

Computational Psychiatry Seminar: Spring 2014

Computational Neuropharmacology

The Computational Role of Neuromodulatory Transmitter Systems in Cortical Plasticity

Andreea O. Diaconescu, David M. Cole and Klaas Enno Stephan

Where & when: The course takes place on Friday afternoons from 14.00-16.00 in room ETZ F 91 (ETZ building on Gloriosastrasse) during the spring semester 02-05, 2014.

Credit: To receive credit points, you must

- **either** give a **1-hr** presentation in one of the seminar sessions covering all the papers suggested for that chapter.
- **or design and program** your own computational model based on the topics discussed in the seminar and apply to simulated data that will be provided. The relevant papers will be highlighted over the course of the seminar.

Basic Principles of Neuropharmacology (21.02-14.03)

Week 1: Introduction to Neuropharmacology

Presenter: Andreea Diaconescu

Reading List

1. Stahl, Stephen M, and Nancy Muntner. 2013. *Stahl's Essential Psychopharmacology: Neuroscientific Basis and Practical Application*. Cambridge: Cambridge University Press. **Chapter 1** ([link to Chapter provided](#))
2. Zucker, R. S., & Regehr, W. G. (2002). Short-term synaptic plasticity. *Annu Rev Physiol*, 64, 355-405.
3. Feldman, Daniel E. 2012. "The Spike-Timing Dependence of Plasticity." *Neuron* 75 (4): 556-71.

4. Pawlak, Verena, Jeffery R. Wickens, Alfredo Kirkwood, and Jason N. D. Kerr. 2010. "Timing Is Not Everything: Neuromodulation Opens the STDP Gate." *Frontiers in Synaptic Neuroscience* 2: 146.

Week 2: Neuromodulators and their role in Cortical Plasticity

Presenter: David Cole

Reading List

1. Stahl, Stephen M, and Nancy Muntner. 2013. *Stahl's Essential Psychopharmacology: Neuroscientific Basis and Practical Application*. Cambridge: Cambridge University Press. **Chapter 2** ([link to Chapter provided](#))
2. Gu, Q. 2002. "Neuromodulatory Transmitter Systems in the Cortex and Their Role in Cortical Plasticity." *Neuroscience* 111: 815–35.
3. Sesack SR, Grace AA. 2010. "Cortico-Basal Ganglia Reward Network: Microcircuitry." *Neuropsychopharmacology* 35: 27-47.

Optional Reading:

1. Cools R, and D'Esposito M. 2011. "Inverted-U shaped dopamine actions on human working memory and cognitive control." *Biological Psychiatry* 69(12): e113-e125.
2. Naidich, Thomas P, and Henri M Duvernoy. 2009. *Duvernoy's Atlas of the Human Brain Stem and Cerebellum High-Field MRI: Surface Anatomy, Internal Structure, Vascularization and 3D Sectional Anatomy*. Wien; New York: Springer. ([link to Textbook provided](#))

Week 3: Computational and Physiological Models (Part 1)

Presenter: Kate Lomakina

Reading List

1. Mathys, C., J. Daunizeau, K. J. Friston, and K. E. Stephan. 2011. "A Bayesian Foundation for Individual Learning under Uncertainty." *Front Hum Neurosci* 5.
2. Friston, Karl. 2010. "The Free-Energy Principle: A Unified Brain Theory?" *Nature Reviews Neuroscience* 11 (2): 127–38.
3. Schultz, Wolfram, Peter Dayan, and P. Read Montague. 1997. "A Neural Substrate of Prediction and Reward." *Science* 275 (5306): 1593–99.

Optional Reading:

1. Bastos, Andre M., W. Martin Usrey, Rick A. Adams, George R. Mangun, Pascal Fries, and Karl J. Friston. 2012. "Canonical Microcircuits for Predictive Coding." *Neuron* 76 (4): 695–711.

