batista[1], Robert Gaunt[1], Michael Boninger[1], Steven Chase[3], Jennifer Collinger[1]

[1]*University of Pittsburgh,* [2]*University of Pittsburgh Medical Center,* [3]*Carnegie Mellon University*

3-B-3 ***Past and future states elicit differences in temporal generalization during bimanual adaptation***

Ian Howard[1], Sae Franklin[2], David Franklin[2]

[1]*University of Plymouth,* [2]*Technical University of Munich*

3-B-4 ***Establishing the non-human primate as an animal model for temporal interference stimulation: simulations and neurophysiological recordings from a deep brain structure in the macaque***

Sarah Kearsley[1], Sebastian Lehmann[1], Adam Williamson[2], Esra Neufeld[3], Melanie Steiner[3], Emma Acerbo[2], Boris Botzanowski[2], Lyle Muller[1], Brian Corneil[1]

[1]*Western University,* [2]*Aix-Marseille Université,* [3]*Foundation for Research on Information Technologies in Society (IT'IS)*

3-B-5 ***Contributions of premotor and primary motor cortex to climbing in mice***

Amy Kristl[1], Natalie Koh[1], Zhengyu Ma[1], Sarah Hsu[1], Andrew Miri[1]

[1]*Northwestern University*

3-B-6 ***The nervous system alters its control strategy in the presence of unpredictable visual disturbances during goal-directed reaching***

Philipp Maurus[1], Ghadeer Mahdi[1], Tyler Cluff[1]

[1]*University of Calgary*

3-B-7 ***Arm and eye movement information of electrocorticographic signals in monkeys***

Pavithra Rajeswaran[1], Leo Scholl[1], Lydia Smith[1], Amy Orsborn[1]

[1]*University of Washington*

3-B-8 ***Neural representations of observed vs executed actions in the frontoparietal grasp network***

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

[1]*German Primate Center,* [2]*cortEXplore*

3-B-9 ***Evidence for submovement encoding in motor cortex during precision reaching***

Kevin Schwartze[1], Weihsien Lee[1], Adam Rouse[1]

[1]*University of Kansas Medical Center*

3-B-10 ***Similarities between feedback and feedforward control***

Jeroen B.J. Smeets[1], Eli Brenner[1]

[1]*Vrije Universiteit Amsterdam*

3-B-11 ***The paradox of apparent Brownian processes in human motor behavior***

Federico Tessari[1], James Hermus[1], Rika Sugimoto Dimitrova[1], Neville Hogan[1]

[1]*Massachusetts Institute of Technology*

3-B-12 ***Revealing the neural basis of muscle synergies in humans through direct electrical stimulation of the motor cortex***

Jodie Jingping Xie[1], Vincent Chi Kwan Cheung[1], Peter Yat Ming Woo[2], Rosa Ho Man Chan[3], Amy H.S. Kong[2], Subing Huang[3], Kelvin Lau Yat Lau[1]

[1]*The Chinese University of Hong Kong,* [2]*Kwong Wah Hospital,* [3]*City University of Hong Kong*

C – POSTURE AND GAIT

3-C-13 *The reflexive control of knee stability during movement*

Muhammet Berkan Kocer[1], Attiyeh Vasaghi[1], Katrina Armstrong[1], Katinka Stecina[1]

[1]*University of Manitoba*

3-C-14 *Vestibular contributions to dynamic postural control in freely moving rhesus monkeys*

Olivia Leavitt[1], Kathleen Cullen[1]

[1]*Johns Hopkins University*

3-C-15 *Reduced cortical sensory processing during whole-body motion perception after stroke*

Jasmine Mirdamadi[1], Scott Boebinger[2], Kennedy Kerr[1], Lena Ting[2], Michael Borich[1]

[1]*Emory University,* [2]*Emory University and Georgia Institute of Technology*

3-C-16 *Speed- and mode-dependent modulation of triceps surae cutaneous reflexes during locomotion*

Alan Phipps[1], Aiko Thompson[1]

[1]*Medical University of South Carolina*

3-C-17 *Beta waves and the control of vocal tract posture*

Arian Shamei[1], Eric Easthope[1], Yadong Liu[1], Bryan Gick[1], Sidney Fels[1]

[1]*University of British Columbia*

3-C-18 *Sensory augmentation strengthens foot placement control but increases center-of-mass variability during steady-state walking*

Moira van Leeuwen[1], Sjoerd Bruijn[1], Jesse Dean[1]

[1]*Vrije Universiteit Amsterdam*

3-C-19 *Anxious arousal modulates with motor adaptation during repeated practice of split-belt treadmill walking*

Kaya Yoshida[1], Shannon Lim[1], Janice Eng[1], Lara Boyd[1], Courtney Pollock[1]

[1]*University of British Columbia*

D – INTEGRATIVE CONTOL OF MOVEMENT

3-D-20 *Reach-to-grasp decoding from macaque posterior parietal cortex via a deep learning approach and interpretation of the most grip-discriminative features*

Davide Borra[1], Matteo Filippini[1], Mauro Ursino[1], Elisa Magosso[1], Patrizia Fattori[1]

[1]*University of Bologna*

3-D-21 *Comparing reach direction decoding in macaque ventral premotor, dorsal premotor, and primary motor cortex*

Sofie De Schrijver[1], Jesus Garcia Ramirez[1], Thomas Decramer[2], Tom Theys[2], Peter Janssen[1]

[1]*KU Leuven,* [2]*UZ Leuven*

3-D-22 *Tongue posture stabilization by reflex mechanism for speech production*

Takayuki Ito[1], Mohamed Bouguerra[1], Morgane Bourhis[1], Pascal Perrier[1]

[1]*GIPSA lab - CNRS*

3-D-23 *Investigating quantitative EEG during dynamic elbow movements: A pilot study*

Christina Jones[1], Likhita Kosuri[2], Justin Andrushko[1], Shie Rinat[1], Anja Cui[1], Lara Boyd[1]

[1]*University of British Columbia,* [2]*University of British Columbia Okanagan*

3-D-24 *Modulation of the somatosensory signals through a cortico-cuneate pathway during voluntary hand movement*

Shinji Kubota[1], Moeko Kudou[1], Satomi Kikuta[1], Junichiro Yoshida[1], Tomomichi Oya[2], Kazuhiko Seki[1]

[1]*National Institute of Neuroscience, National Center of Neurology and Psychiatry,* [2]*University of Western Ontario*

3-D-25 *A "posture subspace" in motor cortex*

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

[1]*University of Pittsburgh,* [2]*Carnegie Mellon University,* [3]*Palladian Partners,* [4]*Starfish Neuro,* [5]*University of California, Davis*

3-D-26 ***Bidirectional effects of eye movements on manual interception and motion perception.***

Justin McCurdy[1], Deborah Barany[1]
[1]University of Georgia

3-D-27 ***Bimanual coordination and spinal cord neuromodulation in the neural control of arm movements***

Behdad Parhizi[1], Vivian Mushahwar[1]
[1]University of Alberta

3-D-28 ***A neural basis for choking under pressure***

Adam Smoulder[1], Patrick Marino[2], Nick Pavlovsky[2], Emily Oby[1], Sam Snyder[2], William Bishop[3], Byron Yu[1], Steven Chase[1], Aaron Batista[2]
[1]Carnegie Mellon University, [2]University of Pittsburgh, [3]Howard Hughes Medical Institute Janelia

3-D-29 ***Mesoscale Ca2+ imaging of the cerebellar cortex reveals independent networks of Purkinje cell dendritic and somatic modulation, with divergent patterns of activity versus synchronicity during locomotion and reaching***

Martha Streng[1], Russell Carter[1], Kayla Togneri[1], Emma Wasserman[1], Benjamin Kottke[1], Vijay Rajendran[1], Suhasa Kodandaramaiah[1], Esther Krook-Magnuson[1], Timothy Ebner[1]
[1]University of Minnesota

3-D-30 ***Neural dynamics of three posterior parietal areas during arm reaching movements evolve in a largely shared neural subspace***

Francesco Vaccari[1], Stefano Diomedi[1], Kostas Hadjidimitrakis[1], De Vitis Marina[1], Matteo Filippini[1], Patrizia Fattori[1]
[1]University of Bologna

3-D-31 ***Aging is detrimental to sensory function. Or is it? Let's have a look at touch and proprioception***

Stien Van De Plas[1], Jean-Jacques Orban de Xivry[1]
[1]KU Leuven

E – DISORDERS OF MOTOR CONTROL

3-E-32 ***Assessing hand grasp representations in children with congenital upper limb deficiencies***

Marcus Battraw[1], Justin Fitzgerald[1], Michelle James[2], Anita Bagley[2], Wilsaan Joiner[1], Jonathon Schofield[1]
[1]University of California, Davis, [2]Shriners Hospital for Children Northern California

3-E-33 ***Finger skin mechanoreceptors could explain deficits in grip force modulation in Parkinson disease.***

Valentine Gusbin[1], Bernard Dachy[2], Isabelle Neu[1], Thomas Pages[1], Joseph McIntyre[3], Ana Bengoetxea[1]
[1]Université Libre de Bruxelles (ULB), [2]CHU Brugmann-Université Libre de Bruxelles (ULB), [3]TECNALIA, Basque Research and Technology Alliance (BRTA)

3-E-34 ***Impacts of epidural stimulation spatial extent on recovery of function in combined bionic and biological SCI therapies***

Andrey Borisyuk[1], Kim Dougherty[1], Simon Giszter[1]
[1]Drexel University College of Medicine

3-E-35 ***Differences in the synergy index for children aged 4-12 years with cerebral palsy and following traumatic brain injury***

