NCM

Society for the
Neural Control of Movement

NCM 24TH Annual Meeting

NH GRAND HOTEL KRASNAPOLSKY | AMSTERDAM

Satellite Meeting April 21, 2014

Annual Meeting April 22 – 25, 2014

Society for the Neural Control of Movement | **www.ncm-society.org**

2014 At-A-Glance Satellite and Annual Meeting Schedule*

NH Grand Hotel Krasnapolsky, Amsterdam, The Netherlands

** Schedule is subject to change.*

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Time		8:00 8:15 8:30 8:45 9:00 9:15 9:30 9:45 10:00 10:15 10:30 10:45 11:00 11:15 11:30 11:45 12:00 12:15 12:30 12:45 13:00 13:15 13:30 13:45 14:00 14:15 14:30 14:45 15:00 15:15 15:30 15:45 16:00 16:15 16:30 16:45 17:00 17:15 17:30 17:45 18:00 18:15 18:30 18:45 19:00 19:15 19:30 19:45 20:00 20:15 20:30 20:45 21:00 21:15 21:30 21:45 22:00 22:15 22:30
Sunday	20-Apr	Arrivals, Free Time Satellite Registration **Satellite Registration** (17:00 - 19:00) **Satellite Drinks Reception** (18:00 - 19:00)
Monday	21-Apr	Registration /Information Desk Open **Satellite Meeting Coffee Service** (08:00 - 08:45) **Satellite Meeting Session 1:** Probabilistic methods and predictive mechanisms in vestibular processing (08:45 - 10:30) **Break** (10:30 - 11:00) **Satellite Meeting Session 2:** Vestibular disorders and therapies (11:00 - 13:00) **Satellite Meeting Poster Session Lunch** (13:00 - 15:30) **Satellite Meeting Session 3:** Vestibular cognition (15:30 - 17:30) Registration (17:00 - 19:00) **Conference Registration** (17:00 - 19:00) **Opening Reception Heineken Brewery, Molenzolder Room** (off-site) (19:00 - 21:00)
Tuesday	22-Apr	Registration / Information Desk Open Posters on Display (Session 1) Exhibits on Display ***Session 1*** **Panel I Miller** (08:00 - 10:15) **Break** (10:15 - 10:45) ***Session 2*** **Panel II Cullen** (10:45 - 13:00) ***Session 3*** **Poster 1 Lunch** (13:00 - 15:00) ***Session 4*** **Individual Presentations I** (15:00 - 16:40) **Break** ***Session 5*** **Keynote Address Dr. David Zee** (17:00 - 18:00) **Free Time and/or Excursions**
Wednesday	23-Apr	Registration / Information Desk Open Posters on Display (Session 1) Exhibits on Display ***Session 6*** **Panel III Konczak** (08:00 - 10:15) **Break** (10:15 - 10:45) ***Session 7*** **Individual Presentations II** (10:45 - 13:00) ***Session 8*** **Poster 1** (continued) **Lunch** (13:00 - 15:00) ***Session 9*** **Panel IV Glasauer** (15:00 - 17:15) **Free Time and/or Excursions**
Thursday	24-Apr	Registration / Information Desk Open Posters on Display (Session 2) Exhibits on Display ***Session 10*** **Individual Presentations III** (08:00 - 10:00) **Members Meeting** (10:00 - 10:15) **Break** (10:15 - 10:45) ***Session 11*** **Panel V Munoz** (10:45 - 13:00) ***Session 12*** **Poster 2 Lunch** (13:00 - 15:00) **Free Time and/or Excursions**
Friday	25-Apr	Registration / Information Desk Open Posters on Display (Session 2) ***Session 13*** **Panel VI Honeycutt** (08:00 - 10:15) **Break** (10:15 - 10:45) ***Session 14*** **Individual Presentations IV** (10:45 - 13:00) ***Session 15*** **Poster 2** (continued) **Lunch** (13:00 - 15:00) ***Session 16*** **Panel VII Zandbelt** (15:00 - 17:15) **Closing Drinks Reception** (17:15 - 18:00) **Free Time and/or Excursions**
Saturday	26-Apr	National Holiday: King's Day

Program 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 and geared 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 300) 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 April every year.

Cover photos credit: Amsterdam Marketing

Welcome

To the Society for the Neural Control of Movement 24th Annual Meeting


Gary Paige, President

Welcome to our 24th Annual Conference in Amsterdam, The Netherlands. At this time it is fitting to provide some comments about NCM, the meeting, and its venue. First, the Society remains both healthy and growing. We have over the past decade witnessed climbing membership and meeting attendance. NCM has witnessed continued engagement and attendance even through the challenging years of international recession. The upcoming conference sits well in a line of exciting meetings in novel locations. NCM continues to attract new and established investigators, from senior faculty ranks to students, and across a uniquely broad blend of disciplines that in turn infuses our novel presentation formats, all matched by a mix of vibrancy, diversity, informality and collegiality. Thanks are due to all within the NCM community.

Second, NCM will continue to succeed only in light of novelty, which ultimately means new members and contributors that stem from young investigators. Roughly a quarter of our meeting attendance now constitutes students, and the proportion of students and post-docs continues to rise. Further, our scholarship program has grown since the early years, thanks to the remarkable efforts of Terry Sanger and now Lee Miller, our current Development Officer. Awards continue to be scattered across North America and abroad alike. The program serves to encourage, and incentivize, participation by students and post-docs within NCM sessions and presentations.

Third, we continue to hone our annual meetings through ‘experiments.’ These include identifying new meeting sites, as you will learn at the meeting. Meanwhile, Amsterdam reflects another step towards diversity and expansion of venues. Opportunity, meeting costs, ecology, and conveniences (scientific and social) are all attributes that enter the equation for a successful and exciting meeting. Our next experiments will follow the trend—innovative scientific programs with similarly exciting locations for attendees and their families to enjoy. For next year Marischal De Armond and I have secured a surprise in the US, while also tickling a remarkable opportunity in the Caribbean for the following year. I look forward to presenting more at the upcoming ‘members meeting’ in Amsterdam, so please attend.

Fourth, experiments in meeting structure continue. Doug Munoz, our VP and Program Chair, has once again organized a magnificent program for Amsterdam. We continue our successful new tradition of holding a grazing lunch during afternoon poster sessions (two days for each of two sets of posters) while also providing time to visit our increasing number of sponsor exhibits. This structure engages attendees intensely throughout the day, ending earlier on some days to allow time with friends, family, and colleagues into the evening. In addition, this year’s meeting follows a recent tradition of including a 1-day satellite on the day preceding the main meeting, here appropriately organized and run by our Dutch colleagues and focussing on vestibular processing in motor control. I and the Board (identifiable by our badges) solicit your feedback on all of the above and including the meeting’s content.

Fifth, NCM continues to reap substantial benefits through our collaboration with De Armond Management Ltd. The guidance and support they provide for our Society's affairs and for the planning and management of our Conferences allow us to enhance the offerings and service to all members. Marischal, Laurie and Breda remain available to you throughout the conference to help with any questions or support you need to ensure a high-quality experience during the meeting.

Finally, I, my fellow Officers, and the NCM Board welcome all to a truly outstanding conference in Amsterdam

Cordially,
Gary Paige, President

NCM Leadership

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

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


Doug Munoz


Steve Scott


Lee Miller

Officers (Executive Committee)

President & Conference Chair
Gary D. Paige (president@ncm-society.org)

Vice President & Scientific Chair
Doug Munoz (vpprogram@ncm-society.org)

Treasurer & Secretary
Steve Scott (treasurer@ncm-society.org)

Development Officer
Lee Miller (sponsor@ncm-society.org)

Board Members

Name	Institution	Country	Term
Amy Bastian[2]	Kennedy Krieger Institute	USA	2011 - 2014
Randy Flanagan[2]	Queens University	Canada	2011 - 2014
Paul Cisek[2]	University of Montreal	Canada	2011 - 2014
Jeroen Smeets[1]	VU University Amsterdam	Netherlands	2011 - 2014
Andrea d'Avella[2]	Santa Lucia Foundation	Italy	2012 – 2015
Chris Miall[2]	University of Birmingham	UK	2012 – 2015
Andrew Pruszynski[1]	Umea University	Sweden	2012 – 2015
Daichi Nozaki[1]	University of Tokyo	Japan	2012 – 2015
Lena Ting[1]	Emroy University	USA	2013 – 2016
Brian Corneil[1]	University of Western Ontario, Canada		2013 – 2016
John van Opstal[1]	Donders Institute	Netherlands	2013 – 2016
Rachel Seidler[1]	University of Michigan	USA	2013 – 2016

Incoming Board Members

The following members will begin their term in April, 2014.

Jeroen Smeets[1]	VU University	Netherlands	2014 – 2017
Jörn Diedrichsen[1]	University College London	England	2014 – 2017
Kathleen Cullen[2]	McGill University	Canada	2014 – 2017
Jean-Jacques Orban de Xivry[1]	Catholic University of Louvain	Belgium	2014 – 2017

[1] *Serving first 3 year term*

[2] *Serving second 3 year term*

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 Treasurer@NCM-Society.org.

NCM Administration

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

De Armond Management Ltd.
Breda Hamill
Laurie De Armond
Marischal De Armond

Membership Information

Society for the
Neural Control of Movement
NCM

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.

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)
- 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.

2015 Annual Meeting

We are pleased to announce the 2015 Annual Meeting will take place in one of the most historic and friendly cities in the United States. Please plan to attend the 25th Annual Meeting in Charleston, United States 'where history lives'.

The Annual Meeting will take place April 20 – 24, 2015 at the Francis Marion Hotel, a stunning and historic hotel, located in the heart of Charleston and 20 minutes from Charleston International Airport.

This venue is named for General Francis Marion, the "Swamp Fox" of the American Revolution, the hotel opened in 1924 as the largest and grandest in the Carolinas. Throughout the years, many notable historic and famous clientele enjoyed the hotel's full service and convenient location. Recent refurbishments have added to the comforts of today and enhanced the hotel's historic ambiance with sleek room décor reminiscent of the 1920's grandeur. This is one meeting you will not want to miss, plan now to attend.

Information about the meeting and the hotel (including reservation information) will be available on the NCM website shortly.

The Francis Marion Hotel

Satellite Meetings

NCM's Board welcomes suggestions for one- or two-day Satellite Meetings in conjunction with future Annual Meetings. Please discuss your ideas with NCM Board Members to formulate an early plan/proposal, and bring this to the NCM President for further consideration (email: President@NCM-Society.org).

Keynote Speakers

NCM provides the opportunity for members to suggest prominent colleagues in the field of neuroscience who would be suitable candidates to provide a Keynote Address during an Annual Meeting. The Keynote is an invited lecture delivered by a prominent colleague whose contributions to neuroscience are widely acknowledged. Individuals and topics outside the normal NCM community are encouraged.

If you wish to recommend a colleague as a future keynote presenter please discuss with an NCM Board Member or Officer or send an email to President@NCM-Society.org.

NCM History

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

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.

Meeting	Dates	City	Country	Hotel
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

General Meeting Information

Meeting Venue

NH Grand Hotel Krasnapolsky

Dam, 9. 1012 JS Amsterdam (The Netherlands)

Check in: 3:00 pm   Check out: 12:00 pm

All conference sessions will take place in this location.

The Opening Reception will be off-site at the Heineken Brewery.

Satellite Meeting

Satellite Meeting registration fees include a complimentary drink during a drop in gathering on Sunday April 20, access to the full day meeting with refreshment breaks and a buffet lunch.

Annual Meeting

Annual Meeting registration fees include: wifi internet, access to all sessions including panel, individual, and poster sessions. Registration also includes daily refreshment breaks, grazing lunches, the Opening Reception at the Heineken Brewery 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. 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, lunch, opening and closing reception. Please wear it at all times. At the end of the Conference we ask that you recycle your name badge in one of the name badge recycling stations that will be set out, or leave it at the Registration Desk.

To help identify and mentor our future investigators, student delegates have red edged badges. All other delegates have clear badges. NCM Officers and Board Members, Exhibitors and Staff will be identified by appropriate 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 outside the Grand Ballroom, will be open during the following dates and times:

Sunday, April 20	17:00 – 19:00
Monday, April 21	08:00 – 15:00 & 17:00 – 19:00
Tuesday, April 22	08:00 – 15:00
Wednesday, April 23	08:00 – 15:00
Thursday, April 24	08:00 – 15:00
Friday, April 25	08:00 – 15:00

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

Message Board

For your convenience, a Message Board will be located near the Registration Desk. Feel free to leave messages of interest to other conference participants.

Poster Information

Set-Up / Removal

Satellite Meeting:

Satellite Meeting poster presenters must set-up and remove their Satellite Meeting posters during the following times:

Set-up: Monday, April 21, between 07:00 and 08:45

Remove: Monday, April 21, between 17:30 and 18:00

Annual Meeting:

Poster Session 1

Set-up: Tuesday, April 22, between 07:00 and 10:00
Remove: Wednesday, April 23, between 17:30 and 18:00

Poster Session 2

Set-up: Thursday, April 24, between 07:00 and 10:00

Remove: Friday, April 25, between 17:30 and 18:00

Information on Poster Authors, Poster Numbers and Poster Titles begins on page 36. For a complete copy of all the poster abstracts, a limited supply of poster abstract booklets are available for purchase at the Registration Desk. Digital copies can be downloaded from the Member Only section of the NCM Website.

Easy reference poster floor plans for each session can be found on the inside back pages of this program.

Staff

NCM staff from De Armond Management Ltd can be identified by ribbons on their name badges. Feel free to ask for assistance. For immediate assistance please visit us at the Registration Desk.

Business Lounge

There will be soft seating and a charging station available in the Golden Palm Bar daily, from Monday to Friday, 07:00 – 15:00 for your convenience and comfort. NCM guests are invited to use this facility for your business needs and for informal discussions during the allocated hours.

Internet Services

NCM is providing wifi internet access with all registrations. To login:

1. Select the SSID "Swisscom" wifi signal
2. Open any internet browser and wait for the login screen to appear
3. Enter the following credentials in the top left login section:

Username: EVENT/NCM   Password: NH2014

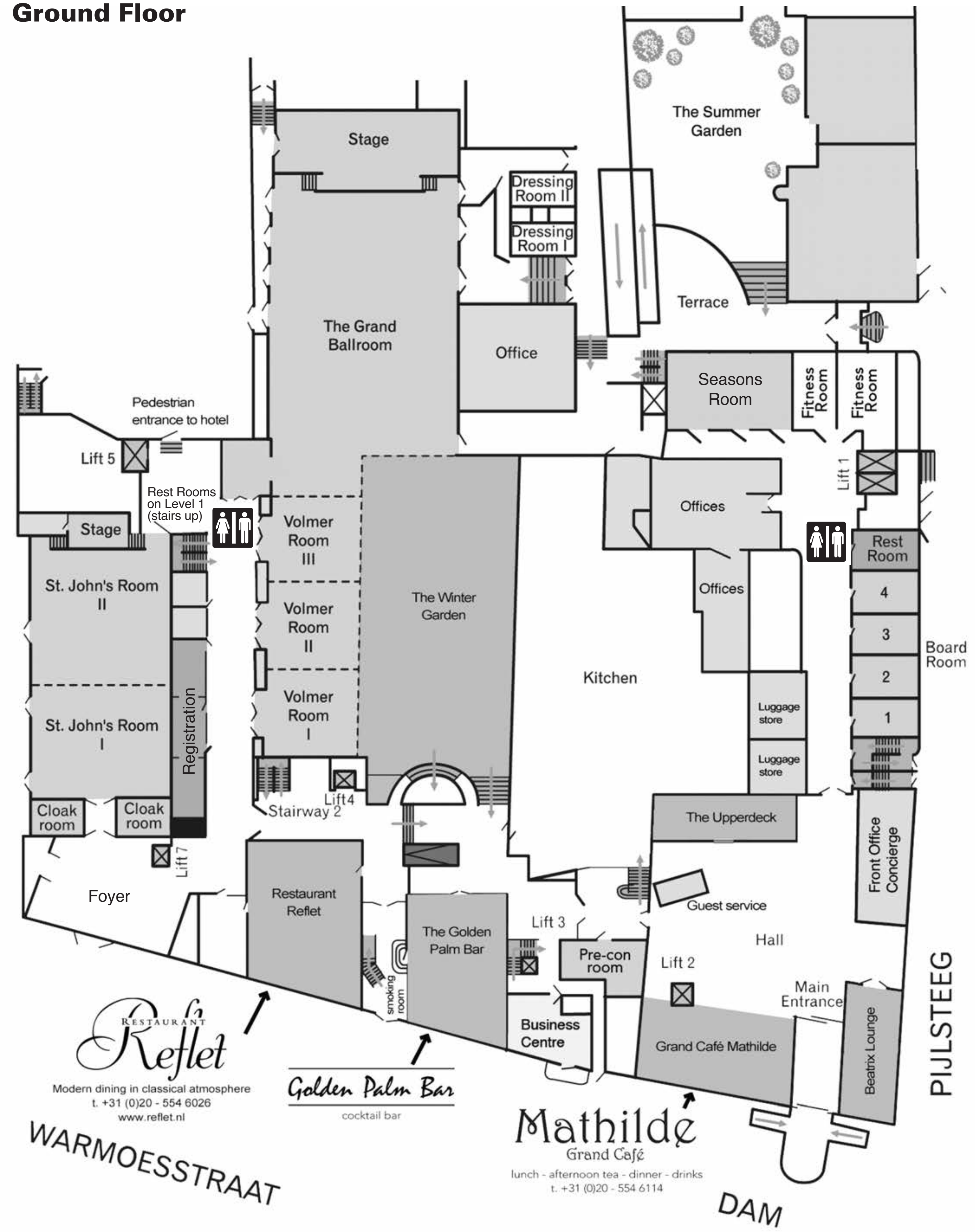
If you require assistance, please visit the registration desk and we will endeavour to assist you. Bedrooms booked through NCM's group room block include complimentary wireless internet. Depending on signal strength, this service will allow connection throughout the hotel's public spaces. Additional connection information is available through the hotel's front desk.

No Smoking Policy

The NH Grand Krasnapolsky has one smoking area next to the 'Restaurant Reflect'. The rest of the Hotel is completely non-smoking.

Meeting Venue Floor Plan

Ground Floor



Special Meetings & Events

Sunday, April 20

18:00 – 19:00

Satellite Drinks Reception
(Satellite Meeting Registrants)
The Golden Palm Bar

Monday, April 21

19:00 – 21:00

Opening Reception, includes an open bar
Molenzolder Room, Heineken Brewery (additional information available at right*)

Thursday, April 24

10:00 – 10:15

NCM Members Meeting
The Grand Ballroom

Friday, April 25

17:15 – 18:00

Closing Drinks Reception
(one complimentary drink, cash bar)

The Winter Garden

Monday April 21 to Friday April 25

06:20 – 07:15

Daily Running Group
Organized by John Van Opstal and Pieter Medendorp – daily morning exercise. This will be a group jog, 5-8 km, from the hotel into the city and back using safe running routes. All interested guests assemble at 6:20 AM in the HQ NH Krasnapolsky Hotel Lobby.

* **Heineken Experience Location**: Stadhouderskade 78, 1072 AE Amsterdam

About the Brewery: The former Heineken brewery is a National Monument and is listed as an anchor point along the European Route of Industrial Heritage. After the Heineken Experience opened its doors in 2001, the attraction developed itself into one of the most popular tourist attractions in the Dutch capital.

About the Opening Reception Venue – Molenzolder Room: It was here that the 'Schrootmolen,' or 'malt mill,' did its milling. Malt grains were crushed and ground to so-called barley meal. Together with water, this ground grain is the most important ingredient in the brewing process.

Directions: The route from the NH Krasnapolsky Hotel (A on map below) is about 15 minutes walking and guests can also take tram 16 or 24 from Dam Square to tramstop 'Stadhouderskade' which is about 5-10 minutes depending on traffic.

Download the official NCM Mobile App!

NCM is excited to announce the launch of our interactive mobile application for the 2014 Annual Meeting! The NCM Mobile App is available for iPhone, Android, Blackberry and any smartphone or tablet that has web-enabled browser capability. Maximize your time and experience with the NCM Meeting – scan the QR code to access the app.

The NCM app allows you to:

- View all conference information (sessions, abstracts, speakers, exhibitors, maps, attendee profiles, etc.) on your mobile device
- Build a personalized schedule and access any session handouts
- Find information quickly with the search feature
- Opt into messaging with other attendees
- Receive important conference-related notifications and updates
- Take notes on your mobile device during specific sessions with the ability to extract the information later
- Browse local restaurants and attractions

And much more...

Conference Excursions

NCM invites you to take advantage of your visit to Amsterdam by exploring what this wonderful city has to offer!

NCM has engaged local tour operators to arrange a variety of packages for NCM guests that are custom designed to fit with the program. A limited number of spaces remain for our NCM Excursions. If you are interested in joining one of these trips, please inquire at the Registration Desk.

Please Note: some excursions may be cancelled, depending on the level of pick up.

An NCM Special

Amsterdam Popular Tour

Thursday 24 April, 15:00 – 22:00, (approx. 7 hrs)
Min. 20 guests / max. 49 guests

If you can only participate in one NCM excursion while in Amsterdam, this should be the one you choose. In just one day, this tour will make you familiar with all the symbols of Holland! The tour includes a visit to open air museum Zaanse Schans, where you will visit a clog-exhibition, an authentic clog maker and see the beautiful windmills of the area. The tour also includes a visit to a cheese farm where you have a chance to see, smell and taste traditional farmer cheese. In Volendam guests will enjoy a walking tour of the town, dinner in a traditional Dutch restaurant and experience the traditional costume of Amsterdam.

Cost per person: $95.
Transport, guide and dinner included.

Concertgebouw

Wednesday April 23 20:15 – 21:55*
Mozart & Beethoven concertos with Jansons and top soloists – Max. 30 guests

** The doors open 40 minutes in advance, latecomers may have to wait until the intermission to enter*

The Concertgebouw is one of the best concert halls in the world, famous for its exceptional acoustics and varied programme. It serves as the home base of the Royal Concertgebouw Orchestra, and features performances by the world's best orchestras, conductors and soloists. Attend a concert and have an evening you will never forget. Please note: NCM will endeavour to have group bookings seated together, however, this may not be possible depending on availability.

Cost per ticket: $135, tax and booking fee included.

Classical concerts at Concertgebouw are open to children six years and older.