Week 4: Computational and Physiological Models (Part 2)

Presenter: Daniel Renz

Reading List

1. Stephan, K. E., L. M. Harrison, S. J. Kiebel, O. David, W. D. Penny, and K. J. Friston. 2007. "Dynamic Causal Models of Neural System Dynamics: Current State and Future Extensions." *Journal of Biosciences* 32: 129–44.
2. Stephan, Klaas Enno, Lars Kasper, Lee M. Harrison, Jean Daunizeau, Hanneke E.M. den Ouden, Michael Breakspear, and Karl J. Friston. 2008. "Nonlinear Dynamic Causal Models for fMRI." *NeuroImage* 42 (2): 649–62.
3. Moran, Rosalyn J., Mkael Symmonds, Klaas E. Stephan, Karl J. Friston, and Raymond J. Dolan. 2011. "An In Vivo Assay of Synaptic Function Mediating Human Cognition." *Current Biology* 21 (15): 1320–25.
4. Schmidt, A., A. O. Diaconescu, M. Kommer, K. J. Friston, K. E. Stephan, and F. X. Vollenweider. 2012. "Modeling Ketamine Effects on Synaptic Plasticity During the Mismatch Negativity." *Cerebral Cortex* 23(10): 2394–406.
5. Den Ouden, H. E. M., J. Daunizeau, J. Roiser, K. J. Friston, and K. E. Stephan. 2010. "Striatal Prediction Error Modulates Cortical Coupling." *Journal of Neuroscience* 30 (9): 3210–19.

Optional Reading:

1. Rolls, Edmund T., Marco Loh, Gustavo Deco, and Georg Winterer. 2008. "Computational Models of Schizophrenia and Dopamine Modulation in the Prefrontal Cortex." *Nature Reviews Neuroscience* 9 (9): 696–709.

Dopamine (21.03-28.03)

Week 5: The Role of Dopamine in Learning and Plasticity

Presenter: Eduardo Aponte

Reading List

1. Calabresi P, Picconi B, Tozzi A, Di Filippo M. 2007. "Dopamine-mediated regulation of corticostriatal synaptic plasticity." *Trends in Neuroscience* 30(5): 211-9.
2. Pawlak, Verena, and Jason N. D. Kerr. 2008. "Dopamine Receptor Activation Is Required for Corticostriatal Spike-Timing-Dependent Plasticity." *The Journal of Neuroscience* 28 (10): 2435–46.

3. Shen, Weixing, Marc Flajolet, Paul Greengard, and D. James Surmeier. 2008. "Dichotomous Dopaminergic Control of Striatal Synaptic Plasticity." *Science* 321 (5890): 848–51.
4. D'Ardenne, Kimberlee, Terry Lohrenz, Krystle A. Bartley, and P. Read Montague. 2013. "Computational Heterogeneity in the Human Mesencephalic Dopamine System." *Cognitive, Affective, & Behavioral Neuroscience* 13 (4): 747–56.
5. Matsumoto, Masayuki, and Masahiko Takada. 2013. "Distinct Representations of Cognitive and Motivational Signals in Midbrain Dopamine Neurons." *Neuron* 79 (5): 1011–24.
6. Friston, Karl J., Tamara Shiner, Thomas FitzGerald, Joseph M. Galea, Rick Adams, Harriet Brown, Raymond J. Dolan, Rosalyn Moran, Klaas Enno Stephan, and Sven Bestmann. 2012. "Dopamine, Affordance and Active Inference." *PLoS Computational Biology* 8 (1).
7. Schultz, Wolfram. 2013. "Updating Dopamine Reward Signals." *Current Opinion in Neurobiology* 23 (2): 229–38.
8. Steinberg, Elizabeth E., Ronald Keiflin, Josiah R. Boivin, Ilana B. Witten, Karl Deisseroth, and Patricia H. Janak. 2013. "A Causal Link between Prediction Errors, Dopamine Neurons and Learning." *Nature Neuroscience* 16 (7).

Week 6: Dopamine and Pathology

Presenter: Helene Haker & Sara Tomiello

Reading List

Schizophrenia

1. Adams, Rick A., Klaas Enno Stephan, Harriet R. Brown, Christopher D. Frith, and Karl J. Friston. 2013. "The Computational Anatomy of Psychosis." *Frontiers in Psychiatry* 4.
2. Stephan, K. E., K. J. Friston, and C. D. Frith. 2009. "Dysconnection in Schizophrenia: From Abnormal Synaptic Plasticity to Failures of Self-Monitoring." *Schizophrenia Bulletin* 35: 509–27.
3. Kapur, Shitij. 2003. "Psychosis as a State of Aberrant Salience: A Framework Linking Biology, Phenomenology, and Pharmacology in Schizophrenia." *American Journal of Psychiatry* 160 (1): 13–23.
4. Winton-Brown, Toby T., Paolo Fusar-Poli, Mark A. Ungless, and Oliver D. Howes. 2014. "Dopaminergic Basis of Salience Dysregulation in Psychosis." *Trends in Neurosciences* 37 (2): 85–94.