Aviva Mimouni-Bloch[1], Sharon Shaklai[1], Moran Levin[2], Moria Ingber[1], Tanya Karolitsky[1], Sigal Grunbaum[1], Jason Friedman[2]
[1]Loewenstein Rehabilitation Medical Center, [2]Tel Aviv University

3-E-36 ***Cognitive load disrupts reach efficiency, speed, and curvature in chronic stroke***

Cory Potts[1], Shailesh Kantak[1], Rand Williamson[1], Joshua Jacob[1], Laurel Buxbaum[1]
[1]Thomas Jefferson University

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

Poster Cluster (3-F-37 & 3-F-38)

3-F-37 ***Effects of neuromuscular fatigue on motor adaptation and savings using a novel mechanical perturbation postural-task paradigm***

Mauro Nardon[1], Francesco Piscitelli[1], Tarkeshwar Singh[2], Matteo Bertucco[1]

[1]University of Verona, [2]The Pennsylvania State University

3-F-38 ***Localized neuromuscular fatigue does not impair postural motor adaptation processes during force field learning***

Mauro Nardon[1], John Kpankpa[2], Eliza Albenze[2], Oindrila Sinha[2], Tarkeshwar Singh[2], Matteo Bertucco[1]

[1]University of Verona, [2]The Pennsylvania State University

3-F-39 ***Adaptation to sensorimotor delays take place in the movement frequency space, not in the domain of time***

Masaya Hirashima[1], Kenichi Shiraki[2], Takashi Yanagi[2], Nobuhiro Hagura[1]

[1]NICT, [2]Honda R&D Co.,Ltd.

3-F-40 ***The effects of training methods with varying degrees of explicitness on short-term and long-term savings following visuomotor adaptation***

Reshma James[1], Jinsung Wang[2]

[1]University of Wisconsin, [2]UWM, Milwaukee

3-F-41 ***Dual strategy use during a visuomotor reach adaptation task***

Olivia Kim[1], Jordan Taylor[1]

[1]Princeton University

3-F-42 ***Cognitive-motor interactions in neurotypical children and young adults using mobile brain-body imaging (MoBI) show age-related differences in neurophysiology and response inhibition task performance***

Paige Nicklas[1], John Foxe[1], Edward Freedman[1]

[1]University of Rochester

3-F-43 ***Quantifying internal model learning in monkeys using a novel continuous tracking task***

Katherine Perks[1], Lydia Smith[1], Samuel Burden[1], Amy Orsborn[1]

[1]University of Washington

3-F-44 ***Vibration-induced modulation in motor control related areas activity***

Clara Pfenninger[1], Marie Fabre[1], Narimane Zeghoudi[1], Ahmed Adham[2], Charles-Etienne Benoit[1], Thomas Lapole[1]

[1]University of Lyon, [2]University of Saint-Etienne

3-F-45 ***Human-machine coupling: sensorimotor integration of the machine and anthropomorphization as a control scheme***

Axel Roques[1], Pierre-Paul Vidal[2]

[1]Centre Borelli (UMR 9010), Laboratoire GBCM (EA7528), Thales AVS France (Training & Simulation), [2]Centre Borelli (UMR 9010)

3-F-46 ***Inhibiting ventrolateral prefrontal cortex in humans affects motor learning***

Neeraj Kumar[1], Ananda Sidarta[2], Chelsea Smith[3], David Ostry[3]

[1]IIT, [2]NTU, [3]McGill University

3-F-47 ***Adaptation, learning, retention: Using canes significantly improves balance but with no aftereffects or longer-term persistence***

Sabra Sisler[1], Marta Russo[2], Dagmar Sternad[1]

[1]Northeastern University, [2]Policlinico at University of Tor Vergata

3-F-48 ***Operant up-conditioning of the motor evoked potential (MEP) to transcranial magnetic stimulation in upper and lower extremity of people with chronic incomplete SCI***

Aiko Thompson[1], Phipps Alan[1], Roland Cote[1], Allison Lewis[1], Blair Dellenbach[1]

[1]Medical University of South Carolina

3-F-49 ***Predictors of sensorimotor adaption: Insights from over 100,000 reaches***

Jonathan Tsay[1], Jonathan Tsay[1], Laura Germine[2], Jeremy Wilmer[3], Richard Ivry[1], Ken Nakayama[4]

[1]University of California Berkeley, [2]Harvard Medical School, [3]Wellesley College, [4]University of California

3-F-50 ***How does context influence implicit sensorimotor adaptation?***

Tianhe Wang[1], Richard Ivry[2]

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

3-F-51 ***The role of cognitive pre-planned aiming strategies in visuomotor adaptation***

Darrin Wijeyaratnam[1], Erin Cressman[1]

[1]University of Ottawa

3-F-52 ***Rehabilitation of the lower limbs of stroke hemiplegic patients using intensive visual simulation training with IVS4***

Narimane Zeghoudi[1], Davy Luneau[2], Thomas Lapole[1]

[1]Laboratoire Interuniversitaire de Biologie de la motricité, [2]Dessintey

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

3-G-53 ***The effect of agency on action selection in reward-based learning***

Sabrina Abram[1], Emily Chun[1], Jonathan Tsay[1], Tianhe Wang[1], Samuel McDougle[2], Richard Ivry[1]

[1]University of California, Berkeley, [2]Yale University

3-G-54 ***Delay compensation: Smith predictors, state-space controllers, and the McRuer crossover are indistinguishable from input-output data***

Di Cao[1], Noah Cowan[1], Amy Bastian[2], James Freudenberg[3]

[1]Johns Hopkins University, [2]Kennedy Krieger Institute; Johns Hopkins University, [3]University of Michigan

3-G-55 ***Studying in silico neural-physical interaction with MyoSuite***

Guillaume Durandau[1], Huawei Wang[1], Vikash Kumar[2], Massimo Sartori[1], Vittorio Caggiano[2]

[1]University of Twente, [2]Meta AI

3-G-56 ***Differential visuomotor feedback response and learning response between the dominant and non-dominant arm***

Yuto Makino[1], Nao Masuda[1], Daichi Nozaki Nozaki[1]

[1]The University of Tokyo

3-G-57 ***Scaling of response times under feedforward and feedback control with sensorimotor delays in terrestrial mammals***

Sayed Naseel Mohamed Thangal[1], Heather More[1], C. David Remy[2], Max Donelan[1]

[1]Simon Fraser University, [2]University of Stuttgart

3-G-58 ***Optimal reaching subject to computational and physical constraints reveals structure of the sensorimotor control system***

Sridevi Sarma[1], Amy Bastian[1], Marc Schieber[2], Patrick Greene[1]

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

3-G-59 ***Behavioral dynamics of hierarchical action selection***

Juliana Trach[1], Samuel McDougle[1]

[1]Yale University

POSTER SESSION 4

FRIDAY, APRIL 21, 2023

A – CONTROL OF EYE & HEAD MOVEMENT

4-A-1 ***Benefits of postural fluctuations to detect challenging visual targets in the standing position***

Cédrick Bonnet[1], Yann-Romain Kechabia[1], Ivan Magnani[1], Jose Barela[2]

[1]SCALab, [2]São Paulo State University

4-A-2 ***Saccadic choice is not consistent with an ergodic process***

Brandon Caie[1], Gunnar Blohm[1]

[1]Queen's University

4-A-3 *Functional mapping and anatomical tracing of the saccade related region in dorsal frontal cortex of common marmoset*

Chih-Yang Chen[1], Akiya Watakabe[2], Denis Matrov[3], Kuan-Ting Ho[4], Wajd Amly[1], Hirotaka Onoe[4], Tetsuo Yamamori[2], Tadashi Isa[4]

[1]Institute for the Advanced Study of Human Biology (ASHBi), Kyoto University, [2]Center for Brain Science, RIKEN, [3]National Institute of Mental Health, National Institutes of Health, [4]Graduate School of Medicine, Kyoto University

4-A-4 *Cognitive control over reflexive saccades*

Rishabh Singhal[1], Becket Ebitz[1]

[1]University of Montreal

4-A-5 *Vestibular contributions to primate head stability during active locomotion*

Ruihan Wei[1], Oliver Stanley[1], Kathleen Cullen[1]

[1]Johns Hopkins University

B – FUNDAMENTALS OF MOTOR CONTROL

Poster Cluster (4-B-6 & 4-F-7)

4-B-6 *Different sensory information is used for state estimation when stationary or moving*

Luke Carter[1], Amanda Therrien[1], Aaron Wong[1]

[1]Moss Rehabilitation Research Institute

4-F-7 *Adapting to novel forces realigns the perception of limb movement, but not limb position*

Dylan Zangakis[1], Aaron Wong[1], Amanda Therrien[1]

[1]Moss Rehabilitation Research Institute

4-B-8 *Contextual effect of visual lead-in movements decreases faster with increasing dwell time compared to passive lead-in movements*

Laura Alvarez Hidalgo[1], David Franklin[1], Ian Howard[1]

[1]University of Plymouth

4-B-9 *Synergies between motor units in a non-compartmentalized muscle*

Sayan De[1], Joseph Ricotta[1], Mauro Nardon[1], Mark Latash[1]

[1]Pennsylvania State University

4-B-10 *Directional discretization of motor cortical responses during motor imagery*

Brian Dekleva[1], William Hockeimer[1], Nicolas Kunigk[1], Raeed Chowdhury[1], Lee Miller[2], Steven Chase[3], Aaron Batista[1], Michael Boninger[1], Jennifer Collinger[1]

[1]University of Pittsburgh, [2]Northwestern University, [3]Carnegie Mellon University