Admission only. Transport and guide not included.

Amsterdam Original Walking Tour

Canal and Jordaan area

Wednesday April 23 17:30 – 22:00 (approx. 4-5 hrs)
Min. 10 guests / max. 20 guests

This area was erected in the 17th century for labourers and emigrants. Today, the neighbourhood is a trendy area that attracts many students, artists and young entrepreneurs. During the tour the guide will pay attention to both of these sides of the Jordaan.

Cost per person: $47. Guide and dinner included.

Amsterdam Red Light District Walking Tour

Wednesday April 23 17:30 - 22:00 (approx. 4-5 hrs)
Min. 10 guests / max. 20 guests

Undoubtedly the most notorious area of the city of Amsterdam is the red light area. The lively history, famous red windows, bars and nightclubs have a huge charm to many visitors. Surprising to some visitors, this area is the oldest part of the city with beautiful historical buildings such as the former town hall. During your walk, your guide will show you both faces of this area.
Please note: during this tour guests will pass by shops with erotic articles and images. If you, or anyone in your group or family, do not wish to be confronted with these elements of the city, it is advisable to consider alternative tours.
Cost per person: $47. Guide and dinner included.

Amsterdam Flower Tour

Thursday 24 April, 15:00 – 22:00, (approx. 7 hrs)
Min. 20 / max. 49 guests

This world famous tour takes you through the colourful tulip fields in the surroundings of Lisse towards the Keukenhof. There is no place on earth where the spring comes alive as colourful as in this park. Keukenhof has millions of tulips on display, breathtaking flower shows, the largest sculpture garden of the Netherlands and may claim to be one of the most photographed spots on earth! Price includes transport, guide and admission fee.

Cost per person: $64. Transport, admission and guide included, excludes dinner.

Heineken Experience

NCM discount available for all delegates

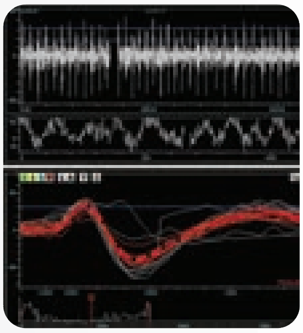
Recommended time: Monday 21 April, 17:30 – 19:30, (approx. 2 hrs) before the opening ceremony

Visit the Heineken and take their sensational self-guided, interactive tour before joining the rest of the NCM 2014 attendees for the official Opening Ceremony for 2014, hosted at the brewery! The former brewery, where Heineken's beer was brewed for a hundred years, has been transformed to a tour where you get the ultimate 'Heineken Experience' and explore the dynamic world of Heineken.

Cost per person:
€12,69 excl. VAT. / €13,50 incl. VAT.

Admission only, transport not included. Available to all NCM delegates at the box office.

N.B. Please show your NCM official name badge to receive your discount. Available for the duration of the meeting, recommended in advance of the Opening Ceremony.




AlphaLab SnR
ALPHA omega

NCM Satellite Meeting Detailed Daily Program

NCM Satellite Meeting, Amsterdam

April 20 – 21, 2014 All sessions will be held in The Grand Ballroom.
Posters will be located in St. John’s Room.

This one-day satellite meeting discusses the role of vestibular processing in motor control, focusing on modern approaches of study in this field. The three oral sessions provide a good mix of well-established and new players in this field, and there is ample time for a poster session giving everybody the opportunity to discuss their newest results.

Sunday, April 20

17:00 – 19:00 Satellite Registration

18:00 – 19:00 Satellite Drinks Reception, The Golden Palm Bar, NH Grand Krasnapolsky Hotel

Monday, April 21

08:00 – 08:45 Satellite meeting coffee service, St. John's Room

08:45 – 09:00 Welcome and Introduction by John van Opstal, Nijmegen

09:00 – 10:30 **Session 1: Probabilistic methods and predictive mechanisms in vestibular processing**

Chair: Paul MacNeilage, Munchen

The neural encoding of vestibular information during natural self-motion
Kathleen Cullen, Montreal

Control of motion and sickness
Jelte Bos, Amsterdam

Functional adaptation of locomotor efference copy-driven gaze stabilization
Hans Straka, München

10:30 – 11:00 **Break - St. John’s Room**

11:00 – 13:00 **Session 2: Vestibular Disorders and Therapies**

Chair: Pieter Medendorp, Nijmegen

Perceptual thresholds can help assay peripheral vestibular function, and may help isolate peripheral deficits
Dan Merfeld, Cambridge

Presentation to be confirmed.
Adolfo Bronstein, London

Augmentation of reduced vestibular function with a vestibular prosthesis: a safety and efficacy trial in human subjects
James Phillips, Seattle

Multiple time scales in AVOR adaptation

Stefano Ramat, Pavia

13:00 – 15:30 **Lunch and Satellite Meeting Poster Session, St. John’s Room**

15:30 – 17:30 **Session 3: Vestibular Cognition**

Chair: Jeroen Smeets, Amsterdam

How can single sensory neurons predict perception?
Dora Angelaki, Houston

Vestibular guidance of action
Brian Day, London

Vestibular contributions to perceptual processing and motor memories
Pieter Medendorp, Nijmegen

What’s so special about the vestibular sense?
Stefan Glasauer, München

19:00 **Opening Dinner for Annual Meeting**, Molenzolder Room, Heineken Brewery

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

Satellite Meeting Poster Sessions | Authors, Titles and Affiliation

S-1 Postural control and evolution of the perceptive style after stroke

Pierre-Paul Vidal[1], Isabelle Bonan[2], Sophie Tassel Tonche[3], Alain Yelnik[1]

[1]CNRS, [2]University Hospital; University of Rennes, [3]GH Saint Louis Lariboisière F.Widal

S-2 Vestibular and kinesthetic information modulate EEG alpha activity during spatial navigation

Petra Fischer[1], Benedikt Ehinger[1], Anna Gert[1], Lilli Kaufhold[1], Felix Weber[1], Gordon Pipa[1], Peter König[1]

[1]University of Osnabrück

S-3 Role of vestibular and visual depth cues in the perception of linear motion

Arjan ter Horst[1], Mathieu Koppen[1], Luc P.J. Selen[1], W. Pieter Medendorp[1]

[1]Radboud University Nijmegen

S-4 Modeling and testing 2D spatial updating during passive body translation

Julian Tramper[1], Pieter Medendorp[1]

[1]Radboud University Nijmegen, Donders Institute

S-5 Head movement predictability explains suppression of vestibular input during locomotion

Paul MacNeilage[1], Julia Rackerseder[2], Stefan Glasauer[2]

[1]University Hospital of Munich, [2]Ludwig-Maximilian University of Munich

S-6 Whole-body motion discrimination in the visually impaired

Ivan Moser[1], Luzia Grabherr[2], Matthias Hartmann[1], Fred Mast[1]

[1]University of Bern, [2]University of South Australia

S-7 The effect of misleading prior information on the subjective visual vertical

Andrew Ellis[1], Fred Mast[1]

[1]University of Bern

S-8 Human sensitivity to visual-inertial self-motion

Alessandro Nesti[1], Karl Beykirch[2], Polo Pretto[1], Heinrich Bülthoff[1]

[1]Max Planck Institute for Biological Cybernetics, [2]AMST-Systemtechnik GmbH

S-9 Optic flow induces vestibular self-motion aftereffect

Luigi Cuturi[1], Paul MacNeilage[1]

[1]German Center for Vertigo (DSGZ)

S-10 Reaching with the sixth sense: vestibulo-motor control in the human right parietal cortex

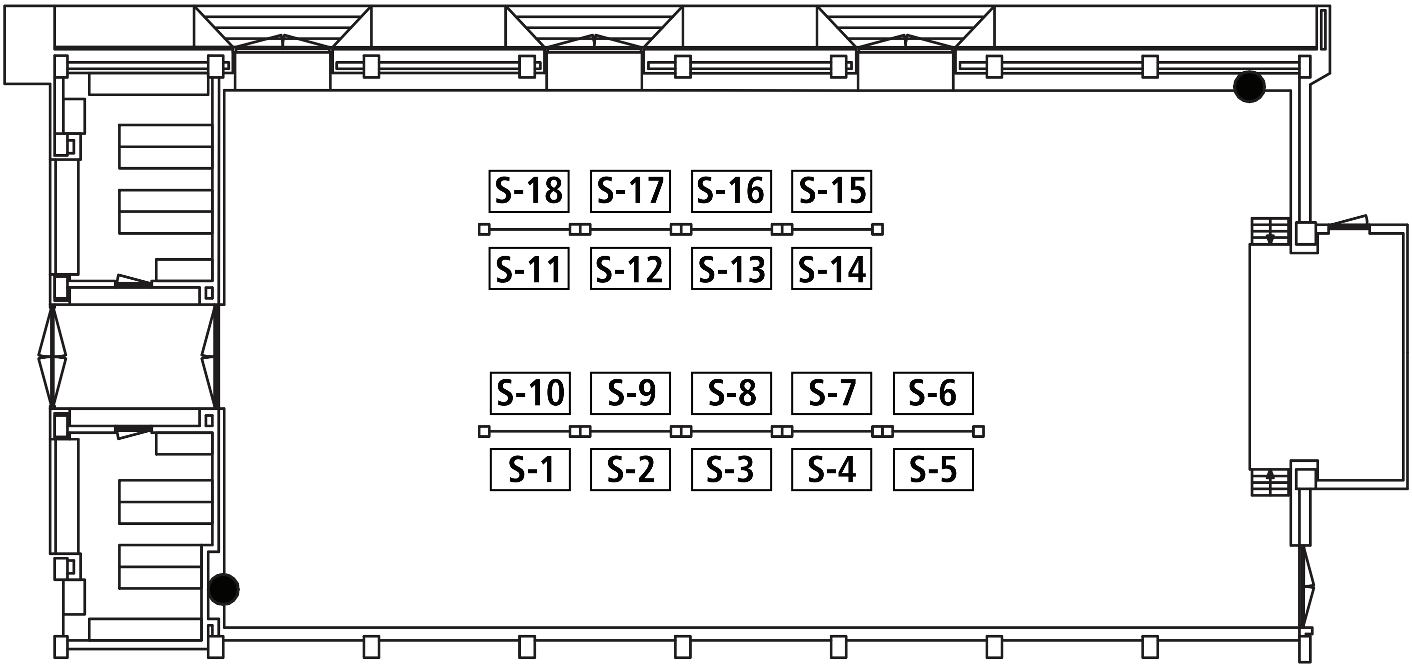
Alexandra Reichenbach[1], Jean-Pierre Bresciani[2], Heinrich Bülthoff[3], Axel Thielscher[4]

[1]University College London, [2]University of Fribourg, [3]Max Planck Institute for Biological Cybernetics, [4]Copenhagen University Hospital

Satellite Meeting Poster Session Floor Plan
St John's Rooms 1 & 2

Monday April 21, 2014

Theme: Vestibular Processing in Motor Control



S-11 Vestibular stimulation influences decision outcome in a trust game.

Nora Preuss[1], Matthias Hartmann[1], Fred Mast[1]

[1]Department of Psychology, University of Bern, Switzerland

S-12 Vestibular-evoked arm movement during standing is a direct consequence of postural sway.

Craig Smith[1], Raymond Reynolds[1]

[1]University of Birmingham

S-13 Vestibular modulation of saccadic target selection

Liliana Rincon Gonzalez[1], Luc Selen[1], Pieter Medendorp[1]

[1]Radboud University Nijmegen

S-14 Vestibulocollic reflexes are modulated to amplitude and bandwidth of lateral torso perturbations

Patrick Forbes[1], Anoek Geers[1], Riender Happee[1], Frans van der Helm[1], Alfred Schouten[1]

[1]Delft University of Technology

S-15 Perception of heading and travelled path during curvilinear trajectories

Suzanne Nooij[1], Paolo Pretto[1], Alessandro Nesti[1], Heinrich Bülthoff[1]

[1]Max Planck Institute for Biological Cybernetics

S-16 Passive whole-body rotation shapes peripersonal space: behavioral evidence

Christian Pfeiffer[1], Jean-Paul Noel[1], Andrea Serino[1], Olaf Blanke[1]

[1]Ecole Polytechnique Federale Lausanne

S-17 A Linear optokinetic paradigm to evaluate Dynamic Subjective Visual Vertical using 3D virtual reality system in healthy subjects

Taiza Santos-Pontelli[1], Jussara Baggio[1], Jessica Vitti[1], Pamella Queluz[1], Rogerio Siqueira[1], Suleimy Mazin[1], Camila Barros[1], Miguel Hyppolito[1], Octavio Pontes-Neto[1], João Leite[1]

[1]Ribeirao Preto Medical School-University of Sao Paulo

S-18 Visual vertical perception during caloric stimulation in healthy subjects

Taiza Santos-Pontelli[1], Martha Funabashi[2], Aline Flores[1], Amanda Vicentino[1], Jussara Baggio[1], Jose Colafemina[1], Octavio Pontes-Neto[1], Joao Leite[1]

[1]Ribeirao Preto Medical School-University of Sao Paulo, [2]University of Alberta


Visit our booth and get a live demo!

Annual Meeting Detailed Daily Program

All sessions will be held in The Grand Ballroom.
Posters will be located in Volmer Rooms, St John's Rooms and Foyer.

DAY 1 Sunday, April 20

15:00 – 19:00	Satellite Registration
18:00 – 19:00	Satellite Drinks Reception, The Golden Palm Bar, NH Grand Krasnapolsky Hotel

DAY 2 Monday, April 21

08:00 – 08:45	Satellite Registration
08:45 – 17:30	Satellite Meeting
17:00 – 19:00	Conference Registration
19:00 – 21:00	Opening Reception including open bar, Molenzolder Room, Heineken Brewery (off-site, directions on page 7)

DAY 3 Tuesday, April 22

08:00 – 10:15	**Session 1, Panel I** **Causing a sensation: Development of a somatosensory afferent interface for BMI users** Organizer: Lee E Miller Participants: Robert A Gaunt, Dustin J Tyler, Sliman J Bensmaia, Philip N Sabes
10:15 – 10:45	**Break** – The Winter Garden and St. John's Room
10:45 – 13:00	**Session 2, Panel II** **Predicting with the cerebellum: Neural Computations for motor control and perceptual stability** Organizer: Kathleen Cullen Participants: Tim J Ebner, Nate B Sawtell, Peter Their
13:00 – 15:00	**Session 3, Poster 1, Lunch**
15:00 – 16:40	**Session 4, Individual Presentations I** **Temporal structure of neuronal population activity supplements the instantaneous rate code in gating saccade initiation** Participants: Uday K Jagadisan, Neeraj J Gandhi **Characterization of postural responses and central vestibular neuron activity during electrical stimulation delivered by a vestibular prosthesis** Participants: Diana Mitchell, Chenkai Dai, Medhi Rahman, Joong Ho Ahn, Charles Della Santina, Kathleen Cullen **An optimal control model for interpreting gaze shifts in vestibular-loss and cerebellar-ataxia patients** Participants: Murat Saglam, Stefan Glasauer, Nadine Lehnen **Neural implementation of Listing's law in the saccade system** Participants: Mayu Takahashi, Yuriko Sugiuchi, Yoshikazu Shinoda **A possible role of the basal ganglia in the spatial-to-temporal transformation in saccadic eye movements: a computational model** Participants: Abbas Al Ali, Fred H Hamker
16:40 – 17:00	**Break**
17:00 – 18:00	**Session 5, Keynote Address** **Effects of MRI machine magnetic fields on the brain: Studies in normal humans, vestibular patients, mice and zebra fish.** David S. Zee, John Hopkins University

Annual Meeting Detailed Daily Program

DAY 4 Wednesday, April 23

08:00 – 10:15 **Session 6, Panel III**

Proprioception: New insights on its neural basis, its dysfunction and training
Organizer: Juergen Konczak
Participants: Amy Bastian, Daniel Goble, David Ostry

10:15 – 10:45 **Break** – The Winter Garden and St. John's Room

10:45 – 13:00 **Session 7, Individual Presentations II**

Brain plasticity in amputees reflects adaptive limb use
Participants: Tamar Makin, Alona O Cramer, Avital Hahamy, Jan Scholz, David Henderson Slater, Irene Tracey, Heidi Johansen-Berg

Exercise-based neurorehabilitation improves sensorimotor responses to perturbation in individuals with Parkinson's disease
Participants: Lena H Ting, J. Lucas McKay, Madeleine E Hackney

Weight illusions and grip force application in patients with damage to the eft and right hemisphere
Participants: Joachim Hermsdoerfer, Marta Bienkiewicz, Gavin Buckingham

Can we maintain optimal behaviors with rapidly changing task demands?
Participants: Jean-Jacques Orban de Xivry, Philippe Lefèvre

Erasing sensorimotor memories II: The role of PKMzeta dependent LTP in S1 receptive fields and behavior in the experimentally naive rat and primate
Participants: Joseph T Francis , Jordan Iordanou, Cliff Kerr, William Lytton, Lee von Kraus

Focal gray matter plasticity as a function of long duration bed rest: preliminary results
Participants: Rachael D Seidler, Vincent Koppelmans, Burak Erdeniz, Yiri E De Dios, Scott J Wood, Patricia A Reuter-Lorenz, Igor Kofman, Jacob J Bloomberg, Ajitkumar P Mulavara

Reward feedback accelerates motor adaptation
Participants: Alaa A Ahmed, Ali Asadi Nikooyan

13:00 – 15:00 **Session 8, Poster 1 continued, Lunch**

15:00 – 17:15 **Session 9, Panel IV**

The oculomotor system as model for investigating the neuroscience of motor control
Organizer: Stefan Glasauer,
Participants: Mike Mustari, John van Opstal, Hans Straka, Pablo Blazquez

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DAY 5 Thursday, April 24

08:00 – 10:00 **Session 10, Individual Presentations III**

Single trial neural correlates of grasping movement preparation in macaque areas AIP and F5
Participants: Jonathan A Michaels, Benjamin Wellner, Hansjörg Scherberger

Information flow in optogenetically stimulated macaque motor cortex: simulation and experiment
Participants: Cliff C Kerr, Daniel J O'Shea, Werapong Goo, Salvador Dura-Bernal, Joseph T Francis, Ilka Diester, Paul Kalanithi, Karl Deisseroth, Krishna V Shenoy, William W Lytton

Common low-frequency dynamics in movement and sleep
Participants: Andrew Jackson, Felipe de Carvalho, Thomas M Hall

Posterior parietal cortex in predictive sensorimotor control
Participants: He Cui, Yuhui Li, Yong Wang

Dissociable motor learning improvements induced by punishment- and reward-based motivation
Participants: Joseph M Galea, Elizabeth Mallia, John Rothwell, Joern Diedrichsen

DAY 5 Thursday, April 24

	Neural control and monitoring of decision making Participants: Jeffrey D Schall
10:00 – 10:15	**Members Business Meeting**
10:15 – 10:45	**Break** – The Winter Garden and St. John's Room
10:45 – 13:00	**Session 11, Panel V** **Recent advances in the role of the superior colliculus in the control of covert and overt orienting.** Organizer: Doug Munoz Participants: Francoise Vitu, Tadashi Isa, Rich Krauzlis
13:00 – 15:00	**Session 12, Poster 2, Lunch**
15:00	**Free Time and Excursions (ticketed)**

DAY 6 Friday, April 25

08:00 – 10:15	**Session 13, Panel VI** **The expanding role of the brainstem in movement: a perspective from mouse to human** Organizer: Claire Honeycutt Participants: Rob Brownstone, Tatiana Deliagina, Stuart Baker, Eric Perreault
10:15 – 10:45	**Break** – The Winter Garden and St. John's Room
10:45 – 13:00	**Session 14, Individual Presentations IV** **Modulation of Motoneuron Firing by Recurrent Inhibition in Adult Rat in vivo** Participants: Timothy C Cope, Ahmed Z Obeidat, Randall K Powers, Paul Nardelli **Parsing out brain-spinal cord contributions to human motor learning using fMRI** Participants: Shahabeddin Vahdat, Ovidiu Lungu, Julien Cohen-Adad, Véronique Marchand-pauvert, Habib Benali, Julien Doyon **Feedback responses can resemble trajectory control when required by the behavioural constraints of the ongoing task** Participants: Tyler Cluff, Stephen H Scott **Octopuses use unique motor control strategies for arm coordination in crawling** Participants: Guy Levy, Tamar Flash, Binyamin Hochner **Gradient-ascent and the exploration-exploitation tradeoff in multi-dimensional reinforcement learning** Participants: Yohsuke R Miyamoto, Maurice A Smith **Precise temporal encoding in a vocal motor system** Participants: Samuel Sober, Claire Tang, Kyle Srivastava, Diala Chehayeb, Ilya Nemenman **Interacting brains: sensory mechanism of physical interactions between humans** Participants: Gowrishankar Ganesh, Atsushi Takagi, Etienne Burdet
13:00 – 15:00	**Session 15, Poster 2 continued, Lunch**
15:00 – 17:15	**Session 16, Panel VII** **Inhibitory control of eye and hand movements** Organizer: Bram B Zandbelt Participants: Aditya Murthy, Katy Thakkar, Chris Chambers
17:15 – 18:00	**Closing Drinks Reception** – The Winter Garden

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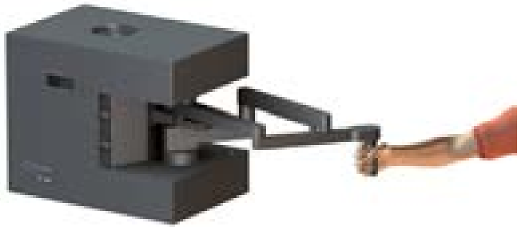

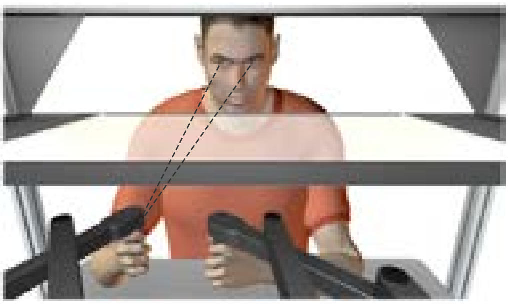

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TECHNOLOGIES

Session 1, Panel I

Tuesday, April 22 8:00 – 10:15

Causing a sensation: Development of a somatosensory afferent interface for BMI users

Lee Miller[1], Robert Gaunt[2], Dustin Tyler[3], Sliman Bensmaia[4], Philip Sabes[5]
[1]Northwestern University, [2]University of Pittsburgh, [3]Case Western Reserve University, [4]University of Chicago, [5]Univ California, San Francisco

Virtually all Brain Machine Interfaces (BMIs) rely on visual feedback, a poor substitute for natural somatosensation. Patients who are not paralyzed, but have lost proprioception, make poorly coordinated movements that require great concentration. Likewise, loss of touch makes manipulation of small objects nearly impossible. For fluid BMI control, it is likely that patients will require an afferent interface for somatosensory feedback in addition to an efferent interface for movement. The purpose of this workshop is to discuss the design of afferent interfaces as well as the scientific insights that can be obtained by studying them. Panel members will discuss a variety of approaches, including manipulation of the natural afferent input to human patients, and electrical stimulation of peripheral nerves and primary somatosensory cortex (S1), in both monkeys and humans. Speakers will have 20-25 minutes to describe their work and to answer questions. The workshop will end with 15 minutes of discussion. Dr. Tyler will describe results obtained through stimulation of cuffs implanted on upper limb nerves of humans with limb amputation. Stimulation has provided stable tactile percepts for over 18 months, allowing the impact of complex pulsing paradigms to be tested through direct reports from the patients. Understanding the transformation of these spatiotemporal patterns from their origins in the periphery to representation in S1 is key to the work of Dr. Bensmaia, who will describe intracortical microstimulation (ICMS) in areas 1 and 3b of monkeys. These experiments allow him to test neural coding theories, and to ask whether biomimetic patterns of stimulation elicit more intuitive sensations than do arbitrary patterns. Similarly, Dr. Miller will describe ICMS within area 2, used to evoke a sense of limb movement. This stimulation is also based on naturally occurring patterns, and Miller will discuss experiments probing the perceptual effects of the stimulation, as well as its utility for correction of movement perturbations. In contrast, Dr. Sabes will describe experiments that explore the brain's ability to adapt to multi-electrode ICMS that provides movement feedback via a smooth, but arbitrary mapping not normally found in the brain. After training, in which ICMS covaried with visual feedback, monkeys could perform the task with ICMS alone and optimally combined the two signals when both were available. Finally, Dr. Gaunt will describe experiments with a patient with paralysis, but essentially normal somatosensory function who controls robotic arm movements through decoded M1 activity. Tests using combinations of natural visual and proprioceptive feedback demonstrate that motor planning and execution are highly impaired without feedback, but are significantly restored with proprioception alone. We anticipate that this broadly multidisciplinary approach to a timely issue with both clinical and scientific importance will appeal to a broad audience.

