



**Champalimaud
Foundation**

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Regarding Project N62909-16-1-2212, please find attached the Federal Technical Report.

Kind regards,

Inês Bonifácio

(Inês Bonifácio)
Office for Sponsored Programmes

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Annex 1

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ONRG, CSP Application

5th Champalimaud Neuroscience Symposium

The 5th Champalimaud Neuroscience Symposium aims at bringing together researchers working on a broad range of areas in Neuroscience, from cognition to synaptic plasticity. This year symposium covers a form of a scientific meeting that includes research at different organizational levels, with different organisms and that apply a wide range of techniques. It is a single-track format so that all participants are exposed to various approaches within Neuroscience. This year's programme includes 20 talks by distinguished invited speakers, 7 talks selected from abstracts and three poster sessions with the most recent results of ongoing research around the world.

Neuroscience is a relatively young, exciting, and fundamentally interdisciplinary field devoted to the study of the nervous systems from different perspectives. As already identified by the US Naval or Marine Corp Science & Technology, Neuroscience through their Warfighter Performance strategy focus area, studies at the level of cognition and behaviour can highly contribute to the understanding of the brain. This event will bring together top researchers in the field of neuroscience to learn from experts, identify areas of consensus, discuss possible collaborative actions, and identify emerging topics and concerns.

Some of the topics that will be addressed during the Champalimaud Neuroscience Symposium will be Neuronal plasticity and its relation with learning and behaviour and Stress and its relation with brain function and behaviour. Both topics can help in understanding of the brain during combat and/or training and help in the development of new training programs to train soldiers to better cope with stress, fatigue, repetitive tasks, immobility, etc.

Final Report for the ONRG - CSP - N62909-16-1-2212 Grant

Introduction

In times in which science, including neuroscience, is becoming more and more specialized, conferences and workshops tend to cater to specific communities and have as a goal the exchange of specialized information within a closed circle of members of specific communities. While necessary, such a specialization hinders the interaction of scientists with diverse backgrounds and the development of innovative transdisciplinary approaches across fields. Such a transdisciplinary approach is especially vital in neuroscience which spans a wide spectrum of approaches and questions, ranging from molecular to whole animal approaches. Currently such a broad overview is mainly offered in big conferences such as the SfN conference or the FENS Forum. But with thousands of participants the format of these events is not conducive to a dynamic exchange of ideas and close interaction among the participants.

As in previous editions the goal of the Champalimaud Neuroscience Symposium 2016 was therefore to bring together a set of speakers who best represent the exciting work being done within current neuroscience while offering enough time and opportunities to interact with the participants, including the speakers. Talks spanned different levels of inquiry, from molecular synaptic mechanisms of learning to the complex interplay of the nervous system with the immune system. We were extremely excited by the quality of the contributions, the discussions they ignited, and the overwhelmingly positive feedback we received.

Important scientific insights from the talks

The talks by the invited speakers were of extremely high quality and managed to give inspirational insights into the cutting edge work being done in a wide variety of fields. As invited speakers used the presentation to put a special emphasis on future perspectives of their fields and approaches. We will highlight here four themes which emerged from the presentations by invited and selected speakers.

Circuits, behavior and cognition

In his keynote presentation, Dr. Edvard Moser from the Kavli Institute for Systems Neuroscience, Norway, first reviewed the work which led to the joint award of the Nobel Prize in Physiology or Medicine in 2014 to him, Dr. May-Britt Moser and

John O'Keefe for the discovery of place cells, which allow the brain to compute the position of the animal in space. He then went on to discuss his ongoing work which aims at understanding the development of this system. From the talk of Dr. Moser and other speakers such as Dr. Paton and Dr. Orger from the Champalimaud Foundation, Portugal, it became clear that the circuit neuroscience field has advanced to a stage in which it does not only allow the understanding of how circuits process sensory information to generate perceptual decisions but also starts to unveil higher order representations of information and ensuing complex behaviors which are hallmarks of cognition. As such it is interesting to note that model organisms are allowing unprecedented insights in fields which normally were thought to be of the domain of human psychology or primate research. This is mainly made possible by the use of sophisticated behavioral tasks and quantitative and high resolution behavioral analysis as well as the possibility to survey and analyze data from large numbers of neurons. Especially impressive is the example of the larval zebrafish in which it is possible to visualize activity at the level of the whole brain. The possibility to use genetic model organisms to study cognition allows a deeper, mechanistic understanding of circuit function underlying cognition. Throughout the meeting the pioneering nature of the work on place cells by Dr. Moser became very clear and why it was selected for the Nobel prize.