Parkinson's Disease

5. Dagher, Alain, and Trevor W. Robbins. 2009. "Personality, Addiction, Dopamine: Insights from Parkinson's Disease." *Neuron* 61 (4): 502–10.

Impulsivity/Compulsivity

6. Everitt BJ, Robbins TW. 2005. "Neural systems of reinforcement for drug addiction: from actions to habits to compulsion." *Nature Neuroscience* 8(11): 1481-9.

Serotonin (04.04-11.04)

Week 7: The Role of Serotonin in Learning and Plasticity

Presenter: Frederike Petzschner & Tina Wentz

Reading List

1. Lesch KP, Waider J. 2012. "Serotonin in the Modulation of Neural Plasticity and Networks: Implications for Neurodevelopmental Disorders." *Neuron* 76(1): 175-91.
2. Dayan, Peter, and Quentin J.M. Huys. 2009. "Serotonin in Affective Control." *Annual Review of Neuroscience* 32 (1): 95-126.
3. Seymour, Ben, Nathaniel D. Daw, Jonathan P. Roiser, Peter Dayan, and Ray Dolan. 2012. "Serotonin Selectively Modulates Reward Value in Human Decision-Making." *The Journal of Neuroscience* 32 (17): 5833-42.
4. Schweighofer, N., S. C. Tanaka, and K. Doya. 2007. "Serotonin and the Evaluation of Future Rewards: Theory, Experiments, and Possible Neural Mechanisms." *Annals of the New York Academy of Sciences* 1104 (1): 289-300.

Week 8: Serotonin and Pathology

Presenter: Quentin Huys

Reading List

Depression

1. Dayan, Peter, and Quentin J. M. Huys. 2008. "Serotonin, Inhibition, and Negative Mood." *PLoS Computational Biology* 4 (2): e4.
2. Vollenweider, Franz X., and Michael Kometer. 2010. "The Neurobiology of Psychedelic Drugs: Implications for the Treatment of Mood Disorders." *Nature Reviews Neuroscience* 11 (9): 642-51.

Impulsivity

1. Crockett MJ, Clark L, Robbins TW. 2009. "Reconciling the role of serotonin in behavioral inhibition and aversion: acute tryptophan depletion abolishes punishment-induced inhibition in humans." *Journal of Neuroscience* 29(38): 11993-9.

2. Miyazaki, Katsuhiko, Kayoko W. Miyazaki, and Kenji Doya. 2012. "The Role of Serotonin in the Regulation of Patience and Impulsivity." *Molecular Neurobiology* 45 (2): 213-24.

Easter holiday: Friday, 18.04.2014 - Sunday, 27.04.2014

Neuromodulatory System Interactions (02.05-16.05)

Week 9: Serotonin and Dopamine

Presenter: Atanas Stankov

Reading List

Opponent/complementary interactions

1. Boureau, Y-Lan, and Peter Dayan. 2010. "Opponency Revisited: Competition and Cooperation Between Dopamine and Serotonin." *Neuropsychopharmacology* 36 (1): 74-97.
2. Guitart-Masip, Marc, Marcos Economides, Quentin J. M. Huys, Michael J. Frank, Rumana Chowdhury, Emrah Duzel, Peter Dayan, and Raymond J. Dolan. 2013. "Differential, but Not Opponent, Effects of L-DOPA and Citalopram on Action Learning with Reward and Punishment." *Psychopharmacology* 231 (5): 955-66.
3. den Ouden HE, Daw ND, Fernandez G, Elshout JA, Rijpkema M, Hoogman M, Franke B, Cools R. 2013. "Dissociable effects of dopamine and serotonin on reversal learning". *Neuron* 80 (4): 1090-1100.

Impulsivity

1. Dalley, J. W., and J. P. Roiser. 2012. "Dopamine, Serotonin and Impulsivity." *Neuroscience* 215: 42-58.
2. Redish, A. D., and A. Johnson. 2007. "A Computational Model of Craving and Obsession." *Annals of the New York Academy of Sciences* 1104 (1): 324-39.
3. Robbins, Trevor W., Claire M. Gillan, Dana G. Smith, Sanne de Wit, and Karen D. Ersche. 2012. "Neurocognitive Endophenotypes of Impulsivity and Compulsivity: Towards Dimensional Psychiatry." *Trends in Cognitive Sciences* 16 (1): 81-91.