Session 2, Panel II

Tuesday, April 22 10:45 – 13:00

Predicting with the cerebellum: Neural Computations for motor control and perceptual stability.

Kathleen Cullen[1], Tim Ebner[2], Nate Sawtell[3], Peter Their[4]

[1]McGill University, [2]University of Minnesota, [3]Columbia University, [4]Hertie Institute for Clinical Brain Research

Understanding the changes that occur in the brain during motor learning is a fundamental problem in neuroscience. To acquire new skills and to maintain mastered skills in response to changes in the internal and external environment, our brain must coordinate changes in the responses of neurons and neural circuits, with motor performance. There is accumulating evidence from behavioral and clinical studies that the brain computes an estimate of the expected sensory consequences of movement that it then compares this prediction to the actual sensory feedback to compute a sensory prediction error. Sensory prediction errors ensure accurate motor performance and drive motor learning. Moreover, there is growing evidence that the cerebellum, a structure that is well conserved across vertebrates and plays a vital role in motor learning, builds a model of the sensory consequences of the motor command. To date, however, it has been difficult to obtain direct evidence that the cerebellum explicitly generates sensory prediction errors during motor learning. The aim of the present panel is to explore more recent work on the neural computations performed by the cerebellum during the planning and adaptation of voluntary movement. Each of the four speakers will address a specific topic. Nate Sawtell will discuss recent in vivo whole-cell recordings and computational analysis of a cerebellum-like sensory structure in electric fish. He will show that granular layer circuitry functions to transform stereotyped corollary discharge input into more temporally diverse and delayed output. This recoding provides a basis for generating temporally-specific predictions in Purkinje-like cells that cancel out the sensory consequences of the fish's own electromotor behavior. Tim Ebner will present data showing that simple spike activity of most Purkinje cells independently encode error signals as well as kinematic signals. He will emphasize the importance of this dual representation in relation to the generation of sensory prediction errors to update an internal model for accurate manual tracking. Kathleen Cullen will discuss how individual cerebellar output neurons dynamically encode sensory prediction errors in monkeys during self-motion, to provide an explicit representation of unexpected motion. She will highlight the importance of this computation for ensuring accurate spatial orientation and postural control. Peter Thier will discuss recent experiments in patients and monkeys with cerebellar lesions. He will consider results of MEG and fMRI during a visual motion perception task that suggest a role for the cerebellum in generating predictions of the sensory consequences of movement and consider how this information could modulate visual motion processing in the cerebral cortex to influence perception. Finally, the panel will discuss whether these new findings are compatible with theories of cerebellar function, and consider what issues remain unresolved.

Session 4, Individual Presentation I

Tuesday, April 22 15:00 – 16:40

Temporal structure of neuronal population activity supplements the instantaneous rate code in gating saccade initiation

Uday Jagadisan[1], Neeraj Gandhi[1]

[1]University of Pittsburgh

Neurophysiologists routinely reference behaviour to the instantaneous firing rate of a neuron or population of neurons. While this approach has provided a fairly rich understanding of the neural code, as estimated by correlation with behaviour, it is unclear whether the temporal relationship between neurons in the population code contains additional information to that provided by the instantaneous rate. Here, we show that in a sensorimotor structure involved in producing orienting movements - the superior colliculus (SC) in the primate midbrain - the temporal relationship between neurons during visual (sensory) activity is different from that during pre-saccadic (premotor) activity. Specifically, the temporal structure fluctuates in the sensory response while remaining relatively stable in the premotor response, specifying a code to distinguish between incoming sensory input and motor preparatory output. We suggest that the instability of the visual response is a possible explanation for why the high frequency visual burst does not initiate a saccade, although it may cross a

firing rate threshold at the population level. Such gating of the visual burst is an important attribute because the SC visuomovement neurons project directly to the brainstem which houses the controller for gaze shifts, and any increase in the incoming drive is poised to trigger a (potentially erroneous) gaze shift. Further, we demonstrate that a simple firing rate-based network with synaptic facilitation can distinguish between stable and fluctuating population codes, suggesting a putative neural mechanism for interpreting temporal structure. Heuristically, this "decoder" keeps track of the short-term history of population activity, uses this "memory" to evaluate stability, and responds selectively when the activity pattern is deemed stable over some time scale. This is achieved by using short-term facilitatory connections from the input population to a leaky accumulator, with a Hebb-like learning rule and weight normalization. We suggest that future studies need to look at the temporal structure of population activity along with currently studied measures to examine their role in neuronal communication and correlation with behaviour.

Characterization of postural responses and central vestibular neuron activity during electrical stimulation delivered by a vestibular prosthesis

Diana Mitchell[1], Chenkai Dai[2], Medhi Rahman[2], Joong Ho Ahn[2], Charles Della Santina[2], Kathleen Cullen[1]

[1]McGill University, [2]Johns Hopkins

Lesions that cause loss of vestibular function are relatively common in humans and hinder the ability to maintain stable gaze and balance. Ongoing research is focused on developing a chronically implanted vestibular prosthesis as a treatment option for patients suffering from vestibular loss. This device consists of a gyroscope, which senses the movement of the head, and electrode arrays implanted in each semicircular canal, which stimulate the vestibular nerve to send head motion information to the brainstem. Behavioral studies have shown that vestibular prosthetic stimulation produces vestibulo-ocular reflex (VOR) eye movements although these responses remain smaller than what would be expected from normal vestibular function. For example, the gain and time constant values of VOR responses evoked by prosthesis stimulation are often lower than those observed in response to natural stimulation. To improve behavioral performance it is necessary to determine how the brain responds to this type of stimulation. First we determined whether prosthetic stimulation evokes a postural response (i.e. reflexive head movements). Next we determined how neurons mediating these reflexive movements (i.e. vestibular-only (VO) neurons in the vestibular nuclei) respond to prosthetic stimulation. We found that stimulation consistently evoked significant head as well as eye movements in the direction contraversive to the stimulated nerve. Additionally, although the evoked head movements were significantly smaller than the evoked eye movements, they substantially contributed to gaze stabilization after 75ms (20-30%). Interestingly, head movement latencies were considerably longer than those of the eye (40 versus 5ms), suggesting the vestibulo-collic reflex pathways play a less dominant role than direct VOR pathways in gaze stabilization. We identified neurons thought to mediate these reflexive head movements (VO neurons) based on their responses to eye position and during whole-body rotation. For neurons receiving direct input from the vestibular nerve, we determined the stimulation current amplitude for each unit by gradually increasing the current amplitude of biphasic pulses (200 s/phase) delivered at 100pps until spikes were reliably evoked at monosynaptic latencies (0.7-1.3ms). Next, we applied pulse trains of 50pps-300pps to determine how neurons responded to sustained stimulation. We found that each neuron's spiking activity was highly time locked to pulses delivered through the prosthesis indicating that the vestibular afferent population was synchronously activated by prosthetic stimulation, which in turn drove synchronous central responses. We hypothesize that this synchronicity is in part the cause for the low behavioral performance obtained using the vestibular prosthesis thus far, and predict that desynchronizing afferent inputs will enhance the response of central vestibular neurons to prosthetic stimulation thereby improving behavioral performance.

An optimal control model for interpreting gaze shifts in vestibular-loss and cerebellar-ataxia patients

Murat Saglam[1], Stefan Glasauer[1], Nadine Lehnen[1]

[1]Ludwig Maximilian University Munich

Optimal control theory is widely used to deal with the redundancy problem, i.e. having infinitely many possible solutions to achieve the goal of a movement. We have used optimal control modeling to explain large gaze shifts that can be realized by infinite combinations of eye and head movements and showed that minimizing the combined impact of signal-dependent and constant noise on the between-trial post movement variability accounts for the highly stereotyped nature of gaze shifts (Saglam et al. 2011). The minimum-variance model not only explained natural eye and head movements but - being dependent on dynamical plant characteristics - also accounted for the kinematic changes of eye and head movements due to experimentally increased head moment of inertia. In the present study, we used this model to interpret gaze shifts in vestibular-loss and cerebellar-ataxia patients, i.e., to ask whether and to what extent gaze optimality in the natural condition and with changed dynamical characteristics of the effector (increased head moment of inertia) are dependent on vestibular input and cerebellar integrity. We compared kinematic eye and head movement parameters such as relative contributions, durations, and velocity profiles that were experimentally observed with those predicted by the model. We observed that healthy subjects updated kinematic parameters towards the optimal model predictions within the course of about ten trials after the head moment inertia was increased. Vestibular-loss patients failed to adjust any of the gaze shift parameters revealing a crucial role of vestibular input in trial-to-trial improvement of gaze optimality, when visual feedback is prevented. Cerebellar ataxia patients could optimize some movement parameters to serve the minimum-variance principle, but persistently undershot the target. However, the updated parameters were appropriate for the inaccurately small gaze shift amplitudes. This shows that cerebellar integrity was not crucial for minimizing between-trial gaze variability but necessary for gaze accuracy in our patient group (Saglam et al. 2014). Optimal control models are useful to gauge the optimality of motor behavior not only in healthy subjects but also in different patient groups.

Acknowledgments: Supported by BMBF (Project IFB 01EO0901)

References: Saglam M, Lehnen N, Glasauer S (2011), J Neurosci, 31:16185-93; Saglam M, Glasauer S, Lehnen N (2014), Brain, accepted.

Neural implementation of Listing's law in the saccade system

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

[1]Tokyo Medical and Dental University

It is believed that the saccade system uses the horizontal and vertical Cartesian coordinates, based on the findings that the lesion in the PPRF causes impaired horizontal saccades, whereas the lesion in the riMLF causes impaired vertical saccades. Neural pathways for generating horizontal saccades from the superior colliculus (SC) were understood well, but those for generating vertical saccades from the SC have not been identified yet. Our recent studies on the pathways for generating vertical saccades from the SC revealed that the saccade system uses the semicircular canal coordinate system rather than the horizontal and vertical coordinate system. Using intracellular recording techniques, we analyzed synaptic connections from the SC to vertical ocular motoneurons and tectoreticular saccade neurons (TRNs) in the opposite SC in anesthetized cats. TRNs in the rostromedial SC activated superior rectus and inferior oblique motoneurons and TRNs in the rostrolateral SC activated inferior rectus and superior oblique motoneurons via the riMLF. These innervation patterns are similar to those in the VOR from the anterior canal and the posterior canal, respectively. Stimulation of the SC and recording postsynaptic potentials (PSPs) in TRNs in the opposite SC showed that the inhibitory commissural connection exists between the medial (lateral) SC representing upward (downward) oblique saccades on one side and the lateral (medial) SC representing

downward (upward) oblique saccades on the other side. This pattern of reciprocal inhibition between the SCs is very similar to that seen between the bilateral vestibular nuclei in the oblique eye movements evoked by head rotation in the plane of anterior semicircular canal on one side and the posterior semicircular canal on the other side. These similarities of the motoneuronal innervation patterns and the commissural inhibitions in the VOR and saccade systems strongly suggested that both systems use the common semicircular canal coordinates. However, if the saccade system uses the semicircular canal coordinate system, then the saccade system may violate Listing's Law (LL), because it is well known that the VOR does not obey the LL. The commissural connection between the SCs was considered to be mainly inhibitory, but we also found that there is a strong commissural excitation between the symmetrical parts of the rostral SCs. TRNs in the rostromedial SC received strong commissural excitation from the rostromedial SC on the opposite side, whereas TRNs in the rostrolateral SC received strong excitation from the rostrolateral SC on the opposite side. When TRNs in the medial (lateral) SC on both sides are activated by commissural excitation, torsional components of individual eyes may cancel each other and upward (downward) saccades occur. Therefore, these tectotectal commissural excitatory connections are considered to minimize torsional movements of eyes and help to maintain Listing's Law in the saccadic system.

A Possible Role of the Basal Ganglia in the Spatial-To-Temporal Transformation in Saccadic Eye Movements: A Computational Model

Abbas Al Ali[1], Fred Hamker[1]

[1]Technische Universität Chemnitz

Superior colliculus (SC) is a midbrain structure known to be involved in controlling fast eye movements called saccades. The deeper layers form a retinotopic motor map of the visual field. Different models were proposed to explain how the spatial distribution of saccade-related activity on the motor map is transformed into a temporal code which results in the stereotyped dynamic characteristics referred to as the 'main sequence'. A static model puts a nonlinear feedback loop locally in the brainstem saccade generator downstream of the SC, where the distribution of SC activity only specifies the coordinates of the saccade displacement. Other dynamic models have put the SC inside the loop and let a nonlinear feedback signal change either the level of activity, 'decaying hill' model, or its locus on the SC, 'moving hill' model. A recent dynamic ensemble coding model proposed by Goossens and Van Opstal (J Neurophysiol, 2006) relocated the SC outside the feedback loop. It was shown that based on measured SC activity a linear feedback loop generated nearly realistic saccades. Due to this model, measured SC activity profiles carry the code for the main sequence kinematics. Following this hypothesis a fundamental question is still open: What is the origin of these activity profiles? We hypothesize that a subcortical colliculo-thalamo-basalganglio-collicular oculomotor loop, may play a role in generating the temporal profiles of the SC burst neurons. We have investigated this by means of a detailed 2D mean rate neuro-computational model composed of a model of the SC, thalamus and basal ganglia. Visuomovement and movement SC cells project to the thalamus (TH) further to the caudate nucleus (CD) and then via the 'direct' pathway to one of the BG output structures, the reticular part of substantia nigra (SNr). The 'indirect' pathway goes from the CD through the external part of the globus pallidus (GPe) and ends on SNr. SNr in turn influences the firing of the burst neurons via a network of interactions (Kaneda, Isa, Yanagawa & Isa, J Neurosci. 2008; Shires, Joshi & Basso, Curr Opin Neurobiol. 2010). Our simulation results show that the generated saccades obey the main sequence kinematics. The model does not make the classic distinction between saccade-related cells (caudal) and fixation cells (rostral) and, in agreement with physiological data measured from the rostral SC pole, supports the notion of a continuum from microsaccdes to normal ones. Due to our model visuomovement cells of the SC drive the direct pathway which cancels the inhibition exerted by SNr on the SC allowing the saccadic movement to start, whereas the burst activity of movement cells also drives the indirect pathway causing the inhibition to return and the movement to stop. Up to our knowledge, this is the first model that addresses a role of the basal ganglia in controlling saccades dynamics, an issue which could be the subject of future experimental investigations.

Session 5, Keynote Address

Sponsored by The Donders Institute for Brain, Cognition and Behaviour

Tuesday, April 22
17:00 – 18:00

Effects of MRI machine magnetic fields on the brain: Studies in normal humans, vestibular patients, mice and zebra fish

David S. Zee[1], Bryan Ward[1], Grace Tan[1], Prem Jareonsettasin[1], John Carey[1], Charles DellaSantina[1], Dale Roberts[1]

[1]Departments of Neurology, Ophthalmology, Otolaryngology - Head and Neck Surgery,Neuroscience, The Johns Hopkins Hospital

Here we discuss the effects of Lorentz forces (static magneto-hydrodynamic forces), induced by ionic currents in fluids interacting with magnetic fields from MRI machines, on the labyrinth. We will discuss the mechanism of MRI-induced nystagmus in normal humans, its role in the analysis of patients with unilateral labythine lesions, and the use of its effects on the behavior of mice and of zebra fish in MRI machines. We discuss the potential implications for studying adaptive control of vestibulo-ocular reflexes, for interpreting of functional MRI studies, and potentials for therapeutic interventions.

Session 6, Panel III

Wednesday, April 23
08:00 – 10:15

Proprioception: New insights on its neural basis, its dysfunction and training

Juergen Konczak[1], Amy Bastian[2], Daniel Goble[3], David Ostry[4]

[1]University of Minnesota, [2]Johns Hopkins School of Medicine, [3]San Diego State University, [4]McGill University

Many neurological and orthopedic disease states are known to be associated with proprioceptive loss, which negatively impacts motor function. The exact mechanisms of how a proprioceptive loss affects multimodal sensory integration, sensorimotor integration and ultimately motor behavior are not fully understood. However, a deeper understanding of how sensory dysfunction contributes to motor dysfunction will have a profound influence on how to design new treatments for rehabilitation. The aim of the panel is threefold: First, to present new data on the circuitry involved in proprioceptive-motor processes. Second, to discuss the current state of knowledge on proprioceptive dysfunction and its impact on motor behavior. Third, to document that sensorimotor learning affects both motor and somatosensory plasticity. Specifically, it will provide new insights from brain imaging studies that reveal areas involved in the processing of proprioceptive signals for motor control in young and older adults (Goble). Further, it will outline how diseases affecting the cerebellum (Bastian) and basal ganglia (Konczak) affect proprioception and distinct processes of proprioceptive-motor integration. While cerebellar dysfunction manifests itself in the inability to generate predicted (somato)sensory feedback, this ability is spared in patients with basal ganglia disease. However, diseases associated with basal-ganglia dysfunction may lead to deficits in processing afferent proprioceptive signals, which is documented by a decrease in precision of proprioceptive and haptic sensing. Finally, the panel will present recent evidence on how somatosensory and motor

learning may be linked, highlighting that somatosensory function and somatosensory brain areas are plastic and systematically modified in conjunction with motor skill acquisition (Ostry). Taken together, this information can serve as a framework for new rehabilitation techniques that ultimately can help to overcome current barriers in treating patients who experience sensorimotor dysfunctions associated with proprioceptive loss.

Session 7, Individual Presentations II

Wednesday, April 23
10:45 – 13:00

Brain plasticity in amputees reflects adaptive limb use

Tamar Makin[1], Alona Cramer[1], Avital Hahamy[2], Jan Scholz[3], David Henderson Slater[4], Irene Tracey[1], Heidi Johansen-Berg[1]

[1]Oxford University, [2]Weizmann Institute of Science, [3]The Hospital for Sick Children, [4]Nuffield Orthopaedic Centre

We aimed to test the extent of experience-dependent adaptive plasticity in the human sensorimotor system. Amputation is a particularly useful model for studying plasticity as it combines two powerful drivers for plasticity - sensory deprivation and altered use (adaptive motor behaviour compensational to the disability). Yet little evidence exists for interaction between sensory deprivation and use-related plasticity. Instead, research on amputation has been mostly restricted to maladaptive plasticity, with a focus on phantom pain. Here we test whether altered limb-use patterns influence cortical reorganisation in individuals with unilateral hand absence. We show that populations with congenital and acquired limb loss have different strategies for adaptive behaviour, which are mapped onto corresponding distinct patterns of functional plasticity in the deprived area of the sensorimotor cortex: Congenitally deprived individuals, who tend to use their residual arm (stump), showed increased representation of the stump in the (contralateral) deprived cortex, as measured using functional MRI (fMRI). By contrast individuals with acquired amputation (who rely more strongly on their intact hand) showed increased ipsilateral representation of the intact hand in the same deprived cortex. In addition to these group differences, and irrespective of age at deprivation, individuals from either group that rely more on their intact hands (and report less frequent stump usage) showed increased representation of the intact hand in the deprived cortex, as well as increased white matter fractional anisotropy underlying the deprived cortex. Finally, while both populations exhibited degraded levels of inter-areal functional connectivity (as measured during a resting-state scan), individuals with congenital limb-loss that rely more heavily on their stump in daily tasks (and therefore exhibit more symmetrical bimanual usage patterns) also showed greater coupling between the two hand areas. Together, our findings demonstrate how experience-driven plasticity in the human brain can transcend boundaries that have been thought to limit reorganisation in adults. The deprived cortex in people with either congenital or acquired limb absence is employed by whichever body-part individuals are over-using to compensate for their disability. This occurs irrespective of which body part that is and the degree to which it is typically represented in this brain area, and is independent of deprivation age.