Brain Machine Interfaces

The use of brain machine interfaces (BMIs) to harness neuronal signals to control computerized devices has become a "hot" field within engineering. What is less well appreciated is the potential this technology offers for studying how the brain encodes information and uses it to produce actions. Dr. Jose Carmena from the University of California, Berkeley, USA gave an impressive overview of how his team is using BMI approaches to understand how the brain learns to make movements and how these insights are helping to design new BMIs to either remotely control devices or help incapacitated people to regain mobility. This talk was highlighted several times as one of the most original and interesting talks at the meeting.

Importance of integrative and transdisciplinary talks

While most contemporary neuroscience focuses on how molecular and circuit mechanisms shape behavior a clear theme which emerged during the conference is the potential of thinking and working beyond these clearly defined boundaries. Neuroscience is becoming an important element in understanding seemingly peripheral fields such as immunology and physiology. Prof. Michal Schwartz from the Weizmann Institute for Science, Israel, gave an impressive overview of her work at the interface of neuroscience and immunology. As a founder of the field of neuroimmunology she highlighted her findings that the immune and the nervous systems interact and strongly influence each other. She went on to exemplify the power of understanding this crosstalk in order to direct the immune system to alleviate neuropathologies and neurodegenerative diseases such as spinal cord injuries and Alzheimer as well as enhancing cognitive abilities of elder animals. Dr. Sofia Grade from the LMU, Munich Germany also highlighting, in a selected talk, the

role of inflammation in stem cell mediated neuronal injury repair. Impressively, the stem cell approach she presented led to the formation of functional circuits. This work was in the meantime published in *Nature* (doi:10.1038/nature20113).

Dr. Tamas Horvath from Yale University, explored the crosstalk between physiology and the brain in mediating feeding and other important physiological responses of the animal. Work on feeding circuits has developed into one of the most rapidly advancing fields within circuit neuroscience. Dr. Horvath nicely exemplified how the acquired knowledge starts to be implemented into a whole brain and whole animal understanding of behavior and physiology control. This field promises to become one of the spearheads for learning how to translate neuroscience knowledge into human applications as it requires a highly integrative whole organism approach to circuits. Especially when it also includes the exploding field of microbiome research. This translation will however first require that we further our understanding of feeding circuits and how the brain and the body interact to shape behavior and physiology in simpler organisms.

Learning and Memory

Analogous to cognition, learning and memory has made tremendous advances over the last decade. The use of optogenetic approaches and sophisticated behavioral analyses were impressively displayed in the talks of Dr. Caroni from the Friedrich Miescher Institute, Basel, Switzerland and Dr. Sheene Josselyn, at Sickkids, Toronto, Canada. Their work is allowing neuroscientists to precisely pinpoint specific phases of memory acquisition and consolidation and the circuit and molecular mechanisms underlying different phases of memory formation. Along the same lines Dr. Robert Malenka from Stanford University, USA highlighted the power of state of the art molecular and genomic engineering approaches to dissect the molecular machinery acting at the synapse to form memories. The combination of circuit neuroscience and state of the art genomic engineering approaches such as CRISPR are likely to lead to a new wave of exciting discoveries on how our brain learns and forms memories.

Importance of model organisms

The new era of integrative neuroscience requires the fusion of a diverse set of approaches ranging from molecular approaches to whole animal approaches such as immunology and physiology to understand overarching questions about how the brain acts within the context of the whole animal. Such an overarching and integrative understanding of neuroscience is key for translating neuroscience findings to humans as such a translation has to be inherently at the level of the whole organism. This integrative process is technically and conceptually challenging. Bearing this in mind it was striking to see how much of the best work presented at the Symposium was performed in model organisms. Two model organisms which exemplified the new era of integrative neuroscience the best were zebrafish larvae and the fruitfly *Drosophila melanogaster*. Four key assets allow these two organisms to spearhead this new era of neuroscience. 1) Sophisticated, automatically and quantitatively analyzable

behavior, 2) the ability to survey large numbers of neurons while the animal performs behaviors (in the extreme case calcium imaging of ALL neurons in the brain), 3) the ease with which molecular manipulations are performed with cellular resolution in specific neurons, and 4) the ability to manipulate and analyze the animal as a whole organism.