4-B-11 *Application of 1 hertz rTMS over right PMd does not affect the production of discrete or rhythmic asymmetric bimanual movements, regardless as to whether action is cued with spatial or symbolic visual cues.*

Ronan Denyer[1], Anjana Rajendran[1], Lara Boyd[1]

[1]University of British Columbia

4-B-12 *Dexterous object manipulation translates to a virtual environment*

Clara Günter[1], Yiming Liu[1], Raz Leib[1], David Franklin[1]

[1]Technical University of Munich

4-B-13 *A novel intramuscular needle-style electrode for electrodiagnostics and SMU recording*

Taegyo Kim[1], Ben Binder-Markey[1], Trevor Smith[1], Andrey Borisyuk[1], Simon Giszter[1]

[1]Drexel University

4-B-14 *Interference in motor working memory*

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

[1]Yale University

4-B-15 *Higher lateral occipital brain activity is associated with increased knee sagittal range of motion during a bilateral leg press task in adolescent female athletes*

HoWon Kim[1], Taylor Zuleger[2], Shayla Warren[2], Alexis Slutsky-Ganesh[2], Jed Diekfuss[2], Manish Anand[2], Bryan Schlink[3], Kim Barber Foss[2], Janet Simon[1], Gregory Myer[2], Dustin Grooms[1]

[1]Ohio University, [2]Emory Sports Performance AND Research Center, [3]Battelle Memorial Institute

4-B-16 *Salient events at movement target locations inhibit rapid sequential hand movements - even if they are task-irrelevant*

Clara Kuper[1], Martin Rolfs[1]

[1]Humboldt University of Berlin

4-B-18 *Measures of corticospinal excitability are invariant among reaction time tasks assumed to involve differential levels of advance motor preparation*

Cassandra Santangelo[1], Christin Sadler[1], Dana Maslovat[1], Anthony Carlsen[1]

[1]University of Ottawa

4-B-19 *Step-to-step locomotor variability reveals hierarchical modulation of control across terrain*

Wei-Chen Wang[1], Alexandra Voloshina[2], Monica Daley[2], Nidhi Seethapathi[1]

[1]MIT, [2]University of California Irvine

C – POSTURE AND GAIT

4-C-20 *Fear of falling and the cortical control of balance*

Toby Ellmers[1], Richard Mills[2], Adolfo Bronstein[1], Elmer Kal[3], Johnny Parr[2]

[1]Imperial College London, [2]Manchester Metropolitan University, [3]Brunel University London

4-C-21 *Central modulation of postural control in response to task demands and fatigue in individuals with and without a history of low back pain.*

Jolene Soliman[1], Jo Armour Smith[1]

[1]Chapman University

4-C-22 *How do humans walk faster and bear extra weight? Examining answers from muscle activity, joint motion, ground reaction force, and H-reflexes*

Bridgette Damewood[1], Aiko Thompson[1]

[1]College of Health Professions, Medical University of South Carolina

4-C-23 *Neural correlates of locomotor adaptation during split-belt walking*

Noelle Jacobsen[1], Daniel Ferris[1]

[1]University of Florida

4-C-24 *Musculoskeletal modeling of static standing balance suggests that metabolic costs are not minimized*

Matto Leeuwis[1], Ajay Seth[2], Patrick Forbes[1]

[1]Erasmus MC, [2]Delft University of Technology

4-C-25 *Towards a parallel model of speech posture and movement control*

Yadong Liu[1], Arian Shamei[1], Najeeb Khan[1], Sidney Fels[1], Bryan Gick[1]

[1]University of British Columbia

4-C-26 *Effect of body weight unloading on intermuscular coherence in the plantar flexor muscles during walking*

Atsushi Oshima[1], Tsukasa Hamada[1], Masaya Kitamura[1], Masaki Takeda[1], Kiyotaka Kamibayashi[1]

[1]Doshisha University

4-C-27 *Neuromuscular signals of postural imbalance in older adults*

Ananda Sidarta[1], Yu Chin Lim[1], Jie Kai Er[1], Carol Er[1], Lek Syn Lim[1], Patrick Wai Hang Kwong[2], Wei Tech Ang[1]

[1]Nanyang Technological University, [2]The Hong Kong Polytechnic University

D – INTEGRATIVE CONTROL OF MOVEMENT

4-D-28 *Low-gravity VR can assist juggling training: spatio-temporal analysis on human EEG*

Wanhee Cho[1], Makoto Kobayashi[1], Hiroyuki Kambara[2], Hirokazu Tanaka[3], Takahiro Kagawa[4], Makoto Sato[1], Hyeonseok Kim[5], Makoto Miyakoshi[6], Scott Makeig[5], John Iversen[5], Natsue Yoshimura[1]

[1]Tokyo Institute of Technology, [2]Tokyo Polytechnic University, [3]Toyko City University, [4]Aichi Institute of Technology, [5]Swartz Center for Computational Neuroscience, University of California San Diego, [6]Cincinnati Children's Hospital Medical Center

4-D-29 *Electrophysiological characterization of motor skill acquisition and feedback processing in a finger tapping task*

Pierre Gianferrara[1], Shawn Betts[1], John Anderson[1]

[1]Carnegie Mellon University

4-D-30 *Dynamic and stable neural codes for facial motor control*

Geena Ianni[1], Yuriria Vázquez[2], Stephen Shepherd[2], Stefan Schaffelhofer[3], Adam Rouse[4], Marc Schieber[5], Farid Aboharb[2], Yifat Prut[6], Winrich Freiwald[2]

[1]Tri-Institutional MD-PhD Program: Rockefeller University, [2]Rockefeller University, [3]CortExplore, [4]University of Kansas, [5]University of Rochester, [6]The Hebrew University of Jerusalem

4-D-31 *Dimensions of automaticity in typing*

Rubi Ruopp[1], Mary Gach[1], Ian Greenhouse[1]

[1]University of Oregon

4-D-32 *Fast prediction in marmoset reach-to-grasp movements for dynamic prey*

Luke Shaw[1], Kuan Wang[1], Jude Mitchell[2]

[1]University of Rochester Medical Center, [2]University of Rochester

4-D-33 *Compensating for missing neural information with surrogate sensory input*

Nicholas Tolley[1], Mukesh Makwana[1], Jacqueline Hynes[1], John Donoghue[1], Carlos Vargas-Irwin[1]

[1]Brown University

E – DISORDERS OF MOTOR CONTROL

4-E-34 *Implicit motor adaptation and perceived hand position without proprioception: A kinesthetic error may be derived from efferent signals*

Anisha Chandy[1], Jonathan Tsay[1], Romeo Chua[2], R. Chris Miall[3], Jonathan Cole[4], Alessandro Farne[5], Richard Ivry[1], Fabrice Sarlegna[6]

[1]University of California, Berkeley, [2]University of British Columbia, [3]University of Birmingham, [4]University Hospitals, Dorset and Bournemouth University, [5]CNRS, [6]Aix-Marseilles University

4-E-35 *Resting state functional connectivity after stroke: A case series*

Fraser MacRae[1], Janice Eng[2], Chieh-Ling Yang[3], Androu Abdalmalak[1], Shannon Lim[2], Sue Peters[1]

[1]Western University, [2]University of British Columbia, [3]Chang Gung University

4-E-36 *Motor unit properties after chronic complete spinal cord injury*

Daniela Souza de Oliveira[1], Patricia Bayer[1], Matthias Ponfick[2], Marius Osswald[1], Andre Cakici[1], Dominik Braun[1], Bjoern Eskofier[1], Thomas Kinfe[1], Alessandro Del Vecchio[1]

[1]Friedrich-Alexander-Universität Erlangen-Nürnberg, [2]Krankenhaus Rummelsberg GmbH

4-E-37 *Evaluating the effects of fatigue on motor learning in people with Multiple Sclerosis*

Eduardo Toledo-Aldana[1], Zahra Moslemi[1], Cameron Mang[1]

[1]University of Regina

4-E-38 *Task-level feedback during combined translational and rotational perturbations of standing balance is impaired in children with cerebral palsy*

Jente Willaert[1], Kaat Desloovere[2], Anja Van Campenhout[2], Lena Ting[3], Friedl De Groote[1]

[1]Katholieke Universiteit Leuven, [2]Katholieke Universiteit Leuven / Universitair Ziekenhuis Leuven, [3]Georgia Institute of Technology & Emory University

F – ADAPTATION & PLASTICITY IN MOTOR CONTROL

4-F-39 *Instrumental learning biases implicit motor adaptation*

Naser Al-Fawakhiri[1], Samuel McDougle[1]

[1]*Yale University*

4-F-40 *Improved cognitive-motor processing speed and decreased functional connectivity after high intensity aerobic exercise in individuals with chronic stroke*

Justin Andrushko[1], Shie Rinat[1], Brian Greeley[1], Beverley Larssen[1], Christina Jones[1], Cristina Rubino[1], Ronan Denyer[1], Jennifer Ferris[1], Kristin Campbell[1], Jason Neva[2], Lara Boyd[1]

[1]*University of British Columbia,* [2]*University of Montreal*

4-F-41 *What happens in Vegas stays in Vegas: concurrent implicit adaptation to multiple opposite perturbations*

Pierre-Michel Bernier[1], Alice Puygrenier[2], Frederic R Danion[2]

[1]*Universite de Sherbrooke,* [2]*Universite de Poitiers*

4-F-42 *Cerebellar damage impairs temporally-persistent, but not temporally-volatile adaptation*

Alkis Hadjiosif[1], Maurice Smith[1]

[1]*Harvard University*

4-F-43 *Proprioceptive precision in reach performance and adaptation*

Denise Henriques[1], B. Marius 't Hart[1]