Exercise-based neurorehabilitation improves sensorimotor responses to perturbation in individuals with Parkinson’s disease

Lena Ting[1], J. Lucas McKay[1], Madeleine Hackney[1]

[1]Emory University and Georgia Tech

Revealing neural mechanisms of motor impairments and rehabilitation is critical to the development of more effective interventions. Our goal was to a combination of experimental and computational methods to reveal neural mechanisms of improved balance and gait in individuals with Parkinson’s disease (PD) who participate in adapted tango (AT) rehabilitation. AT has been demonstrated to improve clinical measures of balance and mobility but the neural mechanisms of improvement are not known. Individuals with PD exhibit co-contraction of agonist and antagonist muscles during reactive balance responses and increased center of mass (CoM) displacement. In healthy subjects, we identified a sensorimotor response model (SRM) that quantifies transformation between multisensory estimates of center of mass (CoM) motion into appropriate neural commands during reactive balance. In effect, the SRM quantifies the sensitivity of the reactive balance response to task-level error of the CoM from the desired, upright state. Here, we hypothesized that improvements in clinical balance measures are due to improved sensitivity of the reactive balance responses to task-level error. Nine individuals with mild to moderate PD were tested while ON medication before and after completing 15, 1.5 hours sessions of AT within 3 weeks. Reactive balance responses were elicited by administering forward support-surface translation perturbations causing backward CoM error. Electromyograms (EMG) from agonist tibialis anterior (TA) and antagonist medial gastrocnemius (MG) were recorded. SRM parameters were identified that described the timecourse of the EMG responses as a delayed, linear combination of CoM displacement, velocity, and acceleration. In healthy subjects, the SRM reproduces activity of TA based on backward CoM kinematic signals, and MG based on forward CoM kinematic signals, resulting in alternating TA and MG activity during reactive balance. However, in individuals with PD, both TA and MG were sensitive to the same backward CoM error signals; this "inappropriate" sensitivity of MG backward error resulted in dynamic co-contraction between TA and MG. Moreover, the "appropriate" response of MG to forward CoM error at the end of perturbations was absent in most participants with PD. After AT, participants demonstrated significant improvements in clinical scales of balance and also exhibited a decrease in "inappropriate" sensitivity of MG to backward CoM error. In several participants, the "appropriate" sensitivity of MG to forward CoM error was also restored. Our results demonstrate that MG activity can be decomposed into contributions from two sensorimotor pathways encoding opposing error signals. The balance of inhibition and excitation between these two pathways is disrupted in PD, and remediated after AT rehabilitation. Additionally our results show neural plasticity in non-voluntary, brainstem-mediated reactive balance responses induced by exercise-based rehabilitation.

Weight illusions and grip force application in patients with damage to the left and right hemisphere

Joachim Hermsdörfer[1], Marta Bienkiewicz[1], Gavin Buckingham[2]

[1]Technische Universität München, [2]Heriot-Watt University

Recent studies in motor learning and adaptation have fueled the interest in the specialized function of the left and right hemisphere in motor control. Recently, we investigated anticipatory grip force control in patients with unilateral brain damage during object lifting with the ipsilesional non-paretic hand. We found imprecise anticipation of grip force to the weight of everyday objects (like a book or a package of paper tissues) in patients with left brain damage but not in right brain damage, suggesting a role of the motor-dominant left brain in coding object properties relevant for manipulation on the basis of their identity. By contrast, we found no indication of a grip force deficit in patients in a size-weight illusion paradigm, when the initial weight information was provided by the size of the object. Also the perceptual illusion was the same in patients and control subject. Here we hypothesized that the so-called material-weight illusion may be reduced in patients with left brain damage, as material information about object characteristics is a less direct cue to weight than size. Twelve patients with left brain damage (LBD), ten patients with right brain damage (RBD) and twelve control subjects (CTR) lifted two pairs of identically-weighted large and small objects which appeared to be made from metal or Styrofoam. Participants’ grip forces and the lift forces were measured with a sensor (170 g) attached to the objects’ top surfaces. Subjects had to indicate which object in a pair is felt heavier before and after 6 lifts of each cube in a pair. Participants in

all three groups experience size weight illusions. The material-weight-illusion was perceived less clearly. Controls typically estimated the weight (correctly) equal (N = 7), while RBDs more frequently reported the illusion (N = 6) and LBDs reported the different answers with equal frequency (N = 4). During the first lift of each object, grip force reflected the objects' apparent weights as indicated by size. The grip force difference as a function of material was less consistent. Overall, performance variability was higher in the patients than in the controls and was higher in LBDs within patient groups. Our results confirm the normal processing of object size information for the scaling of grip forces and for the perception of the size-weight illusion in patients with brain damage, indicating that size processing is resistant to a wide range of brain damage. LBD patients in particular showed no consistent illusion or scaling of grip forces with variations in material properties. Therefore, the lesioned areas in the motor-dominant left hemisphere of these patients seem to play a role in the processing of material information for object manipulation. We conclude that material properties are preferentially processed by the motor-dominant hemisphere in manipulation tasks, however in a less selective way than information derived from object identity.

Can we maintain optimal behaviors with rapidly changing task demands?

Jean-Jacques Orban de Xivry[1], Philippe Lefèvre[1]

[1]Université catholique de Louvain

Our brain adjusts our motor behaviors to different task demands. For instance, following the minimum intervention principle (Todorov and Jordan, 2002), the brain allows a larger variability for movement endpoint when the target is wide than when it is narrow. Here, the dynamics of this reoptimization process is investigated, i.e. how quickly and efficiently the brain can adapt its control policy to changes in target width. Human subjects were asked to reach to targets that were 15cm away. The width of the target was varied (.5cm or 8cm) first on a trial-by-trial basis (random schedule, RND) and then in blocks (blocked schedule, BLK). To probe the control policy, a perturbation that directs the hand 2 cm away from the center of the target through a channel was used in 20% of the trials. The force exerted by the subjects against the wall of the channel was the main dependent variable. In the BLK condition, the subjects followed the minimum intervention principle and pushed stronger against the perturbation for the narrow than for the wide targets. If each and every movement is optimal, the modulation of the force with target width in the RND schedule should be identical to the modulation observed in the BLK schedule. In the RND condition, a larger force was also observed for the narrow targets than for the wide targets but this difference was much smaller than in the BLK schedule. That is, the context influenced the control policy used by the subjects, suggesting that human subjects do not optimize their movements on a trial-by-trial basis. In addition, we tested another group of subjects who performed a second RND block after the BLK schedule. In this group, the modulation of force with target width during the second RND schedule was similar to the modulation during the first RND schedule and smaller than during the BLK schedule. That is, a short period of training during the BLK schedule was insufficient to teach subjects how to rapidly switch between two different but learned control policies. In a second study, we tested whether the force depended on the statistics of the target width. In the 80W block, the wide target was presented in 80% of the trials and the narrow target in the remaining 20%. In the next block (80N block), the narrow target was the most frequent target. These two blocks were inserted after the RND block but before the BLK block. In the 80W and 80N blocks, the force response for the most frequent targets was identical to what was found in the BLK schedule. In contrast, the force for the wide target during the 80N block was equal to the force for the narrow target during the 80W block, like in the RND schedule. This series of results contradicts current theories of optimal motor behavior. These results suggest that motor behaviors are not reoptimized on a trial-by-trial basis (but maybe over a larger number of trials) and that there might be a cost that prevents reoptimization when task demands change too frequently.

Erasing sensorimotor memories II: The role of PKMzeta dependent LTP in S1 receptive fields and behavior in the experimentally naive rat and primate

Joseph Francis[1], Jordan Iordanou[1], Cliff Kerr[1], William Lytton[1], Lee von Kraus[1]

[1]SUNY Downstate Medical Center

Long-term synaptic modification is our best candidate mechanism for long-term memories, both explicit and implicit. There is currently strong evidence that the molecular machinery involved in the maintenance of long-term potentiation (LTP) is mediated by Protein Kinase M (PKM). This evidence includes the 'deletion' of both late-phase LTP and of explicit memories in rats via inhibition of PKM by Zeta Inhibitory Peptide (ZIP).We recently have demonstrated evidence that PKM inhibition can also erase implicit, procedural memories, as measured by performance on a reach to grasp task. However, decreases in performance on this task could be due to erasing "sensoritmotor" memories, or erasing fundamental properties of the sensory representation, or both. To answer this question we have continued our work, in both naïve rats and non human primates, to better determine the influences of PKM on the primary somatosensory cortex. It is known that the primary somatosensory cortex (S1) is organized in a somatotopic manner. It has previously been demonstrated that S1 responses to localized tactile stimuli, termed cortical response fields (CRF), are characterized by a central excitatory response ('core response') with surrounding inhibition ('border response'). The border expanse of CRFs is correlated with the brain's ability to process the respective CRF's sensory inputs. Indeed, these borders can change, sometimes rapidly, as a result of behavioral training or chronic changes in sensory input. While there is evidence that LTP plays a part in allowing such changes to occur, we here present evidence that LTP may also play a part in the long term, 'day to day' maintenance of CRF borders. By injecting a PKM inhibitor (ZIP) into the S1 paw representation of experimentally naïve (i.e. untrained) rodents, we observed changes in CRF electrophysiology, constituted by a simultaneous increase in border CRF responses and a decrease in core responses. Subsequent behavioral testing showed short-lasting effects on naïve behavior suggesting a loss and rapid relearning of baseline functions. The evidence from these studies supports a model of sensory cortex that includes ongoing maintenance of CRF inhibitory surround borders via PKM dependent LTP independent of any explicit sensorimotor training or learning.

Focal Gray Matter Plasticity As A Function Of Long Duration Bed Rest: Preliminary Results

Rachael Seidler[1], Vincent Koppelmans[1], Burak Erdeniz[1], Yiri De Dios[2], Scott Wood[3], Patricia Reuter-Lorenz[1], Igor Kofman[2], Jacob Bloomberg[4], Ajitkumar Mulavara[5]

[1]University of Michigan, [2]Wyle, [3]Azusa Pacific University, [4]NASA Johnson Space Center, [5]Universities Space Research Association

Long duration spaceflight (i.e., 22 days or longer) has been associated with changes in sensorimotor systems, resulting in difficulties that astronauts experience with posture, locomotion, and manual control. It is unknown whether and how spaceflight impacts sensorimotor brain structure and function, and whether such changes may potentially underlie behavioral effects. Long duration head down tilt bed rest has been used repeatedly as a spaceflight analog [1]. Bed rest mimics microgravity in body unloading and bodily fluid shifts. We are currently testing sensorimotor function, brain structure, and brain function pre and post a 70-day bed rest period. We will acquire the same measures on NASA crewmembers starting in 2014. Here we present the results of the first eight bed rest subjects. Subjects were assessed at 12 and 7 days before-, at 7, 30, and ~70 days in-, and at 8 and 12 days post 70 days of bed rest at the NASA bed rest facility in Galveston, TX. At each time point structural MRI scans (i.e., high resolution T1-weighted imaging and Diffusion Tensor Imaging (DTI)) were obtained using a 3T Siemens scanner. Focal changes over time in gray matter density were assessed using the voxel based morphometry 8 (VBM8) toolbox under SPM. Focal changes in white


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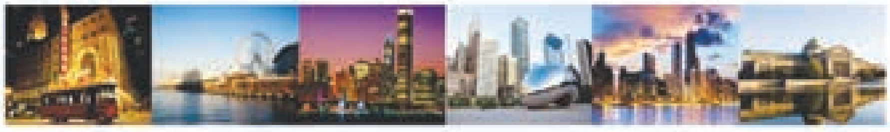

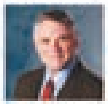

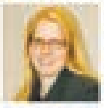

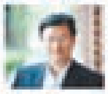

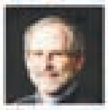

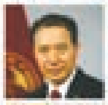

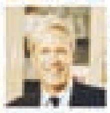

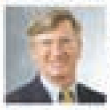

matter microstructural integrity were assessed using tract based spatial statistics (TBSS) as part of the FMRIB software library (FSL). TBSS registers all DTI scans to standard space. It subsequently creates a study specific white matter skeleton of the major white matter tracts. Non-parametric permutation based t-tests and ANOVA's were used for voxel-wise comparison of the skeletons. For both VBM and TBSS, comparison of the two pre bed rest measurements did not show significant differences. VBM analysis revealed decreased gray matter density in bilateral areas including the frontal medial cortex, the insular cortex and the caudate nucleus from pre to in bed rest. Over the same time period, there was an increase in gray matter density in the cerebellum, occipital, and parietal cortices. The majority of these changes did not recover from during to post bed rest. TBSS analyses will also be presented. Extended bed rest, which is an analog for microgravity, can result in gray matter changes and potentially in microstructural white matter changes in areas that are important for neuromotor behavior and cognition. These changes did not recover at two weeks post bed rest. Whether the effects of bed rest wear off at longer times post bed rest, and if they are associated with behavior are important questions that warrant further research. These results have significant public health implications, and will also aid in interpretation of our future data obtained pre and post spaceflight. REFERENCES [1] Reschke MF et al. (2009) Aviat Space Environ 9; 80(5, Suppl.):A1-10

Reward feedback accelerates motor adaptation

Alaa Ahmed[1], Ali Asadi Nikooyan[1]

[1]University of Colorado

Recent findings have demonstrated that reward feedback alone can drive motor adaptation. However, a number of questions remain unanswered. For example, it is not yet clear whether reward feedback alone can lead to learning when a perturbation is introduced abruptly, or how it can modulate the learning process. Here, we provide a more informative reward feedback that decays continuously with increasing error. We asked whether it is possible to learn an abrupt visuomotor rotation by reward alone, and if the learning process could be modulated by combining both reward and sensory feedback and/or by using different reward landscapes. We designed a novel visuomotor adaptation task during which subjects experienced an abruptly introduced rotational perturbation. Subjects (N = 46) grasped the handle of a robotic arm and made 15 cm rapid out-and-back reaching movements to move an on-screed cursor from a home circle to a target arc. After 50 Baseline trials, subjects experienced Rotation trials, where the cursor underwent an abrupt 30 degree rotation with respect to the hand. After 450 Rotation trials, the environment returned to a 0 degree rotation for the remaining 50 trials. Subjects were assigned to groups that received either visual feedback of the cursor alone, reward feedback alone, or a combination of reward and visual feedback. Instead of a binary reward, continuous reward feedback (i.e. a reward gradient) was presented to the subjects in the form of trial score. We tested subjects in a linear reward landscape, where the reward decayed linearly with distance from the target, and a cubic landscape, where the reward decayed more steeply with distance from the target. Results demonstrate that it is possible to learn from reward feedback alone and that the combination of reward and sensory feedback accelerates learning. No significant differences were observed in average error at the start or end of learning between the groups that received only reward feedback (no visual feedback) and the group that received only visual feedback (no reward feedback) ($p > 0.05$). Interestingly, we also observed that the combination of reward and visual feedback accelerated learning. We fit an exponential function to the individual subject error data early in the learning phase to determine the learning rate, c. We found that learning rates in the groups that received a combination of reward and visual feedback were significantly faster than the learning rate measure for the group that received only visual feedback ($p = 0.047$, $c = 0.457 \pm 0.063$, $c = 0.212 \pm 0.063$, respectively). These findings suggest that it would be promising to use reward feedback, either to supplement or substitute sensory feedback, for the development of improved neurorehabilitation techniques. More generally, they point to an important role played by reward in the motor adaptation process.

Session 9, Panel IV

Wednesday, April 23 15:00 – 17:15

The oculomotor system as model for investigating the neuroscience of motor control

Stefan Glasauer[1], Mike Mustari[2], John van Opstal[3], Hans Straka[4], Pablo Blazquez[5]

[1]Klinikum der Universität München, [2]University of Washington, [3]Radboud University Nijmegen, [4]Ludwig-Maximilians-Universität München, [5]Washington University

Research on the oculomotor system has a long tradition starting with the seminal observations by people such as Hermann von Helmholtz in the 19th century. During the last 50 years, our knowledge of the underlying anatomy and physiology has increased immensely. The theoretical efforts of people such as David Robinson have helped to understand the mechanisms of feedforward and feedback control of eye movements at an algorithmic level. The techniques to register eye movements have become more and more sophisticated. Finally, during the last years, new concepts in motor control such as optimal control principles have successfully been shown to hold for eye movements. This wealth of knowledge, its methodological accessibility, and its biomechanical simplicity makes the oculomotor system to an ideal model system to study motor control. However, during the last years, the number of papers published in the oculomotor domain has been stagnating. Is that because we already know everything about it? The goal of our team session is to bring researchers together who, working at the forefronts of experimental animal research, strive to unravel the neural substrates for oculomotor control. We will show that many of the pressing challenges of motor control in general can be investigated successfully in the relatively simple oculomotor system. How are frontoparietal areas interacting in generating motor behavior? How are optimization principles found in motor behavior implemented in the brain? How are forward models required for optimizing motor control implemented in the brain? What is the role of the cerebellum for learning and adaptation in motor control? How are sensory feedback and efference copy signals used for state estimation during active self-motion to achieve efficient motor control? The answers to these questions, each one presented by one speaker, are linked to a variety of brain regions: the differential role of the frontal eye fields and medial superior temporal region in the cortex exemplified for smooth pursuit eye movements (Mike Mustari), the encoding of desired eye-head gaze trajectories by neurons in the midbrain superior colliculus (John van Opstal), the implementation of forward models by different neuron types in the cerebellar cortex (Pablo Blazquez), the role of the cerebellar climbing fibres for motor learning (Peter Thier), and the fusion of self-generated and sensory signals in the brainstem (Hans Straka). In our final discussion, we will outline future challenges, identify gaps in knowledge, introduce new methods, discuss and clarify the limits of the oculomotor system as blueprint for motor control, and argue that the oculomotor system remains one of the best choices to study the neuroscience of motor control.

Session 10, Individual Presentations III

Thursday, April 24 08:00 – 10:00

Single trial neural correlates of grasping movement preparation in macaque areas AIP and F5

Jonathan Michaels[1], Benjamin Wellner[1], Hansjörg Scherberger[1]

[1]German Primate Center

The neural networks of the brain involved in the planning and execution of grasping movements are not fully understood. The network formed by macaque anterior intraparietal area (AIP) and hand area (F5) of the ventral premotor cortex is strongly implicated in the generation of grasping movements. However, the differential role of each area in this fronto-parietal network is unclear. Previously, data collected from these areas were limited to single neuron electrophysiological recordings. Single neuron recordings are not sufficient to elucidate the interaction of neurons at a population level during the formation of a motor plan. To capture network dynamics, we recorded single and multi-unit activity in parallel from chronically implanted electrode arrays in AIP and F5 while two macaque monkeys (female) performed a delayed grasping task (using one of two grip types) that also involved a grip selection component. Firstly, implementing the 'initial condition hypothesis' of movement preparation developed by Afshar et al. (2011), we predicted behavior of the animal on a single trial basis. This hypothesis posits that neural population activity prior to movement is predictive of subsequent reaction times (RTs) of the animal on single trials. In support of Afshar et al., who recorded on the border of dorsal premotor cortex and primary motor cortex in a reaching task, we found this method was able to explain significantly more variance in RT compared to classical methods. We introduce here a new prediction method based on a data-driven selection of relevant neurons and neural population averaging designed to extract a consistent relationship between neural activity and RT. Our method was able to explain the most variance in RTs overall and was the most parsimonious in that it does not rely on complex high-dimensional analyses. No decision related difference was found between conditions where the grip type was instructed and when the monkey chose freely. Furthermore, we were able to compare the information content of areas AIP and F5. We found that F5 was able to predict RT significantly better than AIP. Interestingly, multivariate regression of F5 and AIP together was able to significantly improve prediction using our proposed method. Taken together, these results lend support to the hypothesis that trial-to-trial movement preparation is strongly encoded in F5 and that AIP represents a step in the visuo-motor transformation not well encoding the temporal characteristics of upcoming movements such as RT. Reference: Afshar, A., Santhanam, G., Yu, B. M., Ryu, S. I., Sahani, M., & Shenoy, K. V. (2011). Single-trial neural correlates of arm movement preparation. Neuron, 71(3), 555-564.

Information flow in optogenetically stimulated macaque motor cortex: simulation and experiment

Cliff Kerr[1], Daniel O'Shea[2], Werapong Goo[2], Salvador Dura-Bernal[1], Joseph Francis[1], Ilka Diester[3], Paul Kalanithi[2], Karl Deisseroth[2], Krishna Shenoy[2], William Lytton[1]

[1]SUNY Downstate Medical Center, [2]Stanford University, [3]Ernst Strüngmann Institute

Optogenetics is a powerful tool for performing spatiotemporally precise perturbations to ongoing cortical dynamics in behaving primates. However, current methods allow for only small numbers of neurons to be recorded from simultaneously. In this work, we present a biomimetic spiking network model of macaque motor cortex, including an opsin channel model, in order to extend experimental optogenetics results to the large number of cells required for determining interlaminar information flow. Experimental data were recorded from the primary motor cortex of a male macaque. Optogenetic stimulation targeted excitatory neurons, likely preferentially affecting deeper layers, via the excitatory opsin C1V1TT, with either continuous (200 ms duration) or periodic (20, 40, or 80 Hz) pulses. The network model consisted of 3100 spiking Izhikevich neurons, consisting of regular-firing and bursting pyramidal neurons and fast-spiking and low-threshold-spiking interneurons, with connectivities and proportions of each cell type across each cortical layer drawn from experimental mammalian literature. Opsin channel properties were also based on empirical estimates. The network model was calibrated to reproduce the dynamics of the experimental data, including firing rates of approximately 10 Hz in the quiescent state, 60 Hz following a continuous light pulse, and 20 Hz during periodic stimulation. Applying spectral Granger causality to the LFPs produced in the different cortical layers of the model showed that, in the absence of optogenetic stimulation, the strongest projection was from layer 2/3 to layer 5A. This finding is consistent with the hypothesis that descending excitation is the primary driver of dynamics in the motor cortex. This pathway had roughly double the total Granger causality as the strongest ascending pathway, from layer 5A to layer 2/3. Strong Granger causality from layer 5A to layer 5B was also observed. Across all layer pairs, Granger causality showed a pronounced peak in the mu rhythm band (~9 Hz), with a small, broad gamma peak (~40 Hz) also observed in pathways from layer 2/3 to other layers. Optogenetic stimulation in the model increased Granger causality from layer 5 to other layers in a narrow band near the stimulation frequency. Optogenetic stimulation also increased the amplitude of Granger causality from layer 2/3 to other layers in the mu rhythm band, while decreasing it in the gamma band. In summary, this work demonstrates that (1) biomimetic modeling allows data from optogenetic stimulation experiments to be explored on a network level, and (2) optogenetic stimulation may be used to enhance and suppress information flow in particular frequency bands and between particular cortical layers.