The power of the fruitfly was for example nicely exemplified by the work of Dr. Mala Murthy from Princeton University, USA. She showed how her team combines quantitative behavioral analyses, precise genetic control of the activity of specific neurons, mathematical modeling, and whole brain neuronal activity imaging to understand how animals communicate with each other using sounds. Dr. Casey M Schneider-Mizell from the HHMI Janelia Research Campus, Virginia, USA presented an impressive talk on how high resolution connection maps of fly brains generated using electron microscopy (connectomics) can be used to guide genetic circuit manipulation experiments to study how the brain generates behavior. Furthermore the availability of the extremely precise and comprehensive "connectomics" data allows for the mathematical modeling of how information is processed in brain circuits with single neuron resolution. From his presentation it became clear that the fly brain provides an ideal model for the application of EM "connectomics" as it is complex enough to serve as a model for the vertebrate brain but is small enough to be amenable to the extremely laborious and therefore slow "connectomics" approach. Currently this is the only complex nervous system for which we are likely to have a full connectivity map within the next decade. This map will further increase the importance of the fruit fly for neuroscience research.

Dr. Michael Orger from the Champalimaud Centre for the Unknown, Lisbon, Portugal, presented his pioneering work which he analyzes the activity of all the neurons in the brain of the zebrafish larva in the context of visual behavior to understand how the brain processes visual information to control motor outputs. Such a large scale approach allows the analysis of information processing at the level of neuronal ensembles and not single neurons allowing a more realistic understanding of sensory processing. Finally Dr. Alex Schier from Harvard University, USA presented the power of zebrafish for developing novel technologies. He showed how creative the use of genome engineering methods based on CRISPR technology can be paired with large scale sequencing to provide novel insights into how the nervous system and the whole animal develop. He also gave an outlook on the future of these technologies and how one might use these to survey neuronal architecture and activity as well as to generate models for psychiatric diseases.

Major successes from the meeting

A major success of the meeting was the transdisciplinary perspective achieved by the participants. Most speakers highlighted the high quality of the meeting and the new perspectives gained from attending talks and posters outside of their neuroscience specialty. They also lauded the ability to interact in a relaxed and conducive environment with people outside of their field.

Participants also had the opportunity to interact with scientific editors from the journals *Nature* and *Nature Neuroscience*. This has led to multiple articles based on work presented at the symposium being submitted for publication to these journals.

Feedback from participants

Based on a survey performed at the end of the Symposium 100% of the surveyed participants (95) stated that they would recommend the symposium. The overall evaluation was 4.48 out of a maximum of 5 points. The scientific programme, the talks, and the quality of the facilities and the staff received the highest rating in the survey (4.38, 4.56 and 4.60 points out of 5) and the catering the lowest (3.98 points out of 5). In comments participants highlighted the quality of the platform talks. The main criticism which will need to be addressed in next events will be the quality of the catering and the acoustics in the poster hall.

Furthermore, we put together a video with testimonials of attendees which can be seen using this link: https://youtu.be/xR6yp_k9rl

Media coverage, scientific outreach and dissemination of the symposium, and social media coverage

The symposium received a lot of media attention. It was covered both on national TV and also in major magazines in Portugal. For example:

RTP

http://www.rtp.pt/noticias/mundo/premio-nobel-da-medicina-de-2014-esteve-em-portugal_v949309

Visão Magazine

<http://visao.sapo.pt/actualidade/sociedade/2016-11-15-Nao-e-preciso-estar-em-Nova-Iorque-ou-Boston-para-ganhar-o-Nobel>

Furthermore our internal science communications department interviewed speakers and promoted their work through our science outreach channels. See for example:

Champalimaud Websites | Ar Magazine | YouTube

<http://www.fchampalimaud.org/en/newsroom/fifth-champalimaud-neuroscience-symposium-view/>

