

## **Scientific Report on the ERNI-HSF funded workshop, on Motivation & Action**

Helene Elsass Center, Copenhagen, Denmark, August 16-17 2012

### **Summary**

The aim of the workshop was to bring together basic and clinical scientists from Europe and North America who are each world-renowned for their research investigating Motivation & Action and basal ganglia function. Speakers included experts in: brain imaging; brain stimulation; computational modeling; reinforcement learning; psychopharmacology; etc. who collectively present an overview of the current state-of-the-art on decision making and processing of rewards in the motor context.

The scientific workshop on Motivation & Action was held at the Helene Elsass Center, in cooperation with the Danish Research Centre of Magnetic Imaging (DRCMR), Copenhagen University Hospital Hvidovre, Copenhagen, Denmark on 16<sup>th</sup> & 17<sup>th</sup> August, 2012. We were very pleased to have attracted a number of international experts, both to give invited talks and to attend. There were 70 attendees, including 30 expert speakers, and 4 student speakers, providing a lively and dynamic workshop. There was no registration fee for participants at the workshop and travel bursary for young scientists to encourage the attendance of early career researchers. The workshop was organized by Hartwig Siebner, Copenhagen University Hospital Hvidovre, John Rothwell, Queen Square London, Simon Eickhoff, University of Düsseldorf, Stephen Jackson, University of Nottingham and a local organization committee Anke Karabanov,

Estelle Raffin, Susanne Steffensen and Joyce van der Vegt and was a great success.

## **Scientific content and discussion**

Session I.I (Thursday 16th of August):

Dr. Peter Espen Bilde, Director of the Elsass Center opened the workshop by giving a short 10-minute overview of the impressive neurorehabilitation research that the Elsass Center offers on cerebral palsy. After this introduction the first session was devoted to highlight the role of sub-cortical structures in motivation and action. Professor Henrik Jörntell (University of Lund) opened the session with an excellent electrophysiology talk on cerebellar microcircuits and their role in balancing overall activity in the motor pathway. This was complemented by Professor Peter Redgrave's (University of Sheffield) interesting overview of the basal ganglia's functional anatomy and the importance of its diversely connected micro-architecture in action selection and reinforcement. Finally, Dr. Christelle Baunez presented a series of rodent studies investigating the subthalamic nucleus (STN). She concluded that the role of the STN exceeds classical motor function and includes attentional and motivational processes.

Session I.II (Thursday)

Session 2 was chaired by Professor John Rothwell. The first speaker was Antony Dickinson from Cambridge. He nicely reviewed the role of motivation for actions in various contexts of motor activities and provided detailed examples of goal-directed behaviors, such as food and drug seeking. Hauke Heekeren then talked about the neurobiology of perceptual and reward-based decision-making and insisted on the influence of cognition and emotion on decision-making in social contexts. Next, Birte Fortsmann's talk capitalized on

individual differences in psychological processes involved in decision-making and interference control. She presented structural and functional brain imaging data, which relate inter-individual variation in psychological processes to inter-individual variation in the neural substrate. Rogiers Mars showed recent work focusing on developing formal computation models of action and attention. He presented neural data obtained with functional magnetic resonance imaging, transcranial magnetic stimulation, and electroencephalography and emphasized on the role of the inferior frontal cortex for action and motivation. To conclude this session Yann Pelloux from Marseille presented experimental findings on the beneficial effects of deep brain stimulation of subthalamic nucleus to modulate cocaine intake in rats.

#### Session I.III (Thursday)

Just after lunch, Session 3 chaired by Professor Simon Eickhoff started with a general talk given by Professor John Rothwell (London) about motor correlates of motivation with experimental evidence from recent experiences performed by his group. Subsequently, Professor Richard Ridderinkhof from Amsterdam discussed the fronto-striatal mechanisms of motivation in the context of goal-directed actions as opposed to habitual actions. Later, Sven Bestmann from London introduced the notion of reward and effort for action decisions. Eric Wasserman demonstrated then that reward during procedural learning increases the effect of learning. Finally, Elisabet Linnet approached the importance of age in the process of motivational states. A general discussion on all talks concluded this session.