Common low-frequency dynamics in movement and sleep

Andrew Jackson[1], Felipe de Carvalho[1], Thomas Hall[1]

[1]Newcastle University

It has been known for over a century that upper-limb movements are often composed of discrete submovements, but the origin of this intermittency remains unclear. While neural correlates of submovement frequencies around 2-3 Hz can be found in the primary motor cortex (M1), the temporal profile of movement kinematics is usually assumed to be determined by extrinsic factors such as limb biomechanics and sensory feedback delays. However, another possibility is that movement intermittency arises from an intrinsic rhythmicity in motor networks that causes low frequencies in behavior. Delta activity recorded in the electroencephalogram during slow-wave sleep and from isolated cortical slices points to the existence of neural oscillators at frequencies similar to those found in behavior. However, to our knowledge the low-frequency dynamics of brain activity during movement and sleep have not been directly compared. We therefore used chronic multi-electrode arrays to record neural activity and local field potentials (LFPs) from M1 and ventral premotor cortex (PMv) in monkeys during an isometric wrist movement task, natural sleep and ketamine sedation. We used principal component analysis to project the low-frequency LFP onto a plane, and observed cyclic trajectories in M1 that were phase-locked to each submovement. The areal velocity of trajectories increased for faster submovements, but the angular frequency remained constant at around 3 Hz (the frequency of submovements). During sleep, LFP activity traversed cycles with the same frequency and direction of rotation (albeit with larger amplitude) and under ketamine sedation these were phase-locked to K-complexes occurring at the transition from down- to up-states of the cortex. Neural activity was locked to LFP cycles within the same cortical area under all behavioral conditions, and became synchronized across areas during sleep and sedation. Since the same cortical dynamics are observed during movement and in the absence of behavior during sleep and sedation, we suggest that the motor networks controlling the upper-limb possess intrinsic, low-frequency rhythmicity. In the awake state, periodic descending drive from M1 constrains the temporal structure of tracking movements, while widespread synchronization across cortical areas generates the well-known delta rhythms associated with slow-wave sleep. This work was funded by the Welcome Trust.

Posterior parietal cortex in predictive sensorimotor control

He Cui[1], Yuhui Li[1], Yong Wang[1]

[1]Georgia Regents University

Interaction with the evolving world largely relies on accurate prediction of body and environment based on dynamic interplay between sensory inflow and motor outflow. Numerous studies have shed light on sensorimotor integration in the posterior parietal cortex (PPC), but most have emphasized purely reactive movements toward static targets, in which sensory and motor variables are seamlessly linked, making it difficult to distinguish neural activity predicting the resulting movement from that reflecting target position. To avoid this ambiguity, we recorded single-neuron activity from monkeys trained to manually intercept a circularly moving target in the absence of direct sensory cues instructing where and when the interception was to be made. The monkey initiated a trial by positioning a hand at the center of a touch screen for 600-1200 ms. A peripheral target (green circle), which appeared and moved along a circular annulus of 30° diameter for 1000 ms, had to be intercepted within this period. Once a peripheral location was touched, the target stopped, and if the angle between target and hand endpoint was less than 15°, the trial was a success and the endpoint was marked for feedback with a red circle (blue if missed). The target moved from one of eight locations spaced at 45°, at pseudo-randomly chosen angular velocity of 0 (control), 120 or 240°/s clockwise, or 120 or 240°/s counter-clockwise. Eye and hand positions were sampled with an infrared eye-tracker (ISCAN) and electromagnetic tracking system (Polhemus), respectively. After training, the monkeys were able to make fast and accurate interceptions (reaction time movement time = 422 ±68 ms; SD of touch errors = 11.7°; n = 35701). In contrast to reactive saccades directed to target location at saccade onset, the intercepting reaches were predictive: Hand trajectories intercepted targets with little online correction, suggesting formation of a forward model predicting target/hand locations at interception prior to movement initiation. To date, we have recorded 102 task-related cells in area 5d (n=63) and area 7a (n=39) from two monkeys, and characterized their directional selectivity for different target speeds. Tuning curves and preferred directions were calculated based on firing rate at reach onset (±25ms). Given the incongruent incoming sensory stimuli and outgoing motor commands for different target motion speeds, the tuning properties provided an opportunity to dissociate motor outflow from sensory inflow. Intriguingly, cells in both area 5d and area 7a exhibited invariant tuning to interceptive reaching directions ($p>0.1$), but shifted tuning to instantaneous target location ($p<0.001$). In such a flexible stimulus-response contingency, both area 7a and area 5d explicitly convey information concerned with the impending movement, regardless of the current stimuli, suggesting an intimate role in forward prediction and motor planning.

Dissociable motor learning improvements induced by punishment- and reward-based motivation

Joseph Galea[1], Elizabeth Mallia[2], John Rothwell[2], Joern Diedrichsen[2]

[1]University of Birmingham, [2]UCL

Reward and punishment are powerful factors in motivating humans to adapt behaviour through learning. Most studies have investigated their influence on cognition-based rather than motor-based learning. In fact, a fundamental theoretical gap is the relationship between reward, punishment and motor learning. As the cerebellum is essential for the processing of aversive stimuli, we predicted that monetary punishment would specifically lead to faster error-based motor learning. In contrast, as the neuromodulator dopamine is considered vital for reward-based motivation and its presence in M1 is important for motor skill retention, we predicted that monetary reward would specifically enhance retention. We present 2 human experiments that examine the influence of reward and punishment on motor adaptation; a form of motor learning which adjusts behaviour in response to novel environments. In experiment 1, participants were exposed to visuomotor transformations which alternated randomly. As the perturbation on the last trial was unpredictive of the next, adaptation is caused by an automatic mechanism. Within each block, end-point error was associated with monetary reward, punishment or null feedback. To quantify behaviour, we used a state-space model which measured how much the behaviour changes with each performance error (learning) and how much the memory is forgotten on each trial (retention). We observed a significant increase in learning with punishment ($p<0.001$). In experiment 2, a block design allowed learning to accumulate across trials; participants were exposed to a 30-degree visuomotor transformation. During adaptation, the punishment group exhibited faster learning ($p<0.04$). Following adaptation, we assessed retention (no-vision) under neutral conditions. Performance during no-vision blocks indicated greater retention for the reward group ($p<0.03$). Finally, following washout and under neutral conditions, punishment was associated with faster relearning ($p<0.02$). We propose that relearning improvements were a consequence of the punishment group experiencing increased operant reinforcement (task-success) during adaptation. In support of this, plateau length ($p=0.005$) was positively correlated with relearning across groups. In conclusion, reward- and punishment-based motivation have beneficial but dissociable effects on motor learning.

Neural control and monitoring of decision making

Jeffrey Schall[1]

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This presentation will explore how neurons embedded in distributed circuits decide among alternatives, generate actions and evaluate the consequences of those actions. The argument will be developed based on neurophysiological and electrophysiological data obtained from macaque monkeys performing visual search and stopping tasks. These data provide a foundation on which to formulate and test formal computational models that provide an account of the processes instantiated by the diversity of neurons. The evidence argues that deciding, acting and evaluating are accomplished by distinct neural circuits located in partially overlapping anatomical structures.

Session 11, Panel V

Thursday, April 24
10:45 – 13:00

Recent advances in the role of the superior colliculus in the control of covert and overt orienting.

Doug Munoz[1], Francoise Vitu[2], Tadashi Isa[3], Rich Krauzlis[4]

[1]Queen's University, [2]Aix-Marseille Université, [3]National Institute for Physiological Sciences, [4]Laboratory of Sensorimotor Research, NEI, NIH

The superior colliculus (SC) is a key midbrain structure long known to play a critical role in coordinating the orienting response, including saccadic eye movements. Phylogenetically, the SC is an old structure that was present long before modern cerebral cortex evolved. The superficial SC layers are interconnected with other early visual areas in the brain and the intermediate SC layers also receive inputs from cerebral cortex and basal ganglia. Recent work has also revealed a strong role for the SC in covert orienting of attention from top-down and bottom-up sources. This panel will recent new data showing how the SC has the appropriate organization and signals to control covert and overt orienting. KRAUZLIS will show how the SC is part of the network of brain areas that control spatial attention, and recent findings have refined our understanding of its functional role. The neuronal circuits that link the SC to spatial attention may include attention-related areas of cerebral cortex, but recent findings show that the SC operates through mechanisms independent of the well-known signatures of spatial attention in visual cortex. MUNOZ will show that neurons in the superficial layers of the SC are feature agnostic and form a map of visual saliency, signalling the location of specific salient stimuli that are important for orienting. Analysis of SC activity in the intermediate layers signal priority (saliency relevancy) for the next eye movement. VITU uses models of SC in monkeys to predict where humans move their eyes. We will show, using Ottes et al.'s (1986) logarithmic mapping function of the SC in monkeys, that population averaging in the distorted map of the SC accounts for where humans move their eyes in a variety of visual displays. Finally, ISA will describe lateral interactions in the spatial maps of the SC that were studied by using the "horizontal slices" of the mouse superior colliculus, which revealed that the visual (superficial) layer and motor (intermediate) layer operate as very different processing machinery. The experimental results of in-vivo analysis using 2-photon laser scanning microscope will also be presented.

Session 13, Panel VI

Friday, April 25

08:00 – 10:15

The expanding role of the brainstem in movement: a perspective from mouse to human

Claire Honeycutt[1], Rob Brownstone[2], Tatiana Deliagina[3], Stuart Baker[4], Eric Perreault[5]

[1]Northwestern University, [2]Dalhousie University, [3]Karolinska Institutet, [4]Newcastle University, [5]Rehabilitation Institute of Chicago/ Northwestern University

The brainstem's role in voluntary movement control remains poorly understood. Much of what we know about brainstem control of movement comes from studies which concluded that the brainstem tracts and corticospinal tracts exist within a proximal-distal gradient that defines their influence. Recent work has expanded and challenged this strict framework. Our panel objective is to highlight work pushing forward our understanding of how the brainstem contributes to movement control. We have chosen researchers working in the mouse, lamprey, cat, primate, and human models to allow comparison and introspection on the important similarities across species. Dr. Brownstone will speak about application of mouse genetic techniques to study reticulospinal (RS) systems involved in movement. He will focus on the nucleus reticularis gigantocellularis. Genetically identified RS neurons in this region in mouse receive inputs from the mesencephalic locomotor region (MLR) and are activated in locomotion, thus implicating them as mediating a descending command for locomotion. Dr. Deliagina will discuss supraspinal control of locomotion across movement directions. She recorded RS neuron activity in the lamprey during forward and backward swimming. She found different populations of RS neurons control different aspects of forward and backward locomotion. In decerebrate cats, she studied adaptation of stepping movements during treadmill motion when locomotion was evoked by stimulation of the 1) MLR and 2) spinal cord. MLR stimulation activated neuronal mechanisms only during forward stepping; thus MLR represents the center for forward locomotion. Dr. Baker will highlight his work revealing that the primate RS tract is not just associated with gross movements (locomotion and postural control) but also fine movements of the hand. Though subservient to corticospinal control in health, RS pathways may become important following lesion, such as stroke or spinal cord injury. Following lesion of the pyramidal tract in monkey, he demonstrated strengthening of RS outputs. Strengthening was seen selectively for flexor and intrinsic hand motoneurons; connections to extensor motoneurons remain unchanged. This may underlie the selective nature of recovery in patients, which often leads to overactive flexors, but residual extensor weakness. Dr. Perreault will discuss his work with Dr. Honeycutt utilizing the startle reflex as a probe of brainstem function in human. The startle reflex, mediated via the RS system, involuntarily elicits planned movements. The have evaluated this reflex in both the proximal and distal arm indicating that the RS system contributes to the movement in the distal limb. They have expanded their work to evaluate how the startle reflex (and by extension the brainstem) contributes to the ability to resist external disturbances (perturbations of the arm) and how impairments to the startle reflex from a stroke result in a diminished capacity to perform such tasks.

Session 14, Individual Presentations IV

Friday, April 25

10:45 – 13:00

Modulation of Motoneuron Firing by Recurrent Inhibition in Adult Rat in vivo

Timothy Cope[1], Ahmed Obeidat[1], Randall Powers[2], Paul Nardelli[1]

[1]Wright State University, [2]University of Washington

Recent reports emphasize the role of synaptic inhibition in sculpting the temporal pattern of firing by postsynaptic neurons, e.g. synchronized inhibitory input from cerebellar Purkinje cells is shown to affect instantaneous but not average firing rate of nuclear neurons (Person and Raman, Nature 2012). This concept motivated us to return to unsettled questions about the role of recurrent inhibition (RI) in modulating the firing of spinal motoneurons. In in vivo electrophysiological studies of anesthetized adult rats, we isolated the effects of RI (produced by antidromic electrical stimulation of peripheral nerves in rats with severed dorsal roots) on repetitive firing induced by intracellular current injection into lumbosacral motoneurons. The results provide the first definitive demonstration in living animals that RI can dramatically influence the temporal pattern and/or instantaneous rate of motoneuron firing without altering average rate. RI and its underlying recurrent inhibitory postsynaptic potentials (RIPSPs), when large (>2mV) increased the lag time in occurrence of the next spike (i.e. decreased instantaneous rate of motoneuron firing), but then increased the instantaneous firing rate of the succeeding spike, described as rebound firing. These instantaneous changes were observed both in spike time (post-stimulus time histograms, PSTHs) and in spike rate (peri-stimulus time frequency grams, PSFs). These changes in the inter-spike interval containing an RIPSP and the following interval were offsetting, to yield little to no net change in average firing rate. Small RIPSPs also produced significant effects on spike timing (PSTH), but in some cases had no clear effect on instantaneous firing rate (PSF). These findings demonstrate the capacity of RI to phase-lock motoneuron firing without reducing average firing rate. In this way, RI may aid in producing rapid movements by sustaining coordinated firing among large numbers of motoneurons, without suppressing activity of any motor unit types. This work was supported by NIH, NINDS PO1NS057228.

Parsing out brain-spinal cord contributions to human motor learning using fMRI

Shahabeddin Vahdat[1], Ovidiu Lungu[1], Julien Cohen-Adad[2], Véronique Marchand-pauvert[3], Habib Benali[4], Julien Doyon[1]

[1]University of Montreal, [2]École Polytechnique de Montréal, [3]UPMC/Inserm, [4]Faculté de Médecine Pierre et Marie Curie

Our current understanding of neural substrates mediating motor learning is incomplete, as long as the spinal cord contribution to this process is unaccounted for. Animal research has documented the existence of long-term plasticity in the spinal cord following primitive forms of learning, but whether local plasticity occurs in the human spinal cord during motor skill acquisition is still an open question. Indeed, evidence for intrinsic spinal cord plasticity during human motor learning is based on electrophysiological recordings (reflex activities and TMS) which did not allow distinguishing between the intrinsic spinal plasticity and that due to the changes in descending inflow caused by cerebral plasticity. Here, we provide direct evidence for local spinal plasticity over the course of motor learning in humans, by accounting for supraspinal contributions when linking spinal cord activity to learning-related changes in behavior. For the first time, we used a slice prescription approach to acquire functional scans of the human brain and cervical cord during performance of a motor task. Twenty five healthy adult subjects were scanned while they performed a finger sequence acquisition task (complex condition) and a matched control task (simple condition). We show that compared to the simple motor condition, learning a complex sequence produces greater (both in amplitude and spatial extent) blood oxygenated level dependent (BOLD) activity, which is mainly located on the ipsilateral side at the C6-C8 levels of the cervical cord. Moreover, the amount of improvement in performance during the complex sequence is correlated with activity changes within the same spinal cord region. Using a partial correlation technique to account for the supraspinal contribution to the cervical BOLD signal, we demonstrate that modulation in spinal activity over the course of learning is independent of concomitant signals originating from brain regions that can influence spinal cord excitability (i.e., M1, premotor cortex, SMA, anterior cingulate, thalamus, S1, and cerebellum) or that show sequence learning-dependent modulation (i.e., M1, dorsal premotor, S1, putamen, and cerebellum). Furthermore, an analysis of variance using hierarchical regression models revealed that activity in the spinal cord and brain account for non-overlapping portions of variability (i.e., 80% of the total variance) in performance during motor sequence learning, hence suggesting that different mechanisms are responsible for the activity changes observed in these structures. Finally, a functional connectivity analysis between the spinal cord and brain showed that, as learning proceeds, the spinal cord activity becomes less correlated with that from M1, but becomes more synchronized with that of the anterior cerebellum. Altogether, our findings provide a new understanding of the neural substrates underlying motor learning by attesting local plasticity at all levels of the central nervous system.

Feedback responses can resemble trajectory control when required by the behavioural constraints of the ongoing task

Tyler Cluff[1], Stephen Scott[1]

[1]Queen's University

Trajectory control models were introduced almost 30 years ago to explain our tendency to perform smooth, straight reaching movements. The premise of these models is that the motor system uses stereotyped or 'desired' limb trajectories to control movement. This notion is challenged by flexible feedback corrections that are sensitive to the behavioural constraints of the task. Although recent theories have reinvigorated interest in these goal-directed corrections, the circumstances where feedback responses resemble trajectory control are unclear. Here we use a single-joint paradigm to investigate how changes in the task demand alter feedback responses during reaching. We then extend this paradigm to a multijoint task where subjects reached to a fixed target or tracked a moving target. We predicted that feedback responses would resemble trajectory control when required by the behavioural task constraints. Single-joint reaching task: Subjects ($n=10$) performed 50-degree elbow movements (shoulder clamped) in two conditions. In the time-constrained condition, subjects completed their reach in 600-1000 ms. The target turned green if the reach was completed on time, but otherwise turned blue (too fast) or red (too slow). The target always turned green in the time-unconstrained condition. We probed feedback responses by randomly perturbing the hand toward or away from the target. Subjects performed vigorous corrections to avoid entering the target too quickly in the time-constrained condition. These corrections produced a brief reversal in hand motion that resembled trajectory control (cf. Hogan 1984). In contrast, we observed a clear reduction in movement time in the time-unconstrained condition because subjects allowed the perturbation to carry them directly to the target ($p<0.001$). We found a corresponding reduction in triceps stretch responses in the long latency ($p<0.01$) and voluntary time periods ($p<0.01$) when movements were not time constrained. Multijoint reaching task: Subjects ($n=10$) performed 15 cm reaching movements in 600-1000 ms. Subjects completed blocks of trials in random order where they reached to a fixed target, or tracked a target that moved with a bell-shaped velocity profile between the start position and end target. Target motion was fit to each subject's unperturbed reach kinematics. We probed feedback responses by applying perturbations that produced lateral hand motion. Subjects reduced their integrated hand errors and intercepted the moving target before reach completion, but corrected directly to the goal target when the task did not require precise control of the hand trajectory ($p<0.01$). Triceps stretch responses were increased in the long latency ($p<0.05$) and voluntary ($p<0.001$) time windows when subjects tracked the moving target. Our findings suggest stereotyped movement patterns are not a default property of upper limb control, but are a flexible type of feedback control emerging from the instructed task constraints.

Octopuses use unique motor control strategies for arm coordination in crawling

Guy Levy[1], Tamar Flash[2], Binyamin Hochner[1]

[1]The Hebrew University of Jerusalem, [2]The Weizmann Institute of Science

The long flexible arms of the octopus, each with enormous number of degrees of freedom (DOFs), are extremely complicated to control and coordinate. In goal-directed movements, like the reaching and fetching, the octopus simplifies the control of arm motion by using stereotypical motor programs that reduce the number of DOFs to just few. The control is further simplified because the schemes for these movements are embedded within the neuromuscular system of the arms themselves. Here we analyze the crawling in the octopus in order to gain further understanding of how octopuses coordinate their arms. To kinematically analyze the crawling movements, video images of octopuses crawling from underneath were used to follow specific points on the octopus body (specific suckers and the mouth). Distances were measured and velocities and segment lengths were calculated. Uniquely to the octopus, crawling locomotion is not limited to a specific direction with respect to the body facing direction. The direction of crawling is bilaterally symmetric and the absolute value of crawling direction is skewely distributed around a direction of about 45° either to the left or to the right of the facing direction. Interestingly, the octopus can rotate its body during crawling independently of changing the direction of motion. Statistical analyses show that there is no linear correlation between these two types of maneuvers, suggesting of the existence of two independent mechanisms that are involved in the control of crawling: one controlling the body orientation and the other independently controlling the direction of motion. Stereotypical shortening-suckers attachment-elongating movements create the thrust that pushes the body. Arms that push together (between 1-4 arms) apply virtually equal forces resulting in a movement in the direction of the vectorial summation of the pushing arms. Body rotation is achieved by similar attachment of an arm segment to the substrate, but instead of just elongating the proximal segment, the arm first bends sideways, allowing the elongation to create the radial force necessary for rotating the body. While temporal patterns are often seen in the pushing behavior of single arms, there seems to be no stereotypical pattern involved in the recruitment of the pushing arms during crawling. Therefore the coordination in crawling appears to be centrally controlled by a mechanism that is likely to be based on ad hoc decisions rather than on a high order modulation of a central pattern generator as typical for the majority of animals. Our findings suggest that the unique morphology of the octopus has led to the emergence of unique motor-control strategies that are most suitable for its special embodiment, thus achieving adaptability, simplification, and efficiency in the control of locomotion of soft bodied animal that lacks any rigid skeletal constraints. Supported by the European Commission EP7 projects STIFF-FLOP and OCTOPUS.