[1]*York University*

4-F-44 *Connectivity between the supplementary motor area and primary motor cortex: paired-pulse transcranial magnetic stimulation (ppTMS) study*

Hakjoo Kim[1], Joohyun Rhee[1], Shancheng Bao[1], Angelina Huynh[1], Yuming Lei[1], John Buchanan[1], David Wright[1]

[1]*Texas A&M University*

4-F-45 *Design of a myoelectric co-adaptive decoder for rapid and concurrent acquisition of a hybrid (continuous tracking and discrete classification) task*

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

[1]*University of Washington*

4-F-46 *Kinematic-muscular synergies during locomotor development revealed a higher age-correlated variability of kinematic synergies than muscular synergies*

Jiayin Lin[1], Sophia Ha[1], Janet Zhang[2], Zoe Chan[2], Xiaoyu Guo[3], Rosa Chan[3], Roy Cheung[4], Chao-Ying Chen[5], Vincent Cheung[1]

[1]*Chinese University of Hong Kong,* [2]*The Hong Kong Polytechnic University,* [3]*City University of Hong Kong,* [4]*Western Sydney University,* [5]*Chang Gung University*

4-F-47 *Neural markers for different learning mechanisms in a real-world task*

Federico Nardi[1], Aldo Faisal[2], Shlomi Haar[1]

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

4-F-48 *Analysis of muscle activity related to long-term adaptation after tendon transfer in a macaque monkey*

Naohito Ohta[1], Roland Philipp[1], Yuki Hara[1], Tetsuro Funato[2], Kazuhiko Seki[1]

[1]*National Center of Neurology and Psychiatry,* [2]*The University of Electro-Communications*

4-F-49 *A novel manual control perturbation task to study formation and adaptation of internal models*

Pavithra Rajeswaran[1], Leo Scholl[1], Lydia Smith[1], Amy Orsborn[1]

[1]*UW*

4-F-50 *Adaptability of human standing balance with unexpected sensorimotor delays*

Brandon Rasman[1], Jean-Sébastien Blouin[2], Patrick Forbes[3]

[1]*Erasmus University Medical Center,* [2]*University of British Columbia,* [3]*Erasmus MC, University Medical Center Rotterdam*

4-F-51 ***How eye movements contribute to motor learning in macaque monkeys***

Leo Scholl[1], Pavithra Rajeswaran[1], Lydia Smith[1], Joseph Asfouri[2], Jesus Calabres Quintanilla[1], Amy Orsborn[1]

[1]*University of Washington,* [2]*Rice University*

4-F-52 ***Effects of vibrotactile stimulation on discrimination of visual-proprioceptive reach trajectories***

Annika Szarka[1], Gregg Eschelmuller[1], J. Timothy Inglis[1], Richard Ivry[2], Hyosub Kim[3], Romeo Chua[1]

[1]*University of British Columbia,* [2]*University of California Berkeley,* [3]*University of Delaware*

4-F-53 ***Using Deep Brain Stimulation with sensing capability to record subcortical activity in studies of sensorimotor control and learning in human subjects***

Hantao Wang[1], Jeffrey Herron[1], Gabriel Cler[1], Andrew Ko[1], Ludo Max[1]

[1]*University of Washington*

G – THEORETICAL & COMPUTATIONAL MOTOR CONTROL

4-G-54 ***Simultaneous goal and data-driven modeling of motor cortex using musculo-RNN***

Muhammad Noman Almani[1], Shreya Saxena[1]

[1]*University of Florida*

4-G-55 ***Novel statistical platform offering Interpretable objective biometrics, machine learning and AI tools for personalized diagnosis and treatments of neuromotor control disorders.***

Theodoros Bermperidis[1], Richa Rai[1], Elizabeth Torres[1]

[1]*Rutgers University*

4-G-56 ***Uncontrolled manifold emerges from coordinated feedback in multimodal human-machine interactions***

Amber Hsiao-Yang Chou[1], Momona Yamagami[1], Samuel Burden[1]

[1]*University of Washington, Seattle*

4-G-57 ***Decoupling spatial and temporal variability in time series by nonlinear time-warping***

Aleksei Krotov[1], Reza Sharif Razavian[2], Mohsen Sadeghi[1], Dagmar Sternad[1]

[1]*Northeastern University,* [2]*Northern Arizona University*

4-G-58 ***Merging neural and behavioral modularity through brain-wide compositional modes***

Manuel Beiran[1], Tyler Benster[2], Aaron Andalman[2], Eugene Carter[3], Kanaka Rajan[3], Karl Deisseroth[2], Matthew Perich[4]

[1]*Columbia University,* [2]*Stanford University,* [3]*Icahn School of Medicine at Mount Sinai,* [4]*Université de Montréal*

4-G-59 ***The motor planning phase for a higher effort upper extremity task in stroke increases EEG signal complexity***

Parikshat Sirpal[1], Hazem Refai[1], Yuan Yang[1]

[1]*University of Oklahoma*

4-G-60 ***Force encoding in secondary muscle spindle endings***

Jacob Stephens[1], Paul Nardelli[2], Lena Ting[1], Timothy Cope[1]

[1]*Emory University and Georgia Institute of Technology,* [2]*Georgia Institute of Technology*

Satellite Posters

SP1.1 ***The internal representation of body dynamics and time for standing balance***

Paul Belzner[1], Patrick Forbes[2], Calvin Kuo[1], Jean-Sébastien Blouin[1]

[1]University of British Columbia, [2]Erasmus MC

SP1.2 ***Identification of cortically mediated components of muscle activity in reactive balance***

Scott Boebinger[1], Aiden Payne[2], Giovanni Martino[3], Jasmine Mirdamadi[3], Kennedy Kerr[3], Michael Borich[3], Lena Ting[1]

[1]Georgia Institute of Technology & Emory University, [2]Florida State University, [3]Emory University

SP1.3 ***Benefits of swaying in the standing position to perform and succeed in goal-directed visual tasks***

Cedrick Bonnet[1], Alen Hajnal[2]

[1]University of Lille, [2]University of Southern Mississippi

SP1.4 ***The effect of acute cannabis use on the vestibular control of standing balance: A proposal***

Paige Copeland[1], Quinn Malone[1], Chris McNeil[1], Brian Dalton[1]

[1]University of British Columbia- Okanagan

SP1.5 ***Examining vestibular perception of rotation during height-induced postural threat***

Joshua Donald[1], Romeo Chua[1], Mark Carpenter[1]

[1]University of British Columbia

SP1.6 ***Transient high-frequency head motion in everyday activities***

Fraser Douglas[1], Jean-Sébastien Blouin[1], Calvin Kuo[1]

[1]University of British Columbia

SP1.7 ***Ankle plantarflexor muscle response scaling to ramp stretches and noisy tendon vibration during stance***

Margot Schmidt[1], Gregg Eschelmuller[1], Romeo Chua[1], J. Timothy Inglis[1], Mark Carpenter[1]

[1]University of British Columbia

SP1.8 ***Characterizing vestibular balance control during transient movements: Pitfalls and possible solutions***

Liam Foulger[1], Shin-Yi Chiou[2], Patrick Forbes[3], Jean-Sébastien Blouin[1]

[1]University of British Columbia, [2]University of Birmingham, [3]Erasmus MC

SP1.9 ***Effects of height-induced postural threat on whole-body and upper-limb postural control***

Jeffrey Kelly[1], Heather Pudwell[1], Romeo Chua[1], Mark Carpenter[1]

[1]University of British Columbia

SP1.10 ***Adjustments to balance motor commands underlying learning to stand***

Xiyao Liu[1], Zhuhan Qiao[1], Lyndia Wu[1], Jean-Sébastien Blouin[1]

[1]University of British Columbia

SP1.11 ***A novel device to assess the function of lower limb proprioception during standing balance***

Alex Liu[1], Amin Nasrabadi[1], Jean-Sébastien Blouin[1]

[1]University of British Columbia

SP1.12 ***A "posture subspace" in motor cortex***

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

[1]University of Pittsburgh, [2]Carnegie Mellon University, [3]Palladian Partners, [4]Starfish Neuro, [5]University of California, Davis

SP1.13 ***Modulation of corticospinal excitability with balance task difficulty and cognitive dual task performance***

Catherine Mason[1], Rishabh Rastogi[2], Michael Borich[2], Trisha Kesar[1], Lena Ting[2]

[1]Emory University, [2]Georgia Institute of Technology and Emory University

SP1.14 ***Linear scaling of joint velocities during TUG gait phase in polyneuropathy***

Christoph Maurer[1], Isabelle Walz[1], Sarah Waibel[1], Vittorio Lippi[1]

[1]University Freiburg

SP1.15 ***Reduced cortical sensory processing during whole-body motion perception after stroke***

Scott Boebinger[1], Kennedy Kerr[2], Lena Ting[1], Michael Borich[2]

[1]Emory University and Georgia Institute of Technology, [2]Emory University

SP1.16 ***Exploring the slow dynamics of human balance control***

Kyle Missen[1], Lorenz Assländer[2], Mark Carpenter[1]

[1]University of British Columbia, [2]Universität Konstanz

SP1.17 ***Reinforcement Learning as a framework for modeling standing balance***

Amin Mohammadi Nasrabadi[1], Calvin Kuo[1], Patrick Forbes[1], Jean-Sebastien Blouin[1]

[1]University of British Columbia

SP1.18 ***Cortical responses evoked by upper-limb perturbations during standing and sitting***

Anna Pritchard[1], Jesse DeMatteo[1], Nathan Baune[2], Michael Borich[3], Lena Ting[3]