#### Session I.IV (Thursday)

After a coffee break, Kai Vogeley from Cologne opened session 4 chaired by Stephen Jackson and showed fMRI results on the effects of social gaze on action control. Then, Pelle Guldberg Hansen provided a societal approach to

motor actions introducing specifically the notion of a 'game theory of convention' for general habits in the public domain. Jan Engelmann from Zurich concluded the session and the conference's day with a talk on the impact of the affective context on decision-making and the neural correlates. This session 4 aimed in bringing back a social dimension in motivation and actions.

On Thursday evening, the organization committee had organized a convivial dinner in the center of Copenhagen to facilitate further discussions among the invited speakers and organizers.

### Session II.I (Friday)

The second day started with two talks outlining the impact attention and motivation have on motor actions. Professor Bernhard Hommel (University of Leiden) talked about intentional weighting in cognitive control and provided several experimental examples on how action preparation influences attention. Dr. Yael Niv (Princeton University) presented data from rat experiments describing the effect of motivation on habitual actions. Her interesting experiments showed that extensive training in animals disconnect actions from the value of its consequent outcome thereby rendering it purely habitual. Professor Münte broadened the discussion on the impact of reward by presenting human imaging data on reward expectation demonstrating that a wide network of visual, limbic and striatal structures is activated during reward anticipation and delivery. The session was concluded by a clinical presentation by Dr. Christian Grefkes who gave an excellent talk about the reorganization of cerebral networks after stroke. By using a combination of transcranial magnetic stimulation (TMS) and functional magnetic resonance imaging Dr. Grefkes demonstrated that TMS could be used to transiently remodel functional network architecture of the motor system in stroke patients.

### Session II.II (Friday)

The second morning session focused on reward and novelty processing. After the coffee break, Dr. Robert Rogers (University of Oxford) opened the session with an great overview over the influence of serotonin and dopamine on human decision-making. Dr. Rogers concluded that dopamine mainly mediates learning about outcome value whereas serotonin is crucial when shifting between risk averse and risk seeking behaviors and in social reward situations. Following his talk, Dr. Hanneke den Ouden presented interesting data on the gating influence that the basal ganglia have on sensorimotor coupling. She demonstrated the striatum's important role in updating motor plans in response to environmental changes. The next talk by Dr. Nico Bunzek linked novelty and reward processing: He showed that novelty motivates exploration in search for reward and that the mesolimbic system is involved in both, reward and novelty processing. The session was concluded by Professor Eickhoff, who spoke about external and internal aspects of action control demonstrating that there are differentiable DLPFC networks engaged in internal and external action control

### Session II.III (Friday)

After a nice lunch the Friday afternoon session started with more clinical topics on action selection and reward in Parkinson's Disease. Dr. James Rowe (University of Cambridge) gave an interesting lecture on action selection in Parkinson's disease using the accumulator model with fMRI. Professor Thilo van Eimeren (Kiel University) addressed the important issue of impulse control disorders in Parkinson's disease and gave a nice overview with focus on the risk factors and possible underlying mechanisms in the development of impulse control disorders. In the next lecture Dr. Joseph Galea (University of Birmingham) spoke about action reprogramming and prediction error with the effect of dopamine in Parkinson's disease. He concluded there was an enhanced action selection deficit in Parkinson's disease without medication in response to

unexpected events, which can be explained by decreased confidence about incoming sensory information in combination with low dopamine levels. These three key lectures were followed by two more 10 minutes PhD-student lectures. The first was Joyce van der Vegt, MD (Hvidovre University Hospital) broadened the discussion on the development of impulse control disorders in Parkinson's disease, by looking at the basic reward processing in unmedicated Parkinson's patients, which appears to be already dysfunctional at onset of disease. In the second PhD-student lecture Damian Herz, MD (Hvidovre University Hospital) described his very interesting results of a combined TMS-fMRI study, looking at the modulation of the control over impulsive responses by applying TMS on subjects performing a modified Simon-reward task.