Gradient-ascent and the exploration-exploitation tradeoff in multi-dimensional reinforcement learning

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[1]Harvard University

The algorithms that humans use for reinforcement learning (RL) are largely unknown. Some studies have investigated how humans solve categorical or single-dimensional reinforcement tasks, but even less is known about learning in continuous multi-dimensional task spaces that characterize most ecological reinforcement problems, where exhaustive exploration of the task space is not possible. Here we investigate human RL in a continuous 2-dimensional task, designed to carefully isolate exploration from exploitation and elucidate the strategies for human RL. Via trial-and-error, subjects searched a large circular region for an invisible randomly-placed "hotspot", in blocks of 4-11 trials. In each trial, participants sampled a location, receiving a numerical score based (linearly) on its proximity to the hotspot. Each block was assigned a random score range so that absolute distance could not be determined from the score. Blocks began at the center of the task-region, with each new trial constrained to a small region around the previous 2 locations to enforce a tradeoff between exploration and exploitation. A key feature of the experimental design is that the movement associated with the 3rd trial of each block can be decomposed into orthogonal exploitatory & exploratory dimensions, allowing an assessment of the tradeoff between them. Trial 1 (T1), being at workspace center, provides no information about hotspot direction. T2 is thus purely exploratory. In contrast, T3 introduces the opportunity to exploit the change in reward observed between T1 & T2, with information about the projection of the reward gradient along the T2 movement axis. However, the ability to exploit this information for T3 competes against the ability to acquire information about the component of the gradient on the orthogonal axis. We thus focused our initial analysis on the determinants & consequences of T3 behavior. We found that larger reward gradients between T1 & T2 consistently shifted the exploration-exploitation tradeoff in favor of the exploitation axis, but that greater T3 exploration led to improved future performance. Moreover, we compared two models that have been proposed for exploitation in human RL: Reward-weighted averaging (RWA) & gradient ascent (GA) learning. GA specifies movement in the direction of an inferred reward gradient predicting T3 to lie beyond T2 when reward increases on T2, whereas RWA averages past actions weighted by the size of their rewards, predicting that T3, being an average, will lie between T1 & T2 following both increases & decreases in reward. We found that individual subject data are strikingly consistent with the GA prediction - all 25 subjects display behavior consistent with GA but inconsistent with RWA. These results demonstrate that humans can perform GA-like RL, and provide insight into the exploration-exploitation tradeoff, showing that it positively drives future performance but is negatively regulated by recent reward.

Precise temporal encoding in a vocal motor system

Samuel Sober[1], Claire Tang[2], Kyle Srivastava[1], Diala Chehayeb[1], Ilya Nemenman[1]

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Neurophysiological studies of motor control have almost universally examined firing rates to investigate how brain activity shapes behavior. In principle, however, neurons could transmit information through the precise temporal patterning of their spike trains as well as (or instead of) through their firing rates. Although the importance of spike timing has been demonstrated in many sensory systems, to our knowledge no studies have investigated whether millisecond-scale spike timing differences in motor areas could result in differences in behavior. Using a range of experimental and computational techniques, we tested the hypothesis that significant information about motor output is represented by spike timing in the songbird vocal control system. We recorded neural activity from a motor cortex analog in songbirds and quantified the amount of information available from spike rates and spike timing about vocal motor output. To quantify the temporal scale of information transfer in vocal motor control, we adapted well-established mathematical tools that have previously been applied to sensory systems. First, we used a spike-train distance metric (a variant of the Victor-Purpura distance) to quantify the differences between pairs of spike trains produced during different renditions of individual vocal gestures ("song syllables") and a classification scheme to ask whether distance metrics based on rate or timing yielded the best prediction of syllable acoustics. Second, we used model-independent information theoretic methods to directly compute the mutual information between spike trains and acoustic features. Crucially, we used both techniques to measure information present in the neural activity at different timescales, allowing us to quantify the extent to which premotor spike timing predicts upcoming behavior. Our results indicate that neurons in the vocal motor system convey information via spike timing far more often than via spike rate and that the amount of information conveyed at the millisecond timescale is far greater than that available in spike counts. Additionally, EMG recordings from single motor units in vocal muscles show that spike timing in motor effectors, down to a few milliseconds' precision, can convey information about upcoming behavior even when none is available from a rate code. Our results therefore demonstrate that significant information about behavior can be represented by spike timing in motor circuits and suggest that timing variations can evoke significant differences in motor output.

Interacting brains: sensory mechanism of physical interactions between humans

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From infancy, our motor behaviors are conditioned to respond and adapt to verbal, visual and haptic cues from other humans. These responses manifest as cognitive responses, related to the explicit knowledge of an interacting agent, and motor responses that do not require an explicit interaction with another individual, but are driven by the sensory feedbacks characteristic of an interaction. For example, hearing a scream on the radio makes you feel scared, and tenses your muscles while looking at a happy face on television implicitly induces a smile on your face. However, while human interactions have been systematically studied over the last decades [1,2], the relative contributions of the cognitive and motor responses to these behaviors are still largely unclear. This is particularly true about physical interactions, the understanding of which has developed mainly in the last decade [2] due to the technical difficulties associated with the observation and analysis of the key determinant of physical interaction - haptic feedback. This study investigates, for the first time, the motor responses and the consequent adaptations that govern physical interactions between humans. For this purpose, we developed a novel interactive learning paradigm using a dual robot system in which pairs of individuals are physically connected during a motor task without conscious knowledge of the connection. In contrast to previous joint action studies [2-5], this paradigm enabled us to investigate the reactive motor adaptations driven by the haptic signals during physical interaction without complications from cognitive adaptations related to conscious coordination with the partner. Interestingly, we observed that physical interactions are consistently beneficial to the interacting individuals and enables them to improve their motor performance both during and after interactive practice. We show that these benefits are present only in physical interaction with an active partner and cannot be explained by multisensory integration of the visual and haptic sensory information in an individual. Furthermore, we modulate the interaction characteristics and partner behavior to show that both the quantitative partner performance and qualitative performance (or nature) affect the benefits experienced during physical interaction. Our results reveal fundamental sensory-motor mechanisms active during inter-personal physical interactions that are distinct from the cognitive interactive mechanisms studied previously as theory of mind. 1. Adolphs R (2003), Nat Neurosci Rev 4: 165-78. 2. Sebanz N, Bekkering H & Knoblich G (2006), Trends in Cog Sci 10: 70-7. 3. van der Wel RPRD, Knoblich G & Sebanz N (2011), J Exp Psychol 37: 1420-31. 4. Newman-Norlund RD, Bosga J, Meulenbroek RG & Bekkering H (2008), Neuroimage 41, 169-77. 5. Reed KB & Peshkin M (2008), IEEE Trans Haptics 1: 108-20.

Session 15, Panel VII

Friday, April 25

15:00 – 17:15

Inhibitory control of eye and hand movements

Bram Zandbelt[1], Aditya Murthy[2], Katy Thakkar[3], Chris Chambers[4]
[1]Vanderbilt University, [2]Indian Institute of Science, [3]University Medical Center Utrecht, [4]Cardiff University

The ability to suppress and adjust our actions to our rapidly changing environment is crucial in our daily life. For example, as a pedestrian in Amsterdam, it is of vital importance to be able to inhibit or change our movements abruptly, as cyclists in this city are notorious for running a red light. In the laboratory, these situations have been studied with stop-signal and double-step tasks and performance in these tasks has been understood in terms of an independent race between a GO process that initiates a movement and a STOP process that inhibits movement. Over the last two decades, studies with the motor and oculomotor versions of these tasks in monkeys and humans have begun to reveal the brain mechanisms underlying inhibitory control of eye and hand movements. This panel will update the NCM community on the latest findings and theories in the field of inhibitory control of eye and hand movements. We aim to address the following questions: How does the brain implement this race between going and stopping? How do prefrontal cortex and basal ganglia exert inhibitory control over motor and oculomotor regions? What are the underlying principles of inhibitory control of movements? After a brief introduction into the stop-signal and double-step tasks and the independent race model framework, Aditya Murthy will summarize single-unit recording and microstimulation studies from macaque frontal eye field, providing a close-up view of the neuronal dynamics associated with stopping and changing eye movements. Katy Thakkar will describe functional MRI studies of the double-step task in humans, providing a whole-brain perspective on activation and functional connectivity associated with changing eye movements. Chris Chambers will discuss transcranial magnetic stimulation work in humans, showing the causal contributions of various cortical brain regions to inhibitory control of hand movements. Bram Zandbelt will present stochastic accumulator models of the stop-signal and double-step task that go beyond the classic independent race model by giving insight into the mechanistic principles underlying movement inhibition. Finally, we will have a panel discussion on the differences and similarities between the inhibitory control of eye and hand movements, how prefrontal areas and the basal ganglia orchestrate inhibitory control over motor areas, and how computational models may have to be modified to explain both behavior and neural dynamics.

NCM Scholarship Winners 2014

New investigators and faculty are essential for the future of any field of scientific inquiry. NCM has historically encouraged conference participation by graduate students and post-doctoral fellows. The scholarship program is designed to provide partial support for them to participate in the conference and is open to student and post-doc members in good standing. Our scholarship program is funded through the support of our sponsors.

Below is a list of the 2014 NCM Scholarship Winners:

Scholarship Winner	**Affiliation**	**Mentor**
Yannick Bleyenheuft	Université catholique de Louvain	Jean-Louis Thonnard
Jerome Carriot	McGill University	Kathleen Cullen
Patrick Forbes	Delft University of Technology	Frans CT. van der Helm
Kara Hawkins	York University	Lauren E. Sergio
Uday Jagadisan	University of Pittsburgh	Neeraj Gandhi
Guy Levy	The Hebrew University of Jerusalem	Benny Hochner
Ryan Morehead	University of California, Berkeley	Rich Ivry
Tafadwza Sibini	Erasmus MC	Maarten Frens
Sheena Waters	University College London	Jorn Deidrichsen
Bram Zandbelt	Vanderbilt University	Jeffrey D. Schall

Poster Author Index | By Author Name

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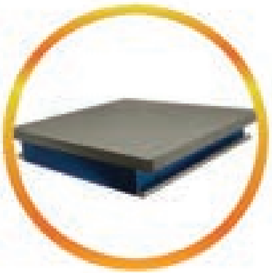
	Wednesday April 23:	08:00 – 17:15
Session 2:	Thursday April 24:	08:00 – 15:00
	Friday April 25:	08:00 – 17:15

Posters in **bold** represent first author

The poster board numbers work in the following way:
Session – Theme – Board Number (Eg. 2-A-43)

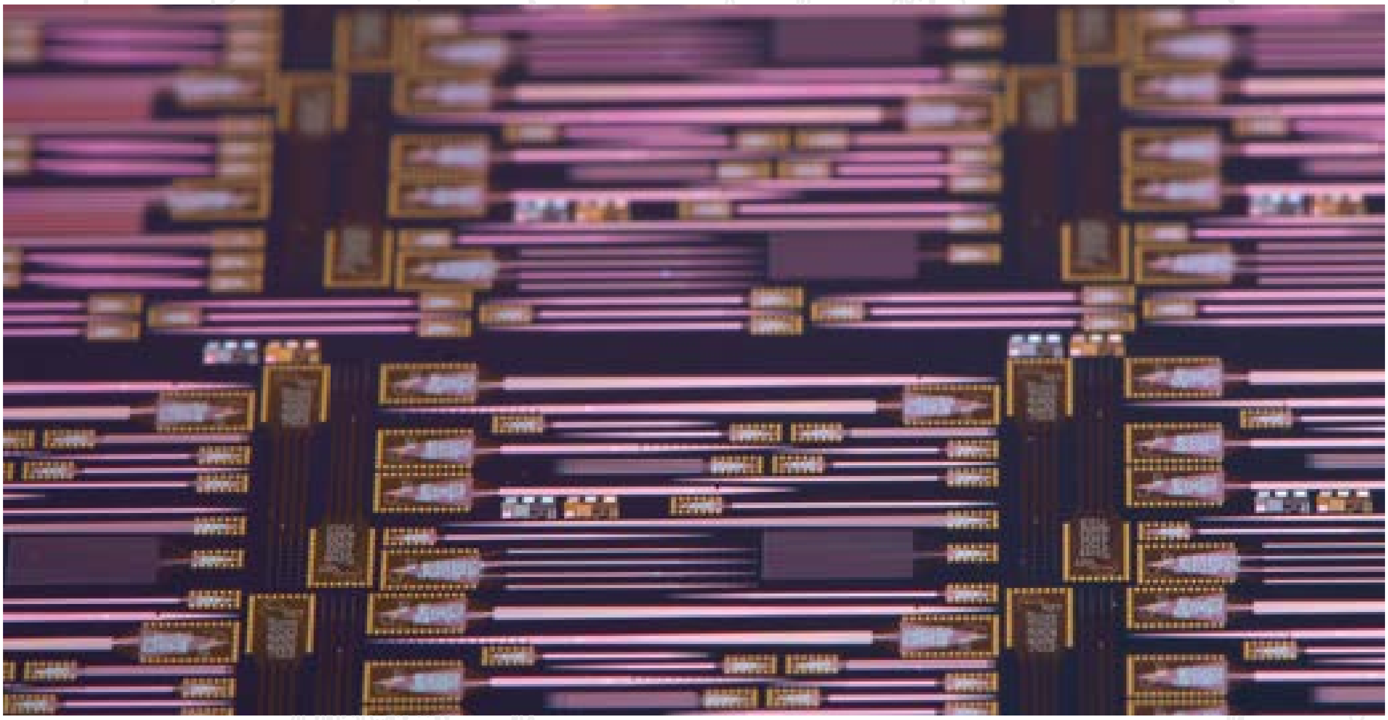
Themes

A	Adaptation & Plasticity in Motor Control
B	Disorders of Motor Control
C	Posture & Gait
D	Theoretical & Computational Motor Control
E	Fundamentals of Motor Control
F	Integrative Control of Movement
G	Control of Eye & Head Movement




Wave

Poster Author Index | By Author Name



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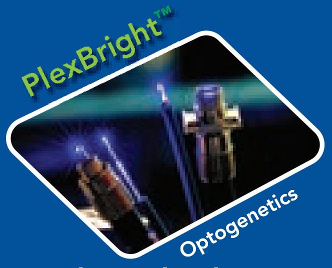
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	Friday April 25:	08:00 – 17:15

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A	Adaptation & Plasticity in Motor Control
B	Disorders of Motor Control
C	Posture & Gait
D	Theoretical & Computational Motor Control
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G	Control of Eye & Head Movement

Author	Session	Theme	Board*	Poster No.
Anderson, J	1	G	98	1-G-98
Arbuthnott, G	1	B	25	1-B-25
Arguelles, E	1	B	21	1-B-21
Arkind, N	1	D	46	1-D-46
Assländer, L	1	C	30	1-C-30
Avila, E	1	A	6	1-A-6
Bakker, R	1	F	86	1-F-86
Barrea, A	1	E	64	1-E-64
Berger, D	1	E	65	1-E-65
Bernardi, N	1	A	7	1-A-7
Bernier, P	1	E	60	1-E-60
Berniker, M	1	D	41	1-D-41
Betti, S	1	E	61	1-E-61
Bhanpuri, N	1	B	26	1-B-26
Binsted, G	1	F	87	1-F-87
Blazquez, P	1	G	99	1-G-99
Bleyenheuft, Y	1	B	27	1-B-27
Bozzacchi, C	1	A	1	1-A-1
Brand, J	1	A	8	1-A-8
Brandes, J	1	F	93	1-F-93
Brennan, A	1	A	9	1-A-9
Brenner, E	1	D	47	1-D-47
Buckingham, G	1	E	53	1-E-53
Cameron, B	1	F	88	1-F-88
Cameron, I	1	G	100	1-G-100
Carriot, J	1	F	83	1-F-83
Carter, M	1	E	62	1-E-62
Cashaback, J	1	A	10	1-A-10
Cenciarini, M	1	C	34	1-C-34
Cheng, D	1	E	63	1-E-63
Cheng, P	1	D	42	1-D-42
Chiovetto, E	1	D	48	1-D-48
Choi, J	1	D	49	1-D-49
Crevecoeur, F	1	D	43	1-D-43
Dagioglou, M	1	A	11	1-A-11
Danion, F	1	F	89	1-F-89
de Brouwer, A	1	G	101	1-G-101
de la Malla, C	1	F	90	1-F-90
Dean, L	1	E	66	1-E-66
del Carmen Herrojo Ruiz, M	1	B	24	1-B-24
Deravet, N	1	G	102	1-G-102
Dhawale, A	1	E	54	1-E-54
Dimitriou, M	1	F	91	1-F-91
Drummond, N	1	E	67	1-E-67
Dunning, A	1	E	68	1-E-68
Dura-Bernal, S	1	A	12	1-A-12
Ebert, J	1	E	55	1-E-55
Ejaz, N	1	E	69	1-E-69
Elaine Little, C	1	C	36	1-C-36
Fenske, S	1	F	92	1-F-92
Fiehler, K	1	G	103	1-G-103
Fischer, P	1	B	22	1-B-22
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Franklin, S	1	E	72	1-E-72
Genna, C	1	E	73	1-E-73
Giszter, S	1	E	56	1-E-56
Glasauer, S	1	G	105	1-G-105
Grent-'t-Jong, T	1	E	82	1-E-82
Greve, C	1	E	57	1-E-57
Gu, C	1	E	74	1-E-74
Haar, S	1	A	13	1-A-13
Hadjiosif, A	1	D	44	1-D-44
Hao, Y	1	E	75	1-E-75
Harris, H	1	E	76	1-E-76
Hawkins, K	1	B	28	1-B-28
Hegele, M	1	A	2	1-A-2
Henriques, D	1	A	3	1-A-3
Hilt, P	1	D	51	1-D-51
Holmes, N	1	E	77	1-E-77
Howard, I	1	E	78	1-E-78
Ingram, J	1	D	52	1-D-52
Ischebeck, B	1	A	14	1-A-14
Jaspers, E	1	E	79	1-E-79
Jenkinson, N	1	A	15	1-A-15
Johansson, A	1	F	94	1-F-94
Kadmon Harpaz, N	1	E	80	1-E-80
Kasuga, S	1	A	16	1-A-16
Kennefick, M	1	E	58	1-E-58
Keyser, J	1	B	23	1-B-23
Kikkert, S	1	A	4	1-A-4
Kistemaker, D	1	E	59	1-E-59
Kohl, R	1	E	81	1-E-81
Kuling, I	1	F	95	1-F-95
Lefumat, H	1	A	17	1-A-17
Liedtke, A	1	C	31	1-C-31
Lin, C	1	C	35	1-C-35
Liyanagamage, S	1	F	96	1-F-96
Lubeck, A	1	C	37	1-C-37
Lunardini, F	1	F	97	1-F-97
Maas, H	1	F	85	1-F-85
MacLellan, M	1	C	38	1-C-38
Maeda, R	1	C	32	1-C-32
Marigold, D	1	C	39	1-C-39
Miall, C	1	A	19	1-A-19
Mirbagheri, M	1	C	40	1-C-40
Morehead, R	1	A	5	1-A-5
Narain, D	1	D	45	1-D-45
Nesher, N	1	F	84	1-F-84
Panouilleres, M	1	A	20	1-A-20
Pope, P	1	G	106	1-G-106
Santos-Pontelli, T	1	C	33	1-C-33
Smorenburg, A	1	B	29	1-B-29
Torrecillos, F	1	A	18	1-A-18

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Author	Session	Theme	Board*	Poster No.
Cheng-Hsin Yang, S	2	E	78	2-E-78
de Boer, C	2	B	25	2-B-25
Diedrichsen, J	2	F	80	2-F-80
Guitton, D	2	G	99	2-G-99
Huddleston, W	2	G	100	2-G-100
Jamieson, E	2	D	43	2-D-43
Jantz, J	2	G	101	2-G-101
Joon Sohn, W	2	B	21	2-B-21
Karklinsky, M	2	D	44	2-D-44
King, M	2	G	97	2-G-97
Koca, E	2	F	93	2-F-93
Koene, A	2	D	45	2-D-45
Kohen, D	2	E	71	2-E-71
Kohl, R	2	E	64	2-E-64
Kolasinski, J	2	E	65	2-E-65
Kornysheva, K	2	E	66	2-E-66
Kuenster, D	2	B	26	2-B-26
Lamperski, A	2	D	46	2-D-46
Lawrence, E	2	E	52	2-E-52
Lebon, F	2	E	53	2-E-53
Maij, F	2	F	81	2-F-81
Mania, P	2	E	67	2-E-67
Manning, F	2	F	82	2-F-82
Matzen, J	2	E	54	2-E-54
Meirovitch, Y	2	D	47	2-D-47
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Nguyen, C	2	F	83	2-F-83
Nonnekes, J	2	C	31	2-C-31
Oh, Y	2	D	48	2-D-48
Omrani, M	2	E	56	2-E-56
Onneweer, B	2	E	57	2-E-57
Oostwoud Wijdenes, L	2	E	68	2-E-68
O'Shea, D	2	E	58	2-E-58
Pani, P	2	F	84	2-F-84
Papaxanthis, C	2	A	3	2-A-3
Papegaaij, S	2	C	34	2-C-34
Park, H	2	A	7	2-A-7
Parr, A	2	F	85	2-F-85
Patricia, L	2	B	20	2-B-20
Pel, J	2	B	27	2-B-27
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Plaisier, M	2	F	86	2-F-86
Potocanac, Z	2	C	32	2-C-32
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Reimann, H	2	C	35	2-C-35
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Sarwary, A	2	A	4	2-A-4
Sawers, A	2	E	59	2-E-59
Schettion, L	2	F	79	2-F-79
Selen, L	2	A	8	2-A-8
Shaharudin, S	2	A	9	2-A-9
Sharma, N	2	E	70	2-E-70
Sibindi, T	2	G	98	2-G-98
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van Beers, R	2	A	12	2-A-12
van der Graaff, M	2	E	74	2-E-74
van der Smagt , P	2	E	75	2-E-75
van Dieen, J	2	C	38	2-C-38
van Eupen, R	2	E	76	2-E-76
Van Hoan, V	2	D	50	2-D-50
Vandermeeren, Y	2	B	22	2-B-22
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Yokoi, A	2	F	94	2-F-94
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Yousif, N	2	A	18	2-A-18
Zaaimi, B	2	A	19	2-A-19
Zatka-Haas, P	2	F	95	2-F-95
Zelik, K	2	C	40	2-C-40
Zhang, L	2	F	96	2-F-96


MOBITA

Poster Session 1 | Authors, Titles and Affiliations

Session 1

Tuesday April 22 and Wednesday April 23.
Posters are listed by theme.

A - Adaptation & Plasticity in Motor Control

1-A-1 On grasping action in absence of feedback

Chiara Bozzacchi[1], Robert Volcic[1], Fulvio Domini[1]
[1]Istituto Italiano Tecnologia

1-A-2 Dissociating explicit and implicit components of dual adaptation: On the concurrent development of multiple internal models

Mathias Hegele[1], Herbert Heuer[2]

[1]University of Giessen, [2]IfADo - Leibniz Research Center for Working Environment and Human Factors

1-A-3 The effect of training with altered visual feedback of the hand on movement and perception.