<http://neuro.fchampalimaud.org/en/news/224/>

https://www.youtube.com/watch?v=xR6yp_k9rl

<http://magazine.ar.fchampalimaud.org/we-had-a-behavior-that-could-be-measured-as-a-physical-property/>

<http://magazine.ar.fchampalimaud.org/the-immune-system-is-needed-for-repair-and-lifelong-maintenance-of-the-brain/>

The symposium was also widely disseminated and discussed on social media using our Facebook and Twitter accounts which have more than 112'000 followers. We also established a dedicated Twitter account @cnp_symp and the symposium was widely discussed on Twitter using the hashtag #cnpsym2016

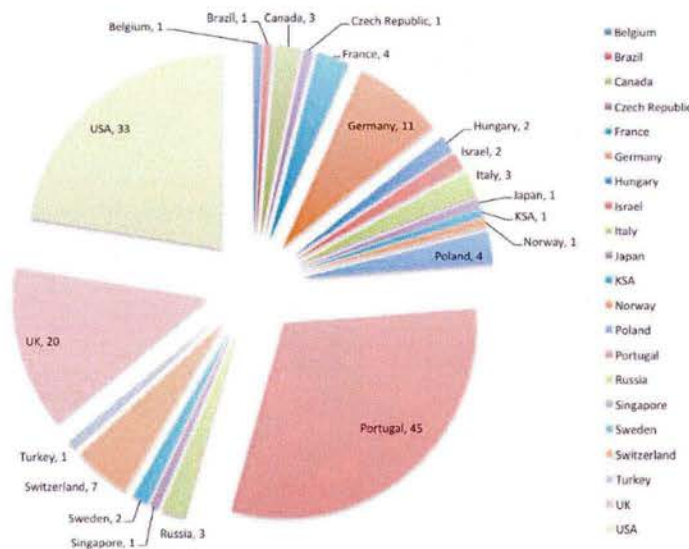
List of individuals whose travel was supported by the grant

Name	Organization	Country	Role in the Conference
Edvard Moser	Norwegian University of Science and Technology	Norway	Keynote Speaker
Carmen Sandi	Ecole Polytechnique Fédérale de Lausanne	Switzerland	Speaker
Kathy Cullen	McGill University	Canada	Speaker
Michal Schwartz	Weizmann Institute of Science	Israel	Speaker
Pico Caroni	Friedrich Miescher Institute for Biomedical Research	Switzerland	Speaker
Sheena Josselyn	University of Toronto	Canada	Speaker
Thomas Mrcic-Flogel	University of Basel	Switzerland	Speaker
Valentina Emiliani	Centre National de la Recherche Scientifique	France	Speaker
Winfried Denk	Max Planck Institute of Neurobiology	Germany	Speaker
Claudia D. Vargas	Institute of Biophysics Carlos Chagas Filho	Brazil	Delegate (poster presentation) - Travel award
Hugo Cruces-Solis	Max Planck Institute of Experimental Medicine	Germany	Delegate (poster presentation) - Travel award
Adil Khan	Biozentrum, University of Basel	Switzerland	Delegate (poster presentation) - Travel award
Lucia Prieto-Godino	University of Lausanne	Switzerland	Delegate (invited talk) - Travel award
Sofia Grade	Ludwig-Maximilians-Universität	Germany	Delegate (invited talk) - Travel award
Mohamed Edfawy	Center for Neuroscience and Cell Biology	Portugal	Delegate (poster presentation) - Travel award
Ida Barlow	University College London	UK	Delegate (poster presentation) - Travel award

Travel awardees were selected by the scientific committee and the chairs of the conference based on information provided during the registration process. These were mainly the scientific excellence of the submitted abstracts and the financial needs of the applicant.

Participants

Overall 325 people attended the Symposium. 16 invited speakers, 299 scientists, 2 editors of scientific journals, 4 members of the press, and 4 representatives of the sponsors. Participants presented 123 posters. The conference was a highly international event with a large external participation from the USA, UK, Germany, and Switzerland.



Conclusion

Overall the Champalimaud Neuroscience Symposium 2016 was a full success. Participants were highly satisfied with the transdisciplinary overview of cutting edge neuroscience presented at the meeting and the possibility to interact with leading figures in neuroscience. We thank the ONR for the generous support of the event which allowed us to organize such a successful event.