[1]Emory/Georgia Tech, [2]Emory University, [3]Emory/Georgia Tech; Emory University

SP1.19 ***Kinetic and kinematic measures of postural control in patients with chronic inflammatory demyelinating polyneuropathy***

Heather Pudwell[1], Kyle Missen[1], Emmanuel Ogalo[1], Chelsea Smith[1], Michael Berger[1], Kristine Chapman[1], Katie Beadon[1], Mark Carpenter[1]

[1]University of British Columbia

SP1.20 ***Multi-segmental model of the medio-lateral kinematics of standing balance***

Calvin Qiao[1], Calvin Kuo[1], Lyndia Wu[1], Jean-Sébastien Blouin[1]

[1]University of British Columbia

SP1.21 ***Phybrata-based assessments of sensory reweighting due to postural stability challenges and electrical vestibular stimulation***

John Ralston[1], Christopher Banman[2], Ryan Peters[2]

[1]Neursantys, Inc., [2]University of Calgary

SP1.22 ***Does visual experience influence proprioception? A comparison of passive arm matching between blind and sighted participants***

Najib Abi Chebel[1], Florence Gaunet[2], Pascale Chavet[1], Christine Assaiante[3], Christophe Bourdin[1], Fabrice Sarlegna[1]

[1]ISM - CNRS & Aix-Marseille University, [2]LPC - CNRS & Aix-Marseille University, [3]LNC - CNRS & Aix-Marseille University

SP1.23 ***The role of arm movements for maintaining balance when walking on a narrow beam***

Reza Sharif Razavian[1], Dagmar Sternad[2]

[1]University of Northern Arizona, [2]Northeastern University

SP1.24 ***Exploring the location dependence of cutaneous reflexes in the Abductor Hallucis muscle***

Tushar Sharma[1], Adam Kapasi[1], Laura Marrelli[1], Leah Bent[1]

[1]University of Guelph

SP1.25 ***Neuromuscular signals of postural imbalance in older adults***

Ananda Sidarta[1], Jie Kai Er[1], Wai Hang Patrick Kwong[2], Lek Syn Alex Lim[1], Carol Er[1], Wei Tech Ang[1]

[1]Nanyang Technological University, [2]The Hong Kong Polytechnic University

SP1.26 ***Biophysical muscle models for simulating muscle and muscle spindle response to stretch***

Surabhi Simha[1], Kenneth Campbell[2], Timothy Cope[1], Lena Ting[1]

[1]Emory University and Georgia Institute of Technology, [2]University of Kentucky

SP1.27 ***Vestibular loss increases kinematic variability and alters gaze control strategy in locomoting primates***

Oliver Stanley[1], Ruihan Wei[1], Kathleen Cullen[1]

[1]Johns Hopkins University

SP1.28 ***Examining task dependent Achilles tendon evoked responses during standing***

Keara Sutherland[1], Gregg Eschelmuller[1], J. Timothy Inglis[1], Mark Carpenter[1]

[1]University of British Columbia

SP1.29 ***Adaptation of vestibular-evoked balance responses with repeated exposure to height-related postural threat***

Solenne Villemer[1], Martin Zaback[2], Kyle Missen[1], J. Timothy Inglis[1], Mark Carpenter[1]

[1]University of British Columbia, [2]Temple University

SP1.30 ***Rapid gaze-shift adaptation during self-generated vestibular prosthetic stimulation***

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

[1]Johns Hopkins University

SP1.31 ***Adaptation of emotional state and standing balance measures after repeated exposure to a virtual postural threat***

Xiangwei Zhang[1], Mark Carpenter[1]

[1]University of British Columbia

NOTES

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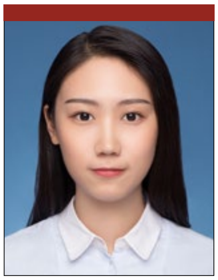
Bence Bagi, *Imperial College London*

Bence Bagi is a 3rd year PhD student at Imperial College London under the supervision of Dr. Juan A. Gallego. In his research he relies on data analysis and computational modeling techniques to investigate how interacting neural populations give rise to skilled movement.



Di Cao, *Johns Hopkins University*

Di Cao is a Mechanical Engineering PhD student at Johns Hopkins University, advised by Prof. Noah J. Cowan. She studies human sensorimotor control, specifically investigating the cerebellum's impact on motor control. Her work is co-advised by Profs. Amy J. Bastian and James S. Freudenberg.

Joanna Chang, *Imperial College London*

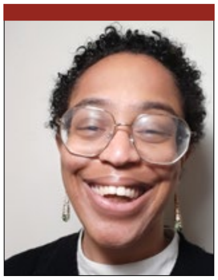
Joanna is a PhD student at Imperial College London, under the supervision of Juan Gallego and Claudia Clopath. Her research focuses on modelling and analyzing motor cortical population neural dynamics to understand motor skill learning.

Jovin Jacobs, *Champalimaud Foundation*

Jovin Jacobs graduated with a B.Sc in Psychology from the University of the West Indies, Jamaica, follwed by an M.Sc in Cognitive and Computational Neuroscience at the University of Sheffield, England. He then did a PhD in Neuroscience at the Champalimaud Foundation in the lab of Dr. Megan Carey, where he studied how dysfunction in distinct cerebellar neurons mapped onto locomotion and locomotor learning outcomes. More generally, he is interested in understanding how neural perturbations across different timescales alter brain-wide dynamics and behavior.

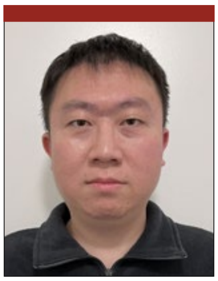
Heejae Jang, *New York University*

Heejae Jang obtained a B.S. in Physics at Princeton University, and is currently pursuing a PhD degree in Neuroscience in the Constantinople Lab at NYU.



Kassia Love, *Massachusetts Eye and Ear*

Kassia Love is a research fellow in the JENKS Vestibular Lab at Mass Eye and Ear. She recently graduated from Harvard University with a B.A. in Biomedical Engineering and Neuroscience. Her main research focuses on computational models that capture the effects of neural noise in the vestibular system on behavior.



Xuan Ma, *Northwestern University*

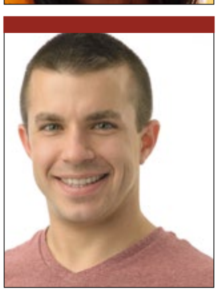
Dr. Xuan Ma works as a postdoctoral research fellow at Northwestern University, United States. He earned his Ph.D. degree from Huazhong University of Science and Technology, China in 2017. He has extensive experience in electrophysiological recordings on non-human primates. His research aims to understand the neural control mechanisms during naturalistic behaviors.

Dulce Mariscal, *University of Pittsburgh*

Dulce is a PhD candidate in the Sensorimotor Learning Laboratory at the University of Pittsburgh. She is interested in understanding how humans adjust their gait to different environmental demands. Her latest work focuses on developing a data-driven model to gain insights into motor commands used to control our movements.

Brandie Morris Verdone, *Johns Hopkins University*

Brandie Morris Verdone is an IRACDA Postdoctoral Fellow in the laboratory of Kathleen Cullen at Johns Hopkins University. Her work focuses on the dynamics of eye-head coordination in everyday activities such as navigation. Previously, she explored motor dysfunction in novel animal models of neurodegeneration, specifically ALS.



Daniel O'Shea, *Stanford University*

Dan is a postdoctoral scholar at Stanford University working with Krishna Shenoy, Maneesh Sahani, and Karl Deisseroth. As a neuroscientist and engineer, he studies the neural mechanisms that establish coordinated movements, and more broadly, how neural populations spanning interconnected brain regions perform the distributed computations that established skilled behavior.

Kantapon Pum Wiboonsaksakul, *Johns Hopkins University*

Pum is a PhD candidate in Biomedical Engineering at Johns Hopkins University, mentored by Dr. Kathleen Cullen. His research focuses on optimizing encoding strategies of vestibular prostheses, and also utilizing the prosthesis as a controlled perturbation to investigate how vestibular pathways process information.

Lucas Rebelo Dal'Bello, *University of Tsukuba*

Lucas Rebelo Dal'Bello is a PhD candidate in the laboratory of Prof. Jun Izawa at University of Tsukuba, Japan. His PhD research focuses on the computational role of motor exploration in the error-based acquisition of new motor skills, utilizing behavioral experiments in humans and computer simulations.

Fabio Rizzoglio, *Northwestern University*

Fabio is a postdoctoral researcher at Northwestern University. The primary goal of his research is to understand the nature of the motor signals within the brain and develop neural decoders that can translate brain activity into motor intent to restore limb movement in individuals with spinal cord injury.

Hunter Schone, *National Institutes of Health & University College London*

Hunter Schone received his B.Sc. in Neuroscience from Westminster College and M.Sc. in Clinical Neuroscience from UCL. As a neuroscience PhD student, co-supervised by Tamar Makin, University of Cambridge and Chris Baker, National Institutes of Health, his research focuses on experience-dependent neural plasticity, hand representation, and motor learning with bionic hands.

Mahdiyar Shahbazi, *Western Institute for Neuroscience*

Mahdiyar is a neuroscience graduate student at Western University. His research interests center on the neural control of complex movements and developing statistical methods for analyzing neuroimaging and electrophysiological data.

Adam Smoulder, *Carnegie Mellon University*

Adam is a PhD candidate at Carnegie Mellon University working with Steven Chase and Aaron Batista. He studies the role of motor cortex in relaying changes in motivation and other internal states into altered movement behavior.