#### Session II.IV

After the coffee break we continued with the final session of the workshop in the interesting field of clinical psychiatry. Dr. Mette Ødegaard Nielsen (Glostrup University Hospital) discussed her experiments in schizophrenia patients which showed alterations of the brain reward system in patients naive to antipsychotic medication associated with the disease and correlated to the severity of disease. Stefano Palminteri, Msc (Paris University) presented the insights in reinforcement learning in different neuropsychiatric diseases. Dr. Ciara McCabe (Oxford University) showed exciting results of the response of previously depressed patients to chocolate and moldy strawberries. She showed these patients still have a reduced neural response to the sight and taste of chocolate, but also an increased response to the sight and taste of unpleasant strawberries and that also a positive family history of depression results in deficits in the processing of reward of these stimuli.

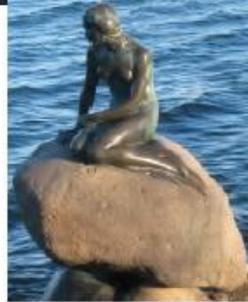
The last lecture was presented by Stephen Jackson (Nottingham) and he spoke about how the brain activity in the supplementary motor area dissociates

volitional and automatic motor control mechanisms in patients with Tourette syndrome.

Overall, the meeting succeeded in bringing together eminent scientists in this field and attracting junior scientists. It provided a state-of-the-art overview of the wide range scientific knowledge on motivation and action.



**Scientific  
Workshop**



**on**

**Motivation & Action**



**Helene Elsass Center  
Copenhagen, Denmark  
August 16-17 2012**

# Thursday 16<sup>th</sup> of August

## Program

|   |             |   |             |
|---|-------------|---|-------------|
| <b>Welcome Note</b>   | 08.45-08.50 | <i>Lunch break</i>  | 12.50-14.15 |
| Hartwig Siebner (Copenhagen)  |             |   |             |
| <b>Session 1</b>  |             | <b>Session 3</b>  |             |
| <b>Chair: Hartwig Siebner</b>   |             | <b>Chair: Simon Eickhoff</b>  |             |
| <b>Neurorehabilitation of Cerebral Palsy at the Elsass Center</b>   | 08.50-09.00 | <b>Motor correlates of motivation</b>   | 14.15-14.40 |
| Peter Esben Bilde (Copenhagen)  |             | John Rothwell (London)  |             |
| <b>Imbalances in motor pathways - connections to activity balancing within cerebellar microcircuits</b>       | 09.00-09.30 | <b>Linking motivation to action control in humans</b>   | 14.40-15.05 |
| Henrik Jörntell (Lund)  |             | Richard Ridderinkhof (Amsterdam)  |             |
| <b>Functional properties of the basal ganglia's re-entrant loop architecture: selection and reinforcement</b> | 09.30-10.00 | <b>Decisions for actions: influence of reward and effort</b>  | 15.05-15.30 |
| Peter Redgrave (Sheffield)  |             | Sven Bestmann (London)  |             |
| <b>Contributions of subthalamic nucleus to motivation in rodents</b>  | 10.00-10.25 | <b>It doesn't smell like ice cream: reward in procedural learning</b>                                 | 15.30-15.55 |
| Christelle Baunez (Marseille)   |             | Eric Wassermann (Bethesda)  |             |
| <i>Coffee Break</i>   | 10.25-11.00 | <b>Age differences in the processes eliciting object affordance and spatial-compatibility effects</b> | 15.55-16.05 |
|   |             | Elisabeth Linnet (Plymouth)   |             |
| <b>Session 2</b>  |             | <i>Coffee Break</i>   | 16.05-16.35 |
| <b>Chair: John Rothwell</b>   |             |   |             |
| <b>The motivation of goal-directed behaviour</b>  | 11.00-11.25 | <b>Session 4</b>  |             |
| Anthony Dickinson (Cambridge)   |             | <b>Chair: Stephen Jackson</b>   |             |
| <b>Adaptive coding of reward prediction errors</b>  | 11.25-11.50 | <b>Social gaze on action control</b>  | 16.35-17.00 |
| Hauke Heekeren (Berlin)   |             | Kai Vogeley (Cologne)   |             |
| <b>Bias in the brain: prior probability and potential payoff</b>  | 11.50-12.15 | <b>Nudging - shaping habits in the public domain</b>  | 17.00-17.25 |
| Birte Forstmann (Amsterdam)   |             | Pelle Guldborg Hansen (Odense)  |             |
| <b>Action, attention and motivation in the human inferior frontal cortex</b>                                  | 12.15-12.40 | <b>Aversive affective context influences the neural correlates of trust decisions</b>                 | 17.25-17.50 |
| Rogier Mars (Oxford)  |             | Jan Engelmann (Zürich)  |             |
| <b>Deep brain stimulation of the subthalamic nucleus prevents escalation of cocaine intake in rats</b>        | 12.40-12.50 | <i>Transportation to the Hotel &amp; Speakers dinner</i>  | 17.50-23.00 |
| Yann Pelloux (Marseille)  |             |   |             |