Denise Henriques[1]
[1]York University

1-A-4 Phantom pain associates with motor control of the missing hand

Sanne Kikkert[1], Melvin Mezue[1], Luke Parker[1], David Henderson-Slater[2], Irene Tracey[1], Heidi Johansen-Berg[1], Tamar Makin[1]

[1]FMRIB Centre, Oxford University, [2]Nuffield Orthopaedic Centre

1-A-5 Illusory differences in movement variability and learning rates as a function of movement amplitude

Ryan Morehead[1], Richard Ivry[1]
[1]University of California, Berkeley

1-A-6 Cerebellar transcranial direct current stimulation influence inward but not outward saccadic adaptation

Eric Avila[1], Josef van der Geest [1], L. Sandra Kengne Kamga Mobou[1], M. Claire Verhage[1], Opher Donchin[2], Maarten Frens[1]
[1]Erasmus MC, [2]Ben Gurion University of the Negev

1-A-7 The contribution of somatosensory perceptual learning to human motor skill acquisition

Nicolò Bernardi[1], Mohammad Darainy[1], David Ostry[1]
[1]McGill University

1-A-8 Neural correlates of error correction and adaptation during visual feedback scaling of finger movements

Johannes Brand[1], Romy Bakker[2], Daniel Kiper[1], Marie-Claude Hepp-Reymond[1], Manfred Morari[3], Lars Michels[4], Kynan Eng[1]

[1]University of Zurich and ETH Zurich, [2]Radboud University Nijmegen, [3]ETH Zurich [4]University Hospital Zurich

1-A-9 Direct control of motor error to understand how errors and rewards drive trial-to-trial learning

Andrew Brennan[1], Maurice Smith[1]
[1]Harvard University

1-A-10 The nervous system shifts the influence of its objectives during a fatiguing task

Joshua Cashaback[1], Tyler Cluff[2]

[1]Western University, [2]Queen's University

1-A-11 Anodal M1 stimulation effects on action acquisition

Maria Dagioglou[1], Samuel Westwood[1], Alexandra Doherty[1], Chris Miall[1]

[1]University of Birmingham

1-A-12 Evaluating Hebbian reinforcement learning BMI using an in silico brain model and a virtual musculoskeletal arm

Salvador Dura-Bernal[1], Noeline Prins[2], Samuel Neymotin[1], Abhishek Prasad[2], Justin Sanchez[2], Joseph Francis[1], William Lytton[1]

[1]SUNY Downstate, [2]University of Miami

1-A-13 Directional tuning in human motor cortex following visuomotor adaptation

Shlomi Haar[1], Opher Donchin[1], Ilan Dinstein[1]

[1]Ben Gurion University

1-A-14 Influence of movement behavior of the cervical spine on eye stabilization reflexes

Britta Ischebeck[1], Jurryt de Vries[1], Maarten Frens[1], Jan Paul van Wingerden[2], Gert Jan Kleinrensink[1], Jos van der Geest[1]

[1]Erasmus MC, [2]Spine & Joint Centre

1-A-15 The interfering effect of washout trials on visuomotor adaptation

Ned Jenkinson[1], John-Stuart Brittain[1], Chirs Miall[2], Muriel Panouilleres[1]

[1]University of Oxford, [2]University of Birmingham

1-A-16 Interaction between adaptation of feedback and feedforward control under the mirror-reversal transformation

Shoko Kasuga[1], Sebastian Telgen[2], Jörn Diedrichsen[2], Junichi Ushiba[1], Daichi Nozaki[3]

[1]Keio University, [2]University College London, [3]The University of Tokyo

1-A-17 Kinematic characteristics and laterality quotient predict interlimb transfer of sensorimotor adaptation

Hannah Lefumat[1], Jean-Louis Vercher[1], Chris Miall[2], Jonathan Cole[3], Lionel Bringoux[1], Franck Buloup[1], Christophe Bourdin[1], Fabrice Sarlegna[1]

[1]UMR 7287 CNRS & Aix-Marseille Université, Faculté des Sciences du Sport, CP 910, 163 av. de Luminy,, [2]Behavioural & Brain Sciences Centre, School of Psychology, University of Birmingham, Birmingham B155, [3]Clinical Neurophysiology, Poole Hospital, Poole

1-A-18 EEG correlates of kinematic-error processing: Exploration of fronto-median and sensorimotor oscillatory activities

Flavie Torrecillos[1], Nicole Malfait[1]

[1]Institut de Neurosciences de la Timone / CNRS

1-A-19 Force field adaption in deafferented participants

Chris Miall[1], Se-Ho Nam[1], Fabrice Sarlegna[2], Jean-Louis Vercher[2], Jonathan Cole[3]

[1]University of Birmingham, [2]CNRS & Aix-Marseille University, [3]Poole Hospital

1-A-20 Transcranial direct current stimulation of the dorsal cerebellum affects saccadic adaptation

Muriel Panouilleres[1], Chris Miall[2], Ned Jenkinson[1]

[1]University of Oxford, [2]University of Birmingham

B – Disorders of Motor Control

1-B-21 Effects of different perturbation durations on the long-latency stretch response in childhood dystonia.

Enrique Arguelles[1], Nasir Bhanpuri[1], Matteo Bertucco[1], Terence Sanger[1]

[1]University of Southern California

1-B-22 Deep brain stimulation in Parkinson's Disease patients modulates visual attention and explorative behaviour during free-viewing

Petra Fischer[1], Johannes Keyser[1], Alessandro Gulberti[2], José Ossandón[1], Christian Moll[2], Peter König[1], Andreas Engel[2]

[1]University of Osnabrück, [2]University Medical Center Hamburg-Eppendorf

1-B-23 The influence of deep brain stimulation on eye movements in Parkinson's Disease: Modulation of visual attention by DBS during visual search

Johannes Keyser[1], Petra Fischer[1], Alessandro Gulberti[2], José Ossandón[1], Christian Moll[2], Andreas Engel[2], Peter König[1]

[1]University of Osnabrück, [2]University Medical Center Hamburg-Eppendorf

1-B-24 Encoding of sequence boundaries in the subthalamic nucleus of patients with Parkinson's disease.

Maria del Carmen Herrojo Ruiz[1], Marco Rusconi[1], Christof Brücke[1], John Dylan Haynes[1], Thomas Schönecker[1], Andrea Kühn[1]

[1]Charité - University of Medicine

1-B-25 Time for a different model of the Basal Ganglia?

Gordon Arbuthnott[1], Marianela Garcia Munoz[1]

[1]Okinawa Institute for Science and Technology

1-B-26 Cortical responses to deep brain stimulation in childhood dystonia reveal abnormal oscillations and stimulation induced plasticity

*Nasir Bhanpur*i[1], Matteo Bertucco[1], Jeffrey Nishida[1], Diana Ferman[2], Terence Sanger[2]

[1]University of Southern California, [2]University of Southern California and Children's Hospital of Los Angeles

1-B-27 Measuring changes of Manual Ability with ABILHAND-Kids during intensive training for children with cerebral palsy: a responsiveness study

Yannick Bleyenheuft[1], Andrew Gordon[2], Rameckers Eugène[3], Jean-Louis Thonnard[1], Carlyne Arnould[4]

[1]Université catholique de Louvain, [2]Columbia University, [3]Maastricht University / Adelante, [4]Haute Ecole Louvain en Hainaut

1-B-28 Neural correlates of changes in visuomotor control associated with normal aging and increased Alzheimer's disease risk

Kara Hawkins[1], Lauren Sergio[1]

[1]York University

1-B-29 The influence of corticospinal system connectivity on the efficacy of bimanual therapy in children with unilateral cerebral palsy.

Ana Smorenburg[1], Hsing-Ching Kuo[2], Claudio Ferre[2], Marina Brandao[3], Jason Carmel[1], Andrew Gordon[2], Kathleen Friel[1]

[1]Burke-Cornell Medical Research Institute, [2]Teachers College, Columbia University, [3]Faculdade de Ciências Médicas de Minas Gerais

C – Posture & Gait

1-C-30 Effects of visual position and velocity cues on the amplitude characteristics of human postural responses to support surface tilt

Lorenz Assländer[1], Georg Hettich[1], Albert Gollhofer[1], Thomas Mergner[1]

[1]Albert-Ludwigs Universität Freiburg

1-C-31 When's a walk not a walk, but still looks like a walk?

Anna Liedtke[1], Simon Wilshin[1], Sarah Moore[1], Thomas Witte[1], Andrew Spence[2]

[1]The Royal Veterinary College, [2]College of Engineering, Temple University

1-C-32 Visuomotor adaptation during precision walking: a case of the ultimate consolidation?

Rodrigo Maeda[1], Daniel Marigold[1]

[1]Simon Fraser University

1-C-33 Assessment of postural control with the 3D electromagnetic system: concurrent validity with force platform posturography

Taiza Santos-Pontelli[1], Nathalia Silva[1], Jussara Baggio[1], Laura Machado[1], Jose Carneiro[1], Tenysson Lemos[2], Antonio Carneiro[2], Renato Moraes[3], Octavio Pontes-Neto[1], João Leite[1]

[1]Ribeirao Preto Medical School-University of Sao Paulo, [2]School of Philosophy, Sciences and Letters-University of Sao Paulo, [3]School of Physical Education and Sport at Ribeirão Preto - University of São Paulo

1-C-34 Investigation of multi-segment coordination in healthy and disease individuals based on a multilink model of human postural control

Massimo Cenciarini[1], Christoph Maurer[1]

[1]Albert-Ludwigs-Universität Freiburg

1-C-35 Falls in the ageing motor system: Sensorimotor uncertainty & control

Chin-Hsuan Lin[1], A. Aldo Faisal[1]

[1]Imperial College London

1-C-36 EEG measures reveal dual-task interference in postural performance in young adults

Carrie Elaine Little[1], Marjorie Woollacott[1]

[1]University of Oregon

1-C-37 The influence of 2D depth cues on roll-vection and postural sway

Astrid Lubeck[1], Jelte Bos[1], John Stins[1]

[1]VU University Amsterdam

1-C-38 Muscle activation patterns are bilaterally linked during split-belt treadmill walking in humans

Michael MacLellan[1], Yuri Ivanenko[2], Firas Massaad[3], Sjoerd Bruijn[3], Jacques Duysens[3], Francesco Lacquaniti[2]

[1]Louisiana State University, [2]IRCCS Santa Lucia Foundation, [3]Katholieke Universiteit Leuven

1-C-39 Modulation of cutaneous reflexes in a precision walking task under simulated visual impairment

Daniel Marigold[1], Andreas Miller[1], Kim Lajoie[1]

[1]Simon Fraser University

1-C-40 Therapeutic effects of pharmacological-robotic training on functional impairment in spinal cord injury: Identification of recovery patterns

Mehdi Mirbagheri[1], Xun Niu[1], Matthew Kindig[1], Lynsey Duffell[1]

[1]Northwestern University/Rehabilitation Institute of Chicago

D – Theoretical & Computational Motor Control

1-D-41 A new perspective on the internal representation of motor behaviors

Max Berniker[1], Konrad Kording[1]

[1]Northwestern University/Rehabilitation Institute of Chicago

1-D-42 Synergy and adaptation by sparse coding of muscle length

Pengxiang Cheng[1], Dana Ballard[1]

[1]The University of Texas at Austin

1-D-43 Effect of multiple delays on multisensory integration following perturbations: does the brain wait for vision?

Frederic Crevecoeur[1], Douglas Munoz[1], Stephen Scott[1]

[1]Queen's University

1-D-44 Visual feedback latency reduces the retention of visuomotor learning and alters its internal representation

Alkis Hadjiosif[1], Katherine Mallett[1], Maurice Smith[1]

[1]Harvard University

1-D-45 The possible origins of the overestimation of serial correlation

Devika Narain[1], Robert van Beers[2], Jeroen Smeets[2]

[1]Max Planck Institute for Intelligent Systems, [2]MOVE Research Institute, Amsterdam

1-D-46 Does the CNS choose integrable solutions to the inverse kinematics problem?

Noam Arkind[1], Tamar Flash[1]

[1]Weizmann

1-D-47 How can people intercept targets so precisely? The critical role of adjusting position rather than time.

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

[1]VU University Amsterdam

1-D-48 Model selection for the extraction of EMG synergies

Enrico Chiovetto[1], Dominik Endres[1], Andrea d'Avella[2], Martin Giese[1]

[1]University of Tuebingen, [2]Santa Lucia Foundation

1-D-49 Nonlinear model predictive control for the design of optimal microstimulation patterns for somatosensory neural prostheses

John Choi[1], Austin Brockmeier[2], Lee von Kraus[1], Arthi Srinivasan[3], Matthew Emigh[2], Jose Principe[2], Joseph Francis[1]

[1]SUNY Downstate Medical Center, NYU Polytechnic, [2]University of Florida, [3]SUNY Downstate Medical Center

1-D-50 Multiple site spatial and temporal dynamics of TMS cortical recovery are investigated through EEG analysis.

Krista Fjeld[1], Darian Cheng[1], Robert Hermosillo[1], Francisco Colino[1], Gordon Binsted[1]

[1]University of British Columbia

1-D-51 Coordination between posture and movement as a motor decision process: an optimal control approach

Pauline Hilt[1], Bastien Berret[2], Thierry Pozzo[3]

[1]Inserm U1093, University of Burgundy , [2]CIAMS laboratory, Université Paris-Sud 11, [3]Inserm U1093, University of Burgundy

1-D-52 Two interacting processes underlie the selection of sensorimotor modules during object manipulation

James Ingram[1], J Randall Flanagan[1], Daniel Wolpert[1]

[1]University of Cambridge

E – Fundamentals of Motor Control

1-E-53 Bimanual object lifting: fingertip force scaling and weight perception in the size-weight illusion experienced with both hands simultaneously

Gavin Buckingham[1], Panagiotis Dimitriou[1]

[1]Heriot-Watt University

1-E-54 The role of the basal ganglia in the execution of motor cortex-independent action sequences

Ashesh Dhawale[1], Raymond Ko[1], Bence Ölveczky[1]

[1]Harvard University

1-E-55 Learning and Exploration in a Novel Dimensionality-Reduction Task

Julia Ebert[1], Sungshin Kim[2], Nicolas Schweighofer[2], Dagmar Sternad[1], Stefan Schaal[3]

[1]Northeastern University, [2]University of Southern California, [3]Max-Planck-Institute for Intelligent Systems

1-E-56 Relating spinal activity dynamics to primitives and behaviors - STA, neural events and jPCA

Simon Giszter[1], David Wallace[2], Arun Ramakrishnan[1]

[1]Drexel University College of Medicine, [2]Drexel University

1-E-57 Exploration of joint space: Effects of physical and dexterity demand on flexibility in motor coordination patterns

Christian Greve[1], Tibor Hortobàgyi[1], Raoul Bongers[1]

[1]Center for Human Movement Science Groningen

1-E-58 Corticospinal excitability as a function of response complexity in simple reaction time tasks

Michael Kennefick[1], Dana Maslovat[2], Romeo Chua[2], Anthony Carlsen[1]

[1]University of Ottawa, [2]University of British Columbia

1-E-59 The cost of moving optimally: kinematic path selection

Dinant Kistemaker[1], Jeremy Wong[1], Paul Gribble[1]

[1]University of Western Ontario

1-E-60 Rapid premotor cortex recruitment for online corrections during reaching

Pierre-Michel Bernier[1], Danny Gaudreau[1], François Thénault[1], Marie-Ève Gagné[1], Kevin Whittingstall[1]

[1]University of Sherbrooke

1-E-61 Kick with the finger: Symbolic actions shape motor cortex excitability

Sonia Betti[1], Umberto Castiello[1], Luisa Sartori[1]

[1]University of Padova

1-E-62 Intentional phase transitions in bimanual coordination following tDCS

Michael Carter[1], Bethany Cseke[1], Neil Drummond[1], Anthony Carlsen[1]

[1]University of Ottawa

1-E-63 Variations in brain activity as a function of task difficulty in visually guided vs. memory guided reaches

Darian Cheng[1], Krista Fjeld[1], Bobby Hermosillo[1], Paul Van Donkelarr[1], Gordon Binsted[1]

[1]University of British Columbia

1-E-64 A simple and reliable method to measure the fingertip coefficient of friction at different levels of grip force

Allan Barrea[1], David Córdova Bulens[1], Philippe Lefèvre[1], Jean-Louis Thonnard[1]

[1]Université catholique de Louvain

1-E-65 Muscle synergies are useful for effective force control

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

[1]Fondazione Santa Lucia

1-E-66 Divergent projections to fore- and hindlimb from the primate reticular formation

Lauren Dean[1], George Omondi[2], Ngalla Jillani[2], Stuart Baker[1]

[1]Newcastle University, [2]Institute of Primate Research

1-E-67 Startle reveals motor preparatory state associated with differential attentional demands

Neil Drummond[1], Isabelle Scantland-Lebel[1], Michael Carter[1], Dana Maslovat[2], Anthony Carlsen[1]

[1]University of Ottawa, [2]University of British Columbia

1-E-68 The tuning of perturbation response to uncertainty and risk in a dynamic environment task

Amber Dunning[1], Matteo Bertucco[1], Terry Sanger[1]

[1]University of Southern California

1-E-69 Neural synergies shape finger representations in the primary motor cortex

Naveed Ejaz[1], Jorn Diedrichsen[1], Alexandra Reichenbach[1]

[1]University College London

1-E-70 Intracellular recording from neurons in the macaque reticular formation

*Karen Fishe*r[1], Boubker Zaaimi[1], Steve Edgley[2], Stuart Baker[1]

[1]Newcastle University, [2]Cambridge University

1-E-71 The influence of varying target width on voluntary reaction time and modulation of the long-latency reflex

Christopher Forgaard[1], Annie Maurer[1], Dana Maslovat[1], Parveen Bawa[2], Romeo Chua[1], Ian Franks[1]

[1]University of British Columbia, [2]Simon Fraser University

1-E-72 Model uncertainty and error expectation affects visuomotor feedback gains

Sae Franklin[1], David Franklin[1]

[1]University of Cambridge

1-E-73 Evaluation of the reliability of muscle synergy estimation by means of factorization analysis using an advanced motor neuron model

Clara Genna[1], Francesco Negro[2], Strahinja Dosen[2], Jakob Dideriksen[2], Bernhard Graimann[1], Dario Farina[2]

[1]Otto Bock HealthCare GmbH, [2]Department of Neurorehabilitation Engineering, Bernstein Focus Neurotechnology Göttingen, Bernstein

1-E-74 Visual responses on human upper limb muscles can be independent of the ensuing reach movement

Chao Gu[1], Daniel Wood[2], Paul Gribble[1], Timothy Doherty[1], Melvyn Goodale[1], Brian Corneil[1]

[1]Western University, [2]Northwestern University

1-E-75 Mapping horizontal cortical connections in primate motor cortex

Yaoyao Hao[1], Alexa Riehle[1], Thomas Brochier[1]

[1]Institut de Neurosciences de la Timone, CNRS-AMU

1-E-76 Event-related desynchronization during motion observation reflects kinematic regularities

Hila Harris[1], Yaron Meirovitch[2], Eran Dayan[3], Amos Arieli[1], Tamar Flash[2]

[1]Department of Neurobiology/Brain Research, Weizmann Institute of Science, [2]Department of Computer Science and Applied Mathematics, Weizmann Institute of Science, [3]Human Cortical Physiology and Stroke Neurorehabilitation Section, National Institute of Neurological Disorders and Stroke

1-E-77 On-line control of reaching, pointing, and grasping to auditory and visual targets: Motion analysis and corticospinal excitability

Nicholas Holmes[1], Rachael Sperring[1]

[1]University of Reading

1-E-78 The value of the follow through: Future movements influence dynamic learning

Ian Howard[1], Daniel Wolpert[2], David Franklin[2]

[1]University of Plymouth, [2]University of Cambridge

1-E-79 Thalamocortical resting state connectivity of the sensorimotor system in typically developing children

Ellen Jaspers[1], Joshua Balsters[1], Dante Mantini[1], Nicole Wenderoth[1]

[1]ETH Zurich

1-E-80 Scale invariant movement encoding

Naama Kadmon Harpaz[1], Nicholas Hatsopoulos[2], Ilan Dinstein[3], Tamar Flash[1]

[1]Weizmann Institute of Science, [2]University of Chicago, [3]Ben-Gurion University

1-E-81 Motor control considerations on the origin of bipedalism; coupling and decoupling of arms and legs

Robert Kohl[1], Raymond McCoy[1]

[1]The College of William and Mary

1-E-82 Competitive interactions in sensorimotor cortex: oscillations express separation between alternative movement targets

Tineke Grent-'t-Jong[1], Robert Oostenveld[1], Ole Jensen[1], W. Pieter Medendorp[1], Peter Praamstra[1]

[1]Radboud University Nijmegen

F – Integrative Control of Movement

1-F-83 Vestibular pathways use a highly non-linear coding scheme to represent natural self-motion

Jerome Carriot[1], Kathleen Cullen[1]

[1]McGill University

1-F-84 Self-avoidance mechanism between skin and suckers prevents octopus arms from interfering with each other - A new dimension in embodied motor control

Nir Nesher[1], Guy Levy[1], Frank Grasso[2], Binyamin Hochner[1]

[1]The Hebrew University of Jerusalem, [2]Brooklyn College

1-F-85 Effects of mechanical interactions between synergistic muscles on sensory encoding

Huub Maas[1], Hiltsje Smilde[1], Guus Baan[1], Paul Nardelli[2], Tim Cope[2]

[1]VU University Amsterdam, [2]Wright State University

1-F-86 Coordination of arm reaching movements during passive sinusoidal whole body motion

Romy Bakker[1], Luc Selen[1], Pieter Medendorp[1]

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1-F-87 Visual enhancement of tactile detection in a reaching and grasping task

Gordon Binsted[1], Francisco Colino[1]

[1]University of British Columbia

1-F-88 Reduced online visual control for reaches to proprioceptive targets

Brendan Cameron[1], Joan López-Moliner[1]

[1]Universitat de Barcelona

1-F-89 Covariation between spatial and temporal variabilities during reciprocal aiming movements performed at various rates

Frederic Danion[1], Raoul Bongers[2], Reinoud Bootsma[1]

[1]CNRS, Aix Marseille University, [2]University of Groningen

1-F-90 Reaction time and movement time coupling revealed through preparation time

Cristina de la Malla[1], Joan López-Moliner[1]