Rachel Swanson, *New York University*

Rachel Swanson is a graduate student at NYU in the labs of Gyorgy Buzsaki and Jayeeta Basu, where she studies multi-scale neural dynamics during sleep. She combines widefield imaging and electrophysiology with dynamical systems theory to further our mechanistic understanding of systems consolidation.

Nina van Mastrigt, *Vrije Universiteit Amsterdam*

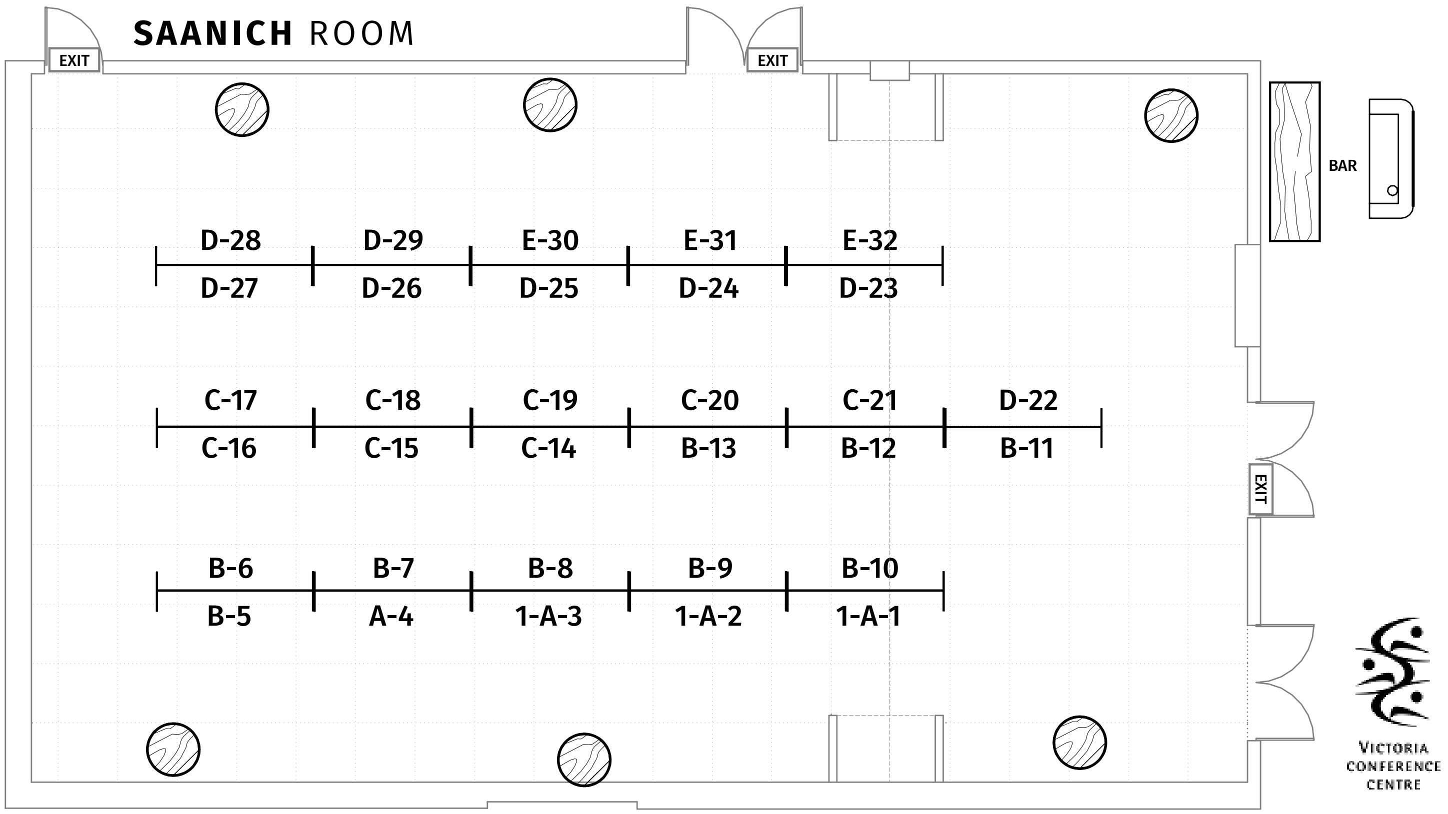
Nina van Mastrigt studied Human Movement Sciences at the Vrije Universiteit Amsterdam. There, she is currently finishing her PhD project on exploration in reward-based motor learning. She is interested in motor control and is looking for a postdoc position.

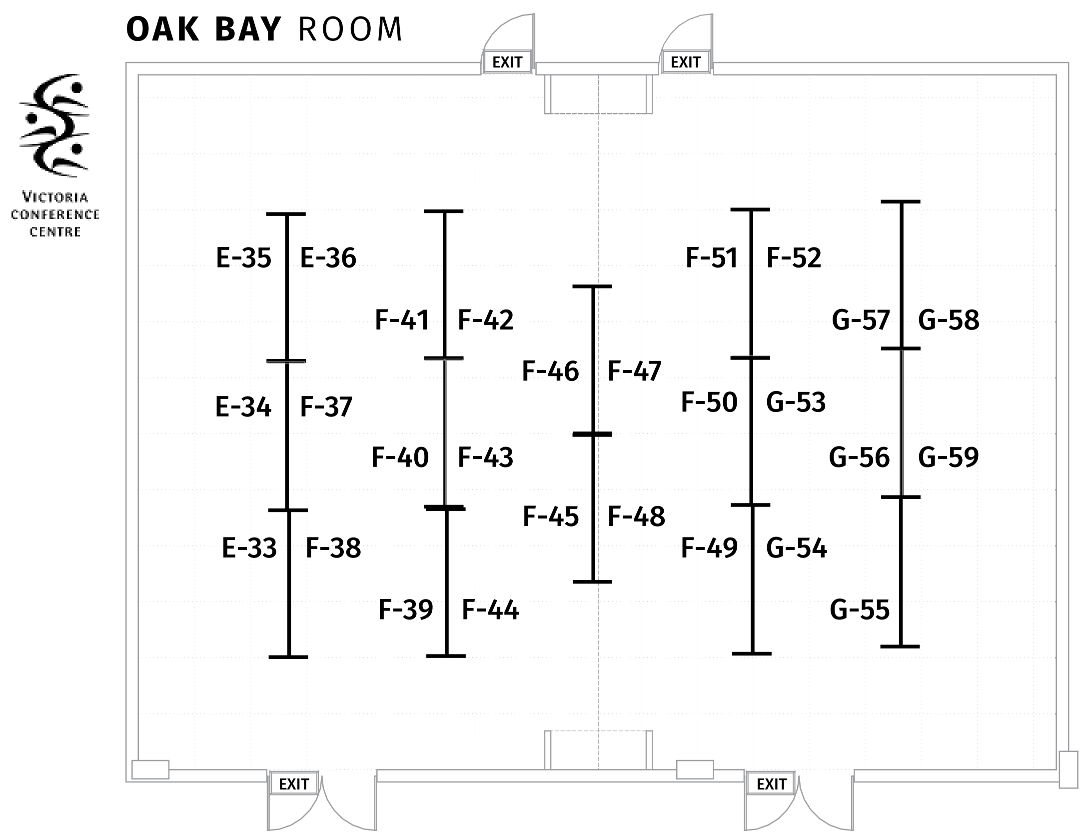
Lahiru Wimalasena, *Emory University/Georgia Tech*

Lahiru is a PhD candidate at the Wallace H. Coulter Department of Biomedical Engineering, working under the guidance of Dr. Chethan Pandarinath in the Systems Neural Engineering Laboratory. His research interests lie at the intersection of motor control, deep learning, and neural population dynamics.