# Friday 17<sup>th</sup> of August

## Program

### Session 1

Chair: Simon Eickhoff

|   |             |
|---|-------------|
| <b>Intentional weighting in cognitive control</b><br>Bernhard Hommel (Leiden)   | 08.40-09.05 |
| <b>Effects of motivation on habitual actions</b><br>Yael Niv (Princeton)  | 09.05-09.30 |
| <b>Delivery and expectancy of rewards using data from fMRI, MEG and EEG experiments</b><br>Thomas Münte (Lübeck)                                      | 09.30-09.55 |
| <b>Reorganization of cerebral networks after stroke - new insights from neuro-imaging with connectivity approaches</b><br>Christian Grefkes (Cologne) | 09.55-10.20 |

*Coffee Break* 10.20-11.00

### Session 2

Chair: Stephen Jackson

|   |             |
|---|-------------|
| <b>The complementary roles of dopamine and serotonin in decision making</b><br>Robert Rogers (Oxford) | 11.00-11.25 |
| <b>The gating function of the basal ganglia</b><br>Hanneke den Ouden (Nijmegen)                       | 11.25-11.50 |
| <b>Links between novelty and reward processing</b><br>Nico Bunzeck (Hamburg)                          | 11.50-12.15 |
| <b>External vs. internal aspects of action control</b><br>Simon Eickhoff (Düsseldorf)                 | 12.15-12.40 |

*Lunch break* 12.40-14.00

### Session 3

Chair: John Rothwell

|   |             |
|---|-------------|
| <b>Action selection in PD: fMRI and accumulator modeling</b><br>James Rowe (Cambridge)  | 14.00-14.25 |
| <b>Impulse control disorders in Parkinson's disease</b><br>Thilo van Eimeren (Kiel)   | 14.25-14.50 |
| <b>Action reprogramming in Parkinson's disease</b><br>Joseph Galea (Birmingham)   | 14.50-15.15 |
| <b>Dysfunctional reward processing in basal ganglia already present at the clinical onset of Parkinson's disease</b><br>Joyce van der Vegt (Copenhagen) | 15.15-15.25 |
| <b>Modulating control over impulsive responses: a TMS-fMRI study</b><br>Damian Herz (Copenhagen)  | 15.25-15.35 |

*Coffee Break* 15.35-16.10

### Session 4

Chair: Hartwig Siebner

|  |             |
|--|-------------|
| <b>Alterations of the brain reward system in antipsychotic naïve schizophrenia patients</b><br>Mette Ødegaard Nielsen (Copenhagen)                                       | 16.10-16.35 |
| <b>Reinforcement learning: insights from neuropsychiatric diseases</b><br>Stefano Palminteri (Paris)   | 16.35-17.00 |
| <b>Anhedonia in depression and neural reward as a risk factor / trait marker</b><br>Ciara McCabe (Oxford)  | 17.00-17.25 |
| <b>Brain activity in the supplementary motor area dissociates volitional and automatic motor control mechanisms in Tourette syndrome</b><br>Stephen Jackson (Nottingham) | 17.25-17.50 |

*Transportation to the Hotel* 18.00-18.30



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European Science Foundation  
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[www.esf.org/home.html](http://www.esf.org/home.html)



Danish Research Centre for Magnetic  
Resonance (DRCMR)  
Copenhagen University  
Hospital Hvidovre,  
Hvidovre, Denmark



## Scientific workshop on Motivation & Action

*Organisers:*

Hartwig Siebner, John Rothwell, Masud Husain,  
Simon Eickhoff and Stephen Jackson