[1]Universitat de Barcelona

1-F-91 Agonist-antagonist activation balance modulates muscle spindle responses to stretch

Michael Dimitriou[1]

[1]University of Umeå

1-F-92 Hand-finger kinematic similarities and individuation in activities in daily living

Sonja Fenske[1], Andreas Thomik[1], Aldo Faisal[1]

[1]Imperial College London

1-F-93 Reach trajectories characterize the timing of tactile localization decisions

Janina Brandes[1], Tobias Heed[1]

[1]University of Hamburg

1-F-94 Biting intentions modulate the human jaw-opening reflex

Anders Johansson[1], Andrew Pruszynski[1], Benoni Edin[1], Karl-Gunnar Westberg[1]

[1]Umeå University

1-F-95 Summing intermodal biases results in predictable drift

Irene Kuling[1], Marieke Van der Graaff[1], Eli Brenner[1], Jeroen Smeets[1]

[1]VU University, Amsterdam

1-F-96 Preferential use of muscle after vibratory feedback during a two-muscle myocontrol task

Shanie Liyanagamage[1], Matteo Bertucco[1], Nasir Bhanpuri[1], Terence Sanger[1]

[1]University of Southern California

1-F-97 Multi-muscle synergy-based control of a robotic device: a promising approach for helping people with movement disorders

Francesca Lunardini[1], Claudia Casellato[1], Denise Berger[2], Matteo Bertucco[3], Andrea D'Avella[4], Terence Sanger[3], Alessandra Pedrocchi[1]

[1]Politecnico di Milano, [2]Fondazione Santa Lucia , [3]University of Southern California, [4]Fondazione Santa Lucia

G – Control of Eye & Head Movement

1-G-98 Detrended Fluctuation Analysis of Eye Movements in Traumatic Brain Injury

John Anderson[1]

[1]Minneapolis VA Health Care System - University of Minnesota

1-G-99 Response properties of neuronal elements of the macaque cerebellar flocculus during oculomotor behaviors

Pablo Blazquez[1], Jean Laurens[1]

[1]Washington University

1-G-100 TMS to DLPFC disrupts Executive Control but TMS to FEF disrupts Visuomotor Processing

Ian Cameron[1], Justin Riddle[1], Mark D'Esposito[1]

[1]University of California, Berkeley

1-G-101 BOLD activity in human parietal cortex during visuomotor updating within an illusory context

Anouk de Brouwer[1], Jeroen Smeets[2], Tjerk Gutteling[1], Ivan Toni[1], *Pieter Medendorp*[1]

[1]Radboud University Nijmegen, [2]VU University Amsterdam

1-G-102 Prior experience biases visually-guided smooth pursuit response

Nicolas Deravet[1], Jean-Jacques Orban de Xivry[1], Gunnar Blohm[2], Philippe Lefèvre[1]

[1]Université catholique de Louvain (UCL), [2]Queen's University

1-G-103 Violating instructed human agency: an fMRI study on ocular tracking of biological and non-biological motion stimuli

Katja Fiehler[1], Maximilian Hilger[1], Mathias Hegele[1]

[1]University Giessen

1-G-104 The effect of balance task and descending motor command on vestibulocollic reflexes

Patrick Forbes[1], Gunter Siegmund[2], Riender Happee[1], Alfred Schouten[1], Jean-Sébastien Blouin[3]

[1]Delft University of Technology, [2]MEA Forensic Engineers & Scientists, [3]University of British Columbia

1-G-105 Optokinetic responses in area MSTd: evidence for eye-velocity gain fields

Stefan Glasauer[1], Lukas Brostek[1], Mike Mustari[2], Ulrich Büttner[1]

[1]Klinikum der Universität München, [2]University of Washington

1-G-106 Processing of visual motion within the cerebellum: an fMRI study

Paul Pope[1], Peter Hansen[1], Ned Jenkinson[2], Chris Miall[1]

[1]University of Birmingham, [2]University of Oxford

Session 2

Thursday April 24 and Friday April 25. Posters are listed by theme.

A - Adaptation & Plasticity in Motor Control

2-A-1 Retinal error vs. Prediction error in prism adaptation

Anne-Emmanuelle Priot[1], Valérie Gaveau[2], Claude Prablanc[2]

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2-A-2 Target visual information affects the decay of adaptation to in-depth distortion

Anne-Emmanuelle Priot[1], Pascaline Neveu[2], Charles-Antoine Salasc[2], Claude Prablanc[3], Corinne Roumes[2]

[1]Institut de recherche biomédicale des armées (IRBA)/Centre de Recherche en Neurosciences de Lyon (CR), [2]Institut de recherche biomédicale des armées (IRBA), [3]Centre de Recherche en Neurosciences de Lyon (CRNL), Inserm U1028 - CNRS UMR5292, ImpAct

2-A-3 Motor imagery practice induces motor cortical plasticity

Charalambos Papaxanthis[1], Nicolas Gueugneau[2], Laura Avanzino[3], Marco Bove[3]

[1]INSERM U1093: Cognition, Action et Plasticité Sensorimotrice, [2]Université de Bourgogne, INSERM U1093: Cognition, Action et Plasticité Sensorimotrice, [3]University of Genoa, Department of Experimental Medicine, Section of Human Physiology

2-A-4 Unmasking interference of motor memories

Adjmal Sarwary[1], Luc Selen[1], Dick Stegeman[1], Pieter Medendorp[1]

[1]Donders Institute

2-A-5 Bihemispheric tDCS facilitates sequence learning by increasing effector-independent encoding in both hemispheres

Sheena Waters-Metenier[1], Tobias Wiestler[1], Masud Husain[2], Joern Diedrichsen[1]

[1]University College London, [2]Oxford University

2-A-6 Anticipatory grip force between 1 and 3g

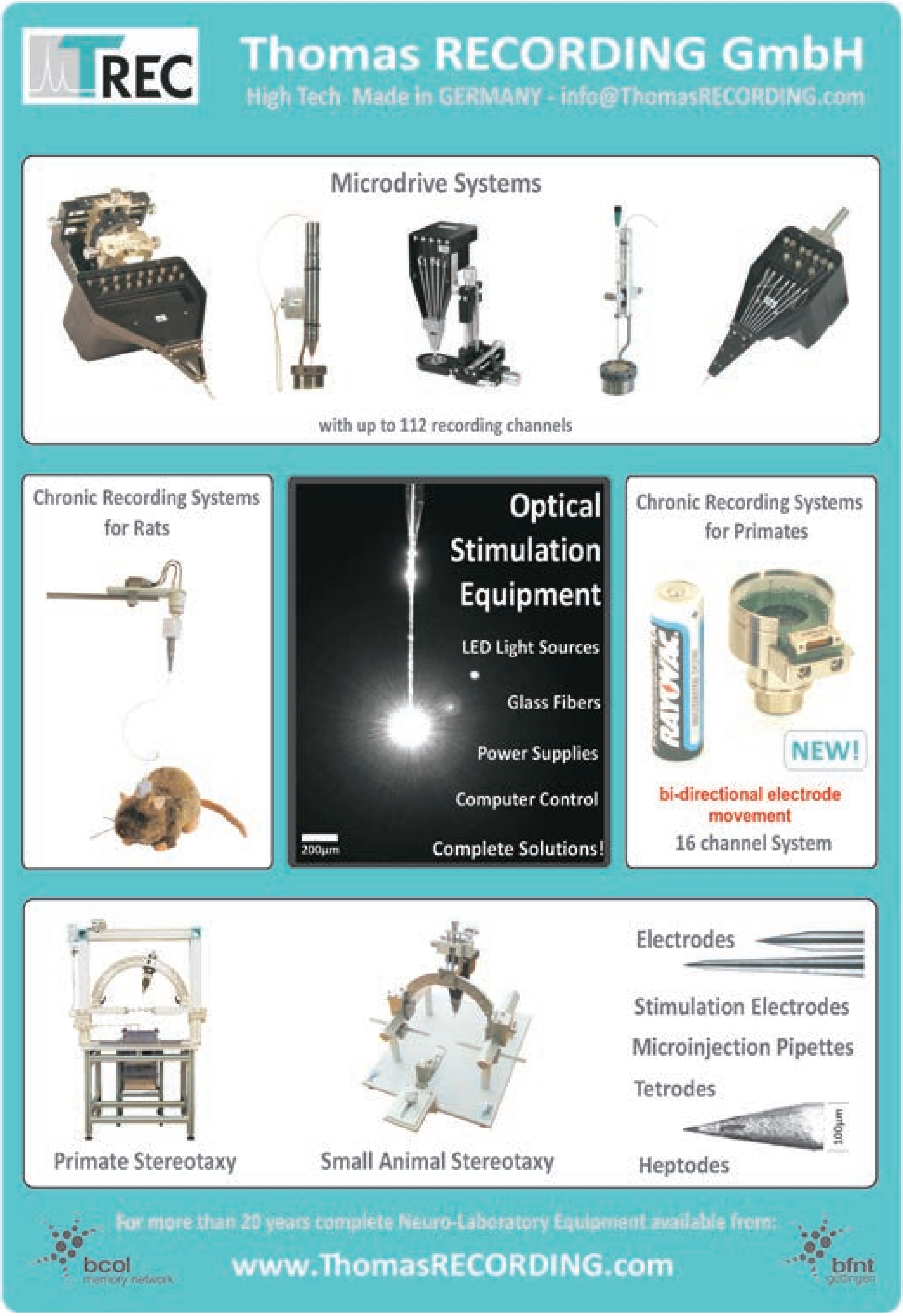
Olivier White[1], Philippe Lefèvre[2], Jean-Louis Thonnard[2], Joachim Hermsdoerfer[3]

[1]Universite de Bourgogne, [2]Universite catholique de Louvain, [3]Technical University of Munich

2-A-7 Motor learning and increased effort induced by adaptive reach training

Hyeshin Park[1], James Gordon[1], Nicolas Schweighofer[1]

[1]USC



2-A-8 Temporal development of an internal model and its generalization

Luc Selen[1], Bas van Lith[1], Adjmal Sarwary[1], Pieter Medendorp[1]

[1]Donders Institute for Brain, Cognition and Behaviour

2-A-9 Muscle synergy during 6min maximal rowing of collegiate rowers and untrained subjects

Shazlin Shaharudin[1], Sunil Agrawal[2]

[1]Universiti Sains Malaysia, [2]Columbia University

2-A-10 Modulation of monosynaptic reflexes during development of spinal motor systems.

Calvin Smith[1], Julian Paton[2], Samit Chakrabarty[1], Ronaldo Ichiyama[1]

[1]University of Leeds, [2]University of Bristol

2-A-11 Dissociation of the temporal correlation between sensory-predication and reward-prediction errors

Jordan Taylor[1], Samuel Brudner[1], Richard Ivry[2]

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

2-A-12 Generalization of error-driven corrections in motor planning is local

Robert van Beers[1]

[1]VU University Amsterdam

2-A-13 Gone for 60 seconds: Reactivation length determines motor memory degradation during reconsolidation

Nicole Wenderoth[1], Toon de Beukelaar[2], Daniel Woolley[2]

[1]ETH Zurich, Neural Control of Movement Lab, [2]KULeuven, Motor Control Lab

2-A-14 Awareness of sensorimotor adaptation to visual rotations of different sizes

Susen Werner[1], Bernice van Aken[2], Thomas Hulst[2], Jos van der Geest[2], Maarten Frens[2], Heiko Strüder[1], Opher Donchin[3]

[1]German Sport University, [2]Erasmus MC, [3]Ben Gurion University of the Negev/Erasmus MC

2-A-15 Nonvisual signals driving compensatory eye movement reflex adaptation of the mouse

Beerend Winkelman[1], Ozgecan Ozyildirim [1], Leonardo Tolosa-Rodríguez[2], Chris de Zeeuw[1]

[1]Netherlands Institute for Neuroscience, [2]iThera Medical GmbH

2-A-16 Primary motor cortex excitability tracks the phases of adaptation to a visuomotor gain

Mathew Yarossi[1], Sergei Adamovich[2], John Krakauer[3], Eugene Tunik[1]

[1]Rutgers Biomedical Health Sciences, [2]New Jersey Institute of Technology, [3]The Johns Hopkins Hospital

2-A-17 Coordinate representations for interference reduction in motor learning

Sang-Hoon Yeo[1], Daniel Wolpert[1], David Franklin[1]

[1]University of Cambridge

2-A-18 Proprioception in motor learning: lessons from a deafferented patient

Nada Yousif[1], Jonathan Cole[2], John Rothwell[3], Joern Diedrichsen[3]

[1]Imperial College London, [2]Poole Hospital, [3]University College London

2-A-19 Changes in intrinsic spiking rhythmicity and task related modulation of primate pontomedullary reticular formation (PMRF) neurons after corticospinal lesion

Boubker Zaaimi[1], Stuart Baker[1]

[1]Newcastle University

B – Disorders of Motor Control

2-B-20 Difference in performing rhythmic and discrete upper-limb movements after stroke

Leconte Patricia[1], Renaud Ronsse[1]

[1]Université catholique de Louvain

2-B-21 Emulating development of focal hand dystonia due to plasticity

Won Joon Sohn[1], Terence Sanger[1]

[1]University of Southern California

2-B-22 Neural substrates of continued motor skill learning with the paretic upper limb one week after real and sham dual-tDCS in chronic stroke patients: a fMRI study

Yves Vandermeeren[1], Laurence Dricot[2], Wojciech Gradkowski[3], Patrice Laloux[1], Philippe Desfontaines[4], Frédéric Evrard[5], André Peeters[6], Jacques Jamart[7], Stéphanie Lefevbre[1]

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2-B-23 An examination of proactive facilitation during motor learning in older adults

Marion Verneau[1], John van der Kamp[1], Michiel de Looze[1], Geert Savelsbergh[1]

[1]Move institute

2-B-24 Hand functioning in children with cerebral palsy

Carlyne Arnould[1], Yannick Bleyenheuft[2], Jean-Louis Thonnard[2]

[1]Haute Ecole Louvain en Hainaut, [2]Université catholique de Louvain

2-B-25 Deficits in eye-hand coordination in dementia patients

Casper de Boer[1], Francesco Mattace - Raso[1], Johannes van der Steen[1], Johan Pel[1]

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Daniela Kuenster[1], Christoph Maurer[1]

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Johan Pel[1], Casper de Boer[1], Johannes van der Steen[1]

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Noham Wolpe[1], James Ingram[1], Daniel Wolpert[1], Cam CAN[2], James Rowe[1]

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Jorik Nonnekes[1], Anass Arrogi[1], Moniek Munneke[1], Edwin van Asseldonk[2], Lars Oude Nijhuis[1], Alexander Geurts[1], Vivian Weerdesteyn[1]

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Zrinka Potocanac[1], Ellen Smulders[2], Mirjam Pijnappels[3], Sabine Verschueren[1], Jacques Duysens[1]

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Anastasia Sylaidi[1], A. Aldo Faisal[1]

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Ken Takiyama[1], Yutaka Sakai[2]

[1]JSPS/Tamagawa University, [2]Tamagawa University Brain science institute

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Matan Karklinsky[1], Tamar Flash[1]

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Bram Onneweer[1], Winfred Mugge[2], Alfred Schouten[1]

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Luis Schettion[1], Sergei Adamovich[2], Eugene Tunik[3]

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2-F-81 External and anatomical coordinates are coupled in tactile information processing

Femke Maij[1], Pieter Medendorp[1], Tobias Heed[2]

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Fiona Manning[1], Jennifer Harris[1], Michael Schutz[1]

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Cassie Nguyen[1], Matteo Bertucco[1], Denise Berger[2], Andrea d'Avella[2], Terence Sanger[1]

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2-F-89 Distinct strategies in line-bisection and obstacle avoidance

Alasdair Ross[1], Thomas Schenk[2], Constanze Hesse[1]

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2-F-90 Zonal organization of cerebellar connections to the sensorimotor cortex in the rat

Tom Ruigrok[1], Sho Aoki[2], Patrice Coulon[3]

[1]Erasmus MC Rotterdam, [2]Okinawa Institute of Science and Technology, [3]Aix-Marseille University

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Atsushi Yokoi[1], Wenjun Bai[1], Joern Diedrichsen[1]

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Peter Zatka-Haas[1], Alexandra Reichenbach[1], Etienne Burdet[2], Joern Diedrichsen[1]

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Lei Zhang[1], Andreas Straube[1], Thomas Eggert[1]

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Michael King[1], Alyssa Taylor[1], Mark Walker[2]

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Jay Jantz[1], Masayuki Watanabe[1], Ron Levy[1], Douglas Munoz[1]

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Michelle Young[1], S. Neggers[2], Bram Zandbelt[1], Jeffrey Schall[1]

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IEEE Engineering in Medicine and Biology Society (EMBS) is the world's largest international society of biomedical engineers. The organization's 10,000 members reside in some 97 countries around the world. EMBS provides its members with access to the people, practices, information, ideas and opinions that are shaping one of the fastest growing fields in science. EMBS members are focused on the development and application of engineering concepts and methods to provide new solutions to biological, medical and healthcare problems.

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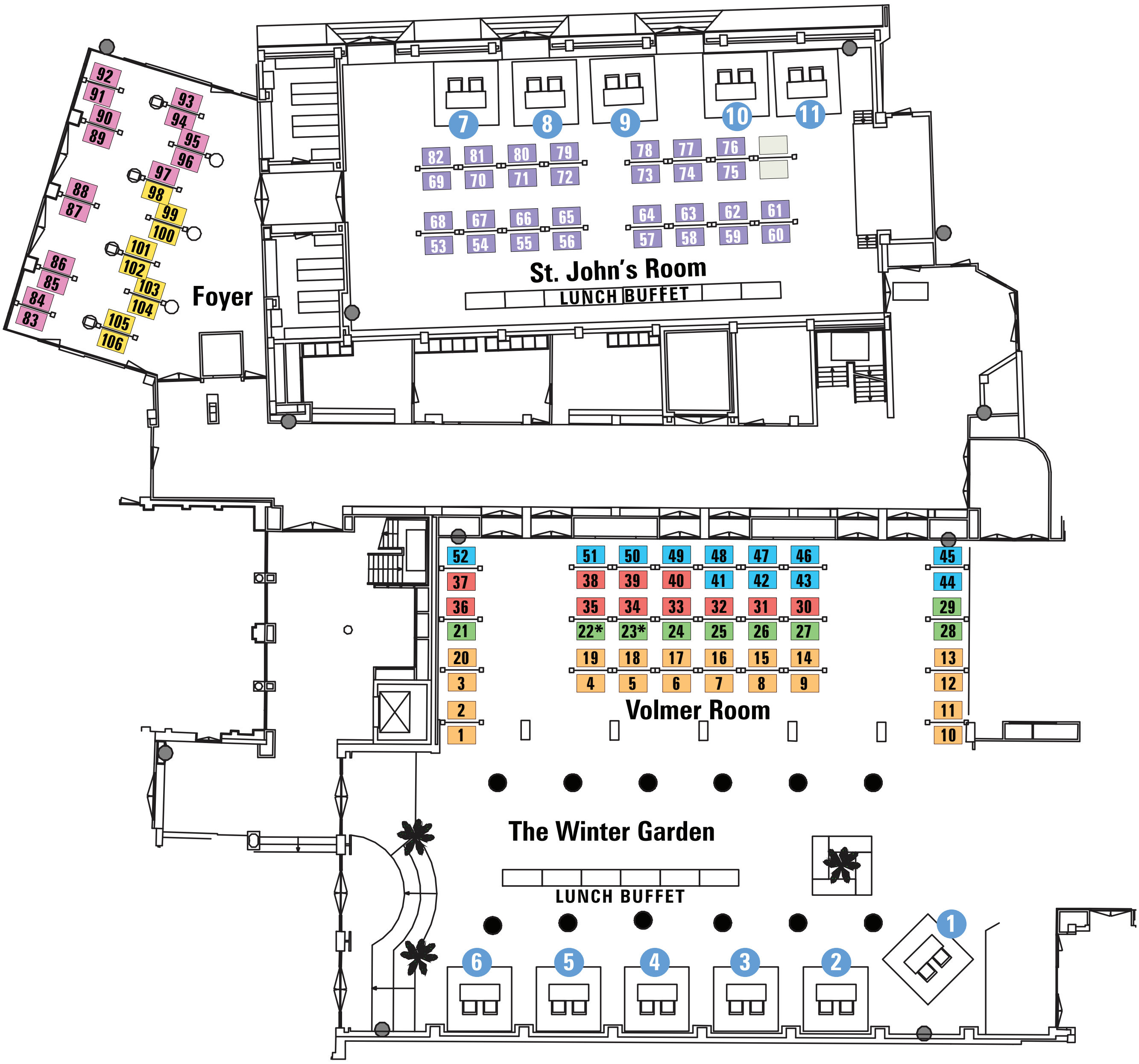
Dr. Daofen Chen, Program Director, Extramural Research Program, The National Institute of Neurological Disorders and Stroke, NIH/NINDS, will be available during poster-lunch periods to provide information and counsel on NIH programs.

Poster Session Floor Plans

Volmer Rooms, St. John's Rooms and Foyer



Session 1

Tuesday April 22
and Wednesday April 23

🟧 A Adaptation & Plasticity in Motor Control

🟩 B Disorders of Motor Control

🟥 C Posture & Gait

🟦 D Theoretical & Computational Motor Control

🟪 E Fundamentals of Motor Control

▨ F Integrative Control of Movement

🟨 G Control of Eye & Head Movement

⬜ Blank poster board

* Poster Cluster: Fischer (1-B-22 and 1-B-23)

Exhibitors (indicated by blue circles)

1	Blackrock Microsystems
2	NDI
3	ANT Neuro
4	Tucker-Davis Technologies
5	Twente Medical Systems International (TMSi) B.V.
6	Cambridge Research Systems Ltd.
7	NeuroNexus Technologies
8	Alpha Omega
9	Noldus Information Technology
10	Plexon Inc
11	CODAMOTION

For information on the exhibitors, please visit the Sponsor/Exhibitor profiles on pages 62-63.

Session 2

Thursday April 24
and Friday April 25

🟧 A Adaptation & Plasticity in Motor Control

🟩 B Disorders of Motor Control

🟥 C Posture & Gait

🟦 D Theoretical & Computational Motor Control

🟪 E Fundamentals of Motor Control

▨ F Integrative Control of Movement

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⬜ Blank poster board

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