Poster Floor Plans

POSTER SESSION 1





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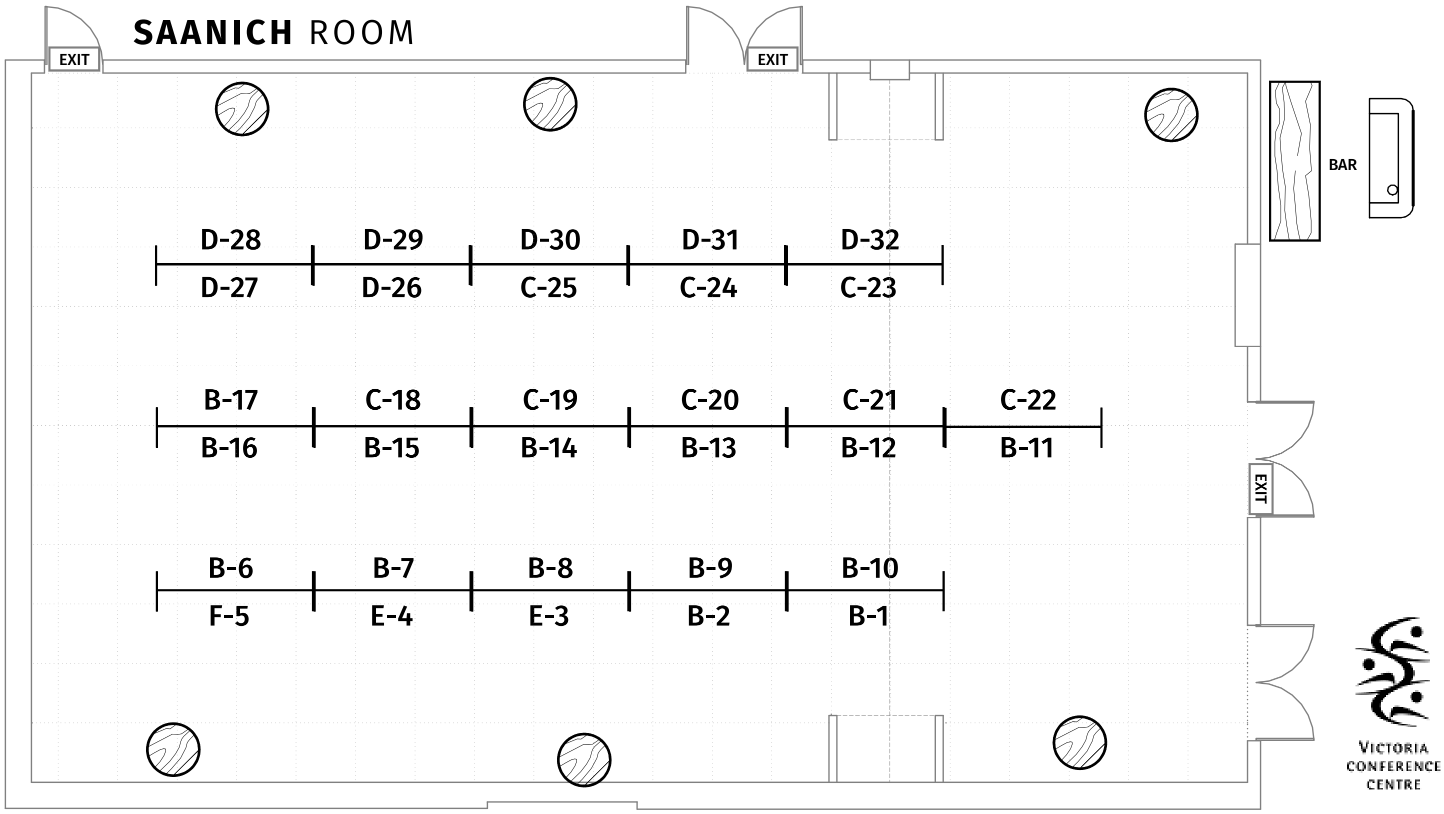
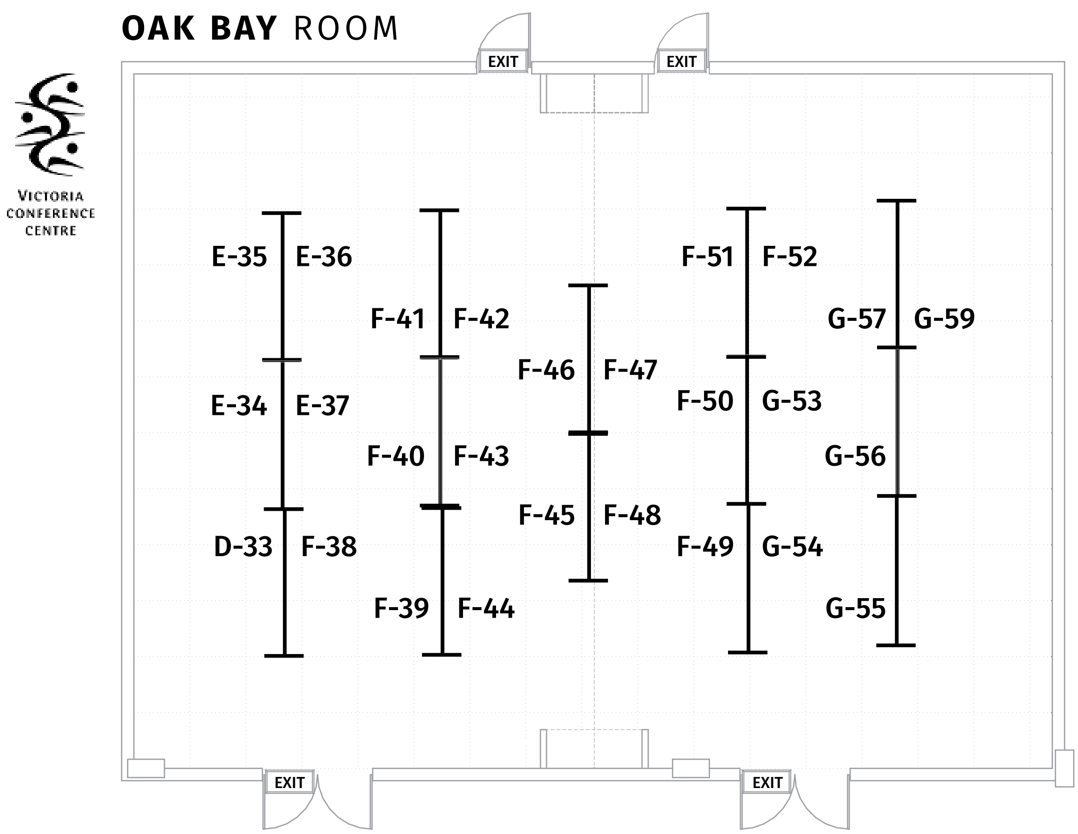
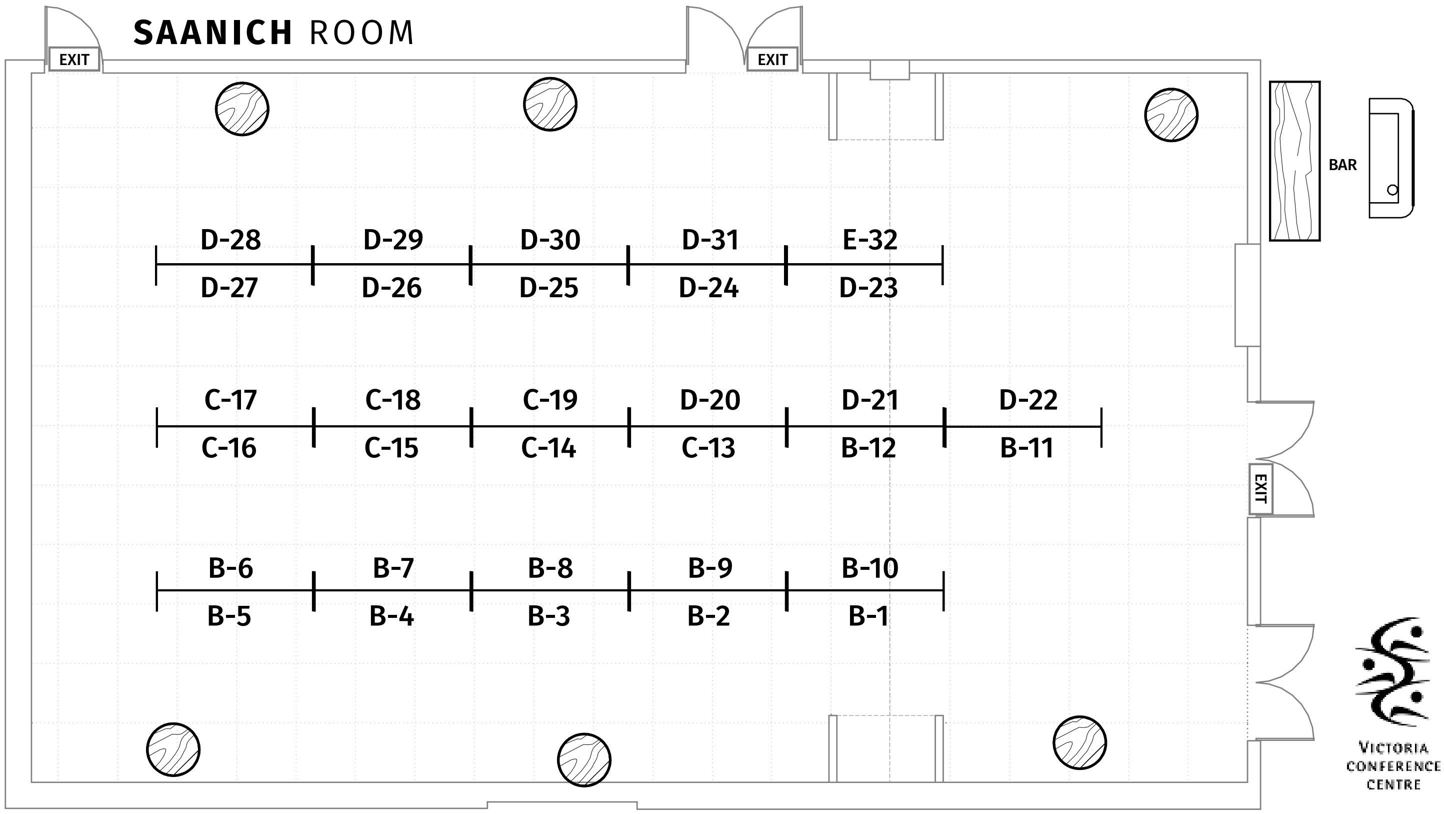
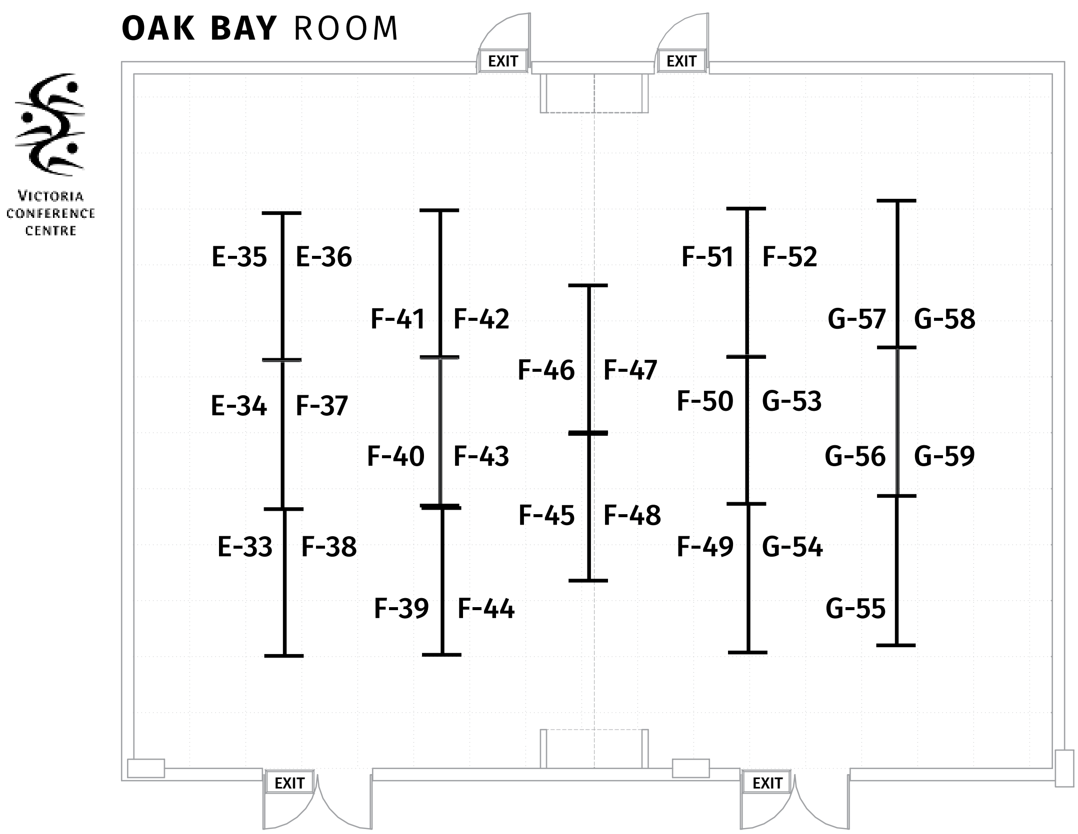