*Local Organisers:*

Anke Karabanov, Estelle Raffin, Susanne Steffensen  
and Joyce van der Vegt

*By:*

The European Science Foundation

*In cooperation with:*

The Control of Action Research group (ContAct),  
Danish Research Centre for Magnetic Resonance

Participants Lists for the ERNI-HSF Copenhagen meeting 'Motivation and Action'

| Status*  | Title**   | Firstname  | Surname         | Gender | Institute  | Country     |
|----------|-----------|------------|-----------------|--------|--|-------------|
| Convenor | Professor | Stephen    | Jackson         | M      | University of Nottingham                               | UK          |
| Convenor | Professor | Harwig     | Siebner         | M      | Copenhagen University Hospital Hvidovre                | Denmark     |
| Speaker  | Professor | John       | Rothwell        | M      | UCL Institute of Neurology                             | UK          |
| Speaker  | Professor | Simon      | Eickhoff        | M      | HHU Düsseldorf   | Germany     |
| Speaker  | Dr.       | Christelle | Baunez          | F      | CNRS   | France      |
| Speaker  | Dr.       | Hanneke    | den Ouden       | F      | Radboud University Nijmegen                            | Netherlands |
| Speaker  | Dr.       | Joseph     | Galea           | M      | UCL  | UK          |
| Speaker  | Dr.       | Yael       | Niv             | F      | Princeton University                                   | USA         |
| Speaker  | Dr        | Pelle      | Guldborg Hansen | M      | University of Southern Denmark and Roskilde University | Denmark     |
| Speaker  | Dr        | Birte      | Forstmann       | F      | University of Amsterdam                                | Netherlands |
| Speaker  | Dr        | Thilo      | van Eimeren     | M      | Christian-Albrechts University, Kiel                   | Germany     |
| Speaker  | Professor | Peter      | Redgrave        | M      | University of Sheffield                                | UK          |
| Speaker  | Dr        | Rogier     | Mars            | M      | University of Oxford                                   | UK          |
| Speaker  | Dr        | Stefano    | Palminteri      | M      | Brain and Spine Institut                               | France      |
| Speaker  | Dr        | Ciara      | McCabe          | F      | University of Oxford                                   | England     |
| Speaker  | Professor | Kai        | Vogeley         | M      | Psychiatry   | Germany     |
| Speaker  | Dr        | Sven       | Bestmann        | M      | Institute of Neurology                                 | UK          |
| Speaker  | Dr        | Christian  | Grefkes         | M      | Max Planck Institute for Neurological Research Cologne | Germany     |
| Speaker  | Dr        | K. Richard | Ridderinkhof    | M      | University of Amsterdam                                | Netherlands |
| Speaker  | Professor | Hauke      | Heekeren        | M      | Affective Neuroscience                                 | Germany     |
| Speaker  | Professor | Anthony    | Dickinson       | M      | Cambridge University                                   | UK          |

|             |           |                |                    |   |   |             |
|-------------|-----------|----------------|--------------------|---|---|-------------|
| Speaker     | Professor | Bernhard       | Hommel             | M | Institute for psychological research                    | NL          |
| Speaker     | Mr        | Damian         | Herz               | M | Copenhagen University Hospital Hvidovre                 | Denmark     |
| Speaker     | Ms        | Joyce          | van der Vegt       | F |   | Denmark     |
| Speaker     | Dr        | Henrik         | Jörntell           | M | Experimental Medical Science, Lund University           | Sweden      |
| Speaker     | Dr        | Eric           | Wassermann         | M | National Institute of Neurological Disorders and Stroke | USA         |
| Speaker     | Dr        | Yann           | Pelloux            | M | Institut des Neurosciences de la Timone CNRS UMR 7289   | France      |
| Speaker     | Miss      | Elisabeth      | Linnet             | F | Plymouth University                                     | England     |
| Speaker     | Dr        | Jan            | Engelmann          | M | Neuroscience University of Zurich Bluemlisalpstrasse 10 | Switzerland |
| Speaker     | Dr        | Thomas         | Muente             | M | University of Lübeck                                    | Germany     |
| Speaker     | Professor | Robert         | Rogers             | M | University of Oxford                                    | UK          |
| Speaker     | Dr        | Nico           | Bunzeck            | M | University Medical Center Hamburg-Eppendorf             | Germany     |
| Speaker     | Dr        | James          | Rowe               | M | Cambridge University                                    | UK          |
| Speaker     | Dr        | Mette Odegaard | Nielsen            | F | CNSR  | Denmark     |
| Participant | Ms        | Soyoung        | Kim                | F | University of Nottingham                                | UK          |
| Participant | Mr        | Mark           | Schram Christensen | M | Hvidovre Hospital                                       | Denmark     |
| Participant | Ms        | Susanne        | Henningsson        | F | DRCMR   | Denmark     |
| Participant | Ms        | Agnes          | Norbury            | F | University College London                               | UK          |
| Participant | Mr        | Ollie          | hulme              | M | DRCMR   | Denmark     |
| Participant | Mr        | Ulrich         | Kirk               | M | Virginia Tech Carilion Research Institute               | USA         |
| Participant | Ms        | Jyothika       | Kumar              | F | The University of Nottingham                            | UK          |