Week 10: Acetylcholine and Dopamine

Presenter: Sandra Iglesias

Reading List

1. Iglesias, Sandra, Christoph Daniel Mathys, Kay Henning Brodersen, Lars Kasper, Hanneke E.M. den Ouden, and Klaas E. Stephan. 2013. "Hierarchical Prediction Errors in Midbrain and Basal Forebrain during Sensory Learning." *Neuron* 80(2):519-30.
2. Moran, Rosalyn J., Pablo Campo, Mkael Symmonds, Klaas E. Stephan, Raymond J. Dolan, and Karl J. Friston. 2013. "Free Energy, Precision and Learning: The Role of Cholinergic Neuromodulation." *The Journal of Neuroscience* 33 (19): 8227-36.
3. Yu, Angela J., and Peter Dayan. 2005. "Uncertainty, Neuromodulation, and Attention." *Neuron* 46 (4): 681-92.
4. Lester, Deranda B, Tiffany D. Rogers, and Charles D. Blaha. 2010. "Acetylcholine-Dopamine Interactions in the Pathophysiology and Treatment of CNS Disorders." *CNS Neuroscience & Therapeutics* 16 (3): 137-62.
5. Mansvelder, Huibert D, and Daniel S McGehee. 2000. "Long-Term Potentiation of Excitatory Inputs to Brain Reward Areas by Nicotine." *Neuron* 27 (2): 349-57.
6. Mao, Danyan, Keith Gallagher, and Daniel S. McGehee. 2011. "Nicotine Potentiation of Excitatory Inputs to Ventral Tegmental Area Dopamine Neurons." *The Journal of Neuroscience* 31 (18): 6710-20.

Week 11: The Role of Noradrenaline in Learning and Plasticity

Presenter: Valance Wang & Gabor Stefanics

Reading List

1. Dayan, Peter. 2012. "Twenty-Five Lessons from Computational Neuromodulation." *Neuron* 76 (1): 240-56.
2. Chamberlain SR, Müller U, Blackwell AD, Clark L, Robbins TW, Sahakian BJ. 2006. "Neurochemical modulation of response inhibition and probabilistic learning in humans." *Science* 311(5762): 861-3.
3. Doya K. 2008. "Modulators of decision making." *Nature Neuroscience* 11(4): 410-6.
4. Preuschoff, Kerstin, Bernard Marius 't Hart and Wolfgang Einhäuser. 2011. "Pupil Dilation Signals Surprise: Evidence for Noradrenaline's Role in Decision Making." *Frontiers in Neuroscience* 5: 115.
5. Yu, Angela J., and Peter Dayan. 2005. "Uncertainty, Neuromodulation, and Attention." *Neuron* 46 (4): 681-92.
6. Eldar, Eran, Jonathan D. Cohen, and Yael Niv. 2013. "The Effects of Neural Gain on Attention and Learning." *Nature Neuroscience* 16 (8): 1146-53.

Seminar Finale: Guest Lecture & Student Project Presentations (23.05-30.05)

Week 12: Implications of Cocaine Use in Impulsivity and Social Interaction

Presenter: Prof. Boris Quednow

Reading List

1. Hulka, L. M., C. Eisenegger, K. H. Preller, M. Vonmoos, D. Jenni, K. Bendrick, M. R. Baumgartner, E. Seifritz, and B. B. Quednow. 2013. "Altered Social and Non-Social Decision-Making in Recreational and Dependent Cocaine Users." *Psychological Medicine*: 1–14.
2. Preller, Katrin H., Marcus Herdener, Leonhard Schilbach, Philipp Stämpfli, Lea M. Hulka, Matthias Vonmoos, Nina Ingold, Kai Vogeley, Philippe N. Tobler, and Erich Seifritz. 2014. "Functional Changes of the Reward System Underlie Blunted Response to Social Gaze in Cocaine Users." *Proceedings of the National Academy of Sciences*: 201317090.
3. Vonmoos, M., et al. (2013). "Differences in self-reported and behavioral measures of impulsivity in recreational and dependent cocaine users." *Drug Alcohol Depend* 133(1): 61-70.
4. Preller, K. H., et al. (in press). "Impaired emotional empathy and related social network deficits in cocaine users." *Addict Biol*.

Week 13: Student Project Presentations