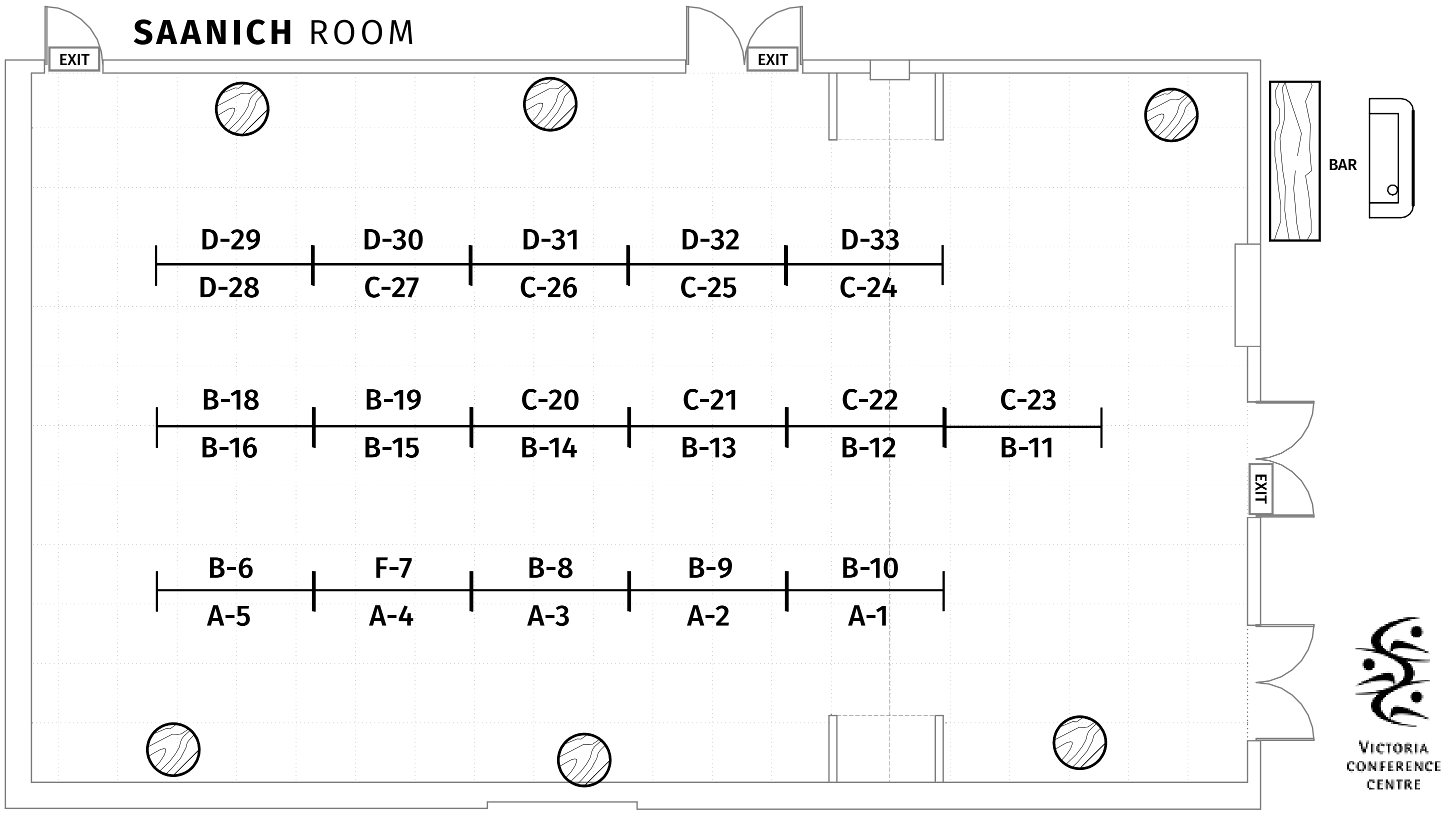


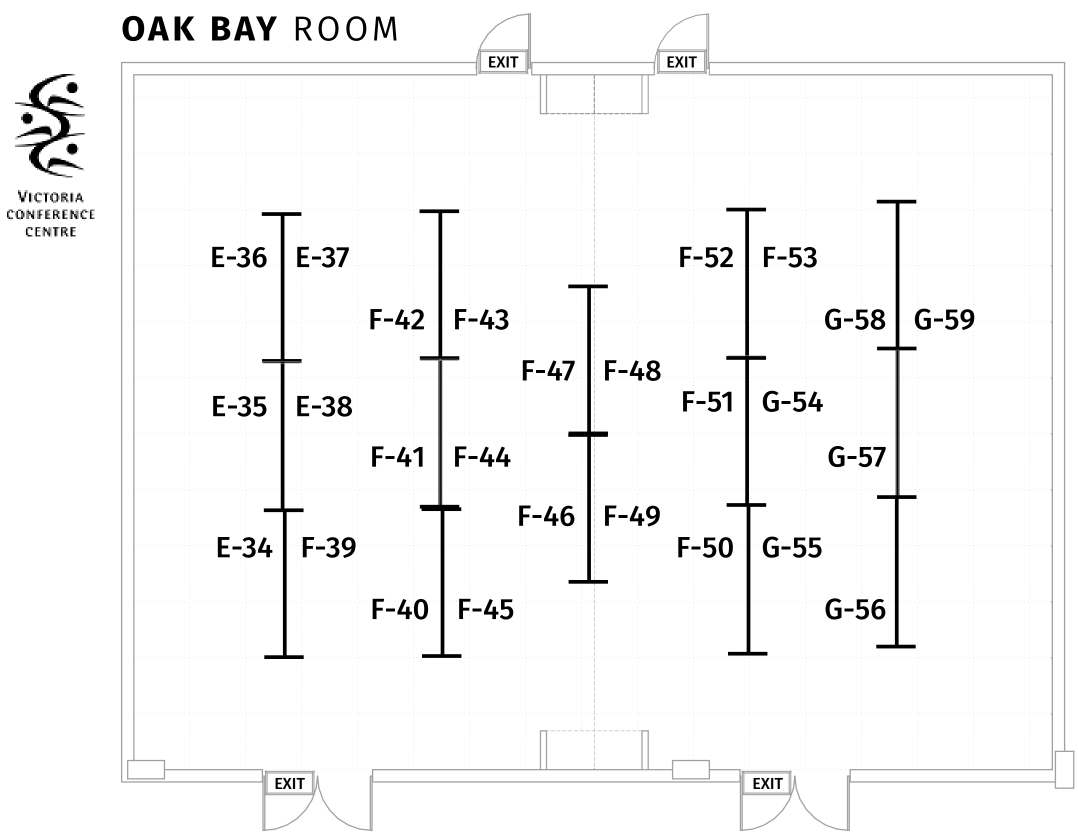
POSTER SESSION 3





POSTER SESSION 4





Society for the
Neural Control
of Movement

NCM

33rd NCM Annual Meeting

Valamar Lacroma Dubrovnik Hotel
Dubrovnik, Croatia

April 15 – 19, 2024

Dubrovnik, Croatia is a UNESCO World Heritage protected city and is surrounded by 1,940 meters of unique medieval ramparts preserved in their original form. With a slogan of **Full.Of.Life**, the city of Dubrovnik has something for everyone from history to activities and abundant culture. An unrivalled scientific program matched with the beauty and diversity of Dubrovnik, makes for a meeting that shouldn't be missed.

Abstracts Open
October 30, 2023

Oral Submissions Close
December 4, 2023

Poster Submissions Close
February 19, 2024

Early Bird Registration
March 4, 2024

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