|             |           |                |             |   |  |                 |
|-------------|-----------|----------------|-------------|---|--|-----------------|
| Participant | Mr        | Tom            | Ziemke      | M | University of Skövde   | Sweden          |
| Participant | Dr        | India          | Morrison    | F | University of Gothenburg   | Sweden          |
| Participant | Mr        | Steffen        | Angstmann   | M | Danish Research Center for Magnetic Resonance (DRCMR)                                      | Denmark         |
| Participant | Dr        | Serge          | Thill       | M | University of Skövde   | Sweden          |
| Participant | Professor | Edward H.F.    | de Haan     | M | Universiteit van Amsterdam   | the Netherlands |
| Participant | Dr        | Lowe           | Robert      | M |  | Sweden          |
| Participant | Mr        | Noham          | Wolpe       | M | University of Cambridge  | UK              |
| Participant | Mr        | Kasper Winther | Jørgensen   | M |  | Denmark         |
| Participant | Dr        | Alessandro     | Tomassini   | M | University College London  | UK              |
| Participant | Dr        | Estelle        | Raffin      | F | Hvidovre hospital  | denmark         |
| Participant | Ms        | Anina          | Rosenbaum   | F | exercise and sport science   | Denmark         |
| Participant | Dr        | Annetette      | Løkkegaard  | F | Bispebjerg University Hospital   | Denmark         |
| Participant | Mr        | David          | Meder       | M | DRCMR  | Denmark         |
| Participant | Ms        | Kathrine Skak  | Madsen      | F | Danish Research Centre for Magnetic Resonance  | Denmark         |
| Participant | Dr        | Brian          | Haagensen   | M | Hvidovre Hospital  | Denmark         |
| Participant | Mr        | Norbert        | Brueggemann | M | DRCMR  | Denmark         |
| Participant | PhD       | Anke           | Karabanov   | F | DRCMR  | Denmark         |
| Participant | Professor | Kerstin        | Plessen von | F | Capital Region Psychiatry & Copenhagen University  | Denmark         |
| Participant | Ms        | Noemie         | Frezel      | F |  | Denmark         |
| Participant | Mr        | Jonatan        | Kornholt    | M |  | Denmark         |
| Participant | Ms        | Sofie          | Gelskov     | F |  | Denmark         |
| Participant | Dr        | Birgitte Klee  | Burton      | F | Mental health Centre Copenhagen & Mental Health Centre for Child and Adolescent Psychiatry | Denmark         |

|             |    |         |              |   |  |         |
|-------------|----|---------|--------------|---|--|---------|
|             |    |         |              |   | Bispebjerg,<br>Capital Region,<br>Copenhagen     |         |
| Participant | Mr | Lasse   | Christiansen | M | University of<br>Copenhagen                      | Denmark |
| Participant | Mr | Martin  | Skov         | M | Copenhagen<br>University<br>Hospital<br>Hvidovre | Denmark |
| Participant | Mr | Bjørn   | Hallsson     | M |  | Denmark |
| Participant | Dr | Zhang   | Jiaxiang     | M | Medical<br>Research<br>Council                   | UK      |
| Participant | Ms | Valerie | Bonnelle     | F | UCL  | UK      |