

Opto-fMRI of Monoaminergic Systems and Psychotropic Drugs

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Introduction

- One
- Two
- Four

Monoaminergic systems are ensembles of neurons defined by the primary production of monoamine neurotransmitters (most prominently serotonin, dopamine, and noradrenaline). The current project aims to establish opto-fMRI as an assay for monoaminergic systems. This assay will help elucidate the functional mechanisms of psychotropic drugs, and facilitate the establishment of functional connectivity and inter-connectivity models for these most pervasive neuronal systems.

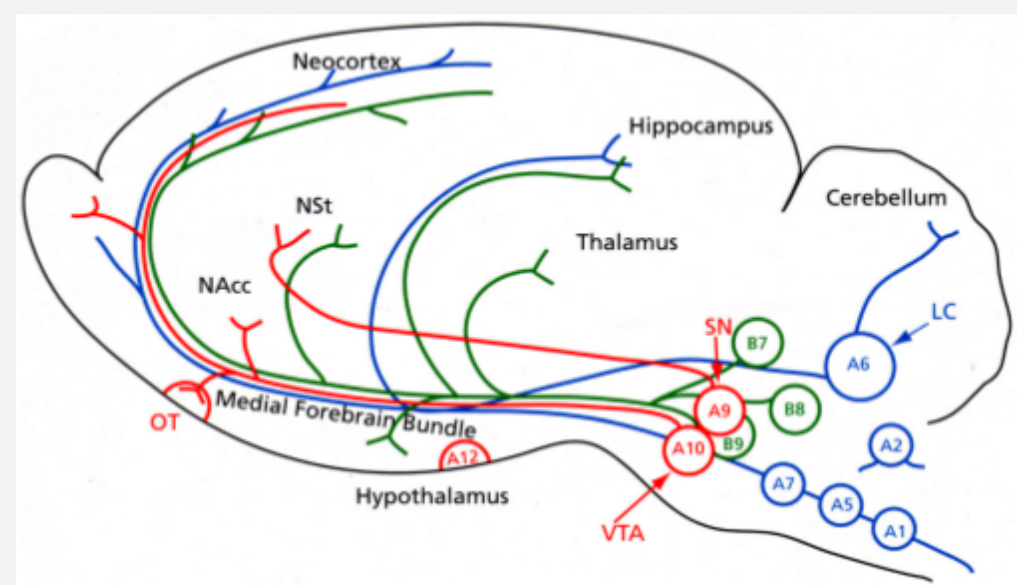


Figure 1: Serotonergic (green), dopaminergic (red), and noradrenergic (blue) nuclei and significant projections [1]

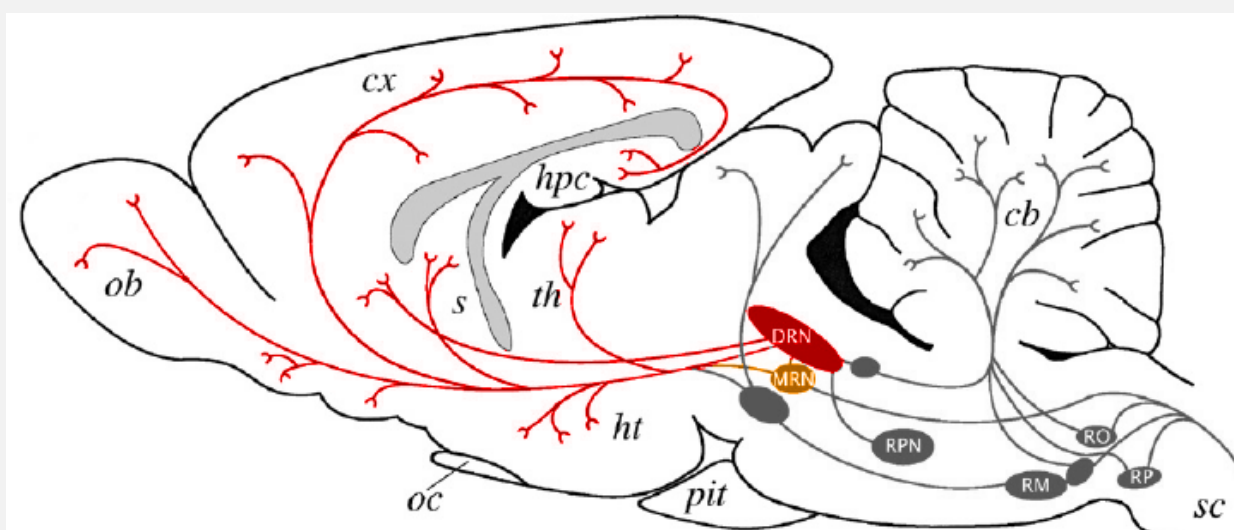


Figure 2: Ascending serotonergic projections alone innervate the majority of cortical and subcortical areas [2]

Methods

For robust genotyping we have designed 2 multiplex-compatible primer pairs for the Cre recombinase (transgene construct) and GAPDH (positive control). These are listed below, alongside a genotyping assay featuring 3 controls (water, known transgene, and known wildtype - on the first, second-to-last and last non-ladder lanes respectively): To facilitate multimodal and exploratory data analysis, LabbookDB - a relational database structure - was developed to replace the common lab book and integrate metadata directly with analysis tools. In order to facilitate rapid, cheap, and flexible access to the high computing power needed for exploratory fMRI analysis, a cloud-computing GNU/Linux image, NeuroGentoo was created; and populated with a multitude of neuroimaging package atoms.



Figure 5: NeuroGentoo Logo; for the software repository see: github.com/TheChymera/neurogentoo



Figure 6: Generic DB logo (CC BY-NC-SA Barry Mieny); for the software package see: github.com/TheChymera/labbookdb

Chronic Serotonin Reuptake Inhibition

Selective Serotonin Reuptake Inhibitors (SSRI) are used in the treatment of depression, and have differing acute (e.g. stimulant and anxiogenic) and chronic (antidepressant and anxiolytic) effects - with the neuronal mechanism of the latter still being widely debated. Possible explanations include the down-regulation of either the serotonin transporter protein (SERT), and/or serotonergic autoreceptors (5-HT_{1A}). We are administering fluoxetine both chronically and acutely to a number of animals prepared for opto-fMRI; we present the timetable of the first cohort in figure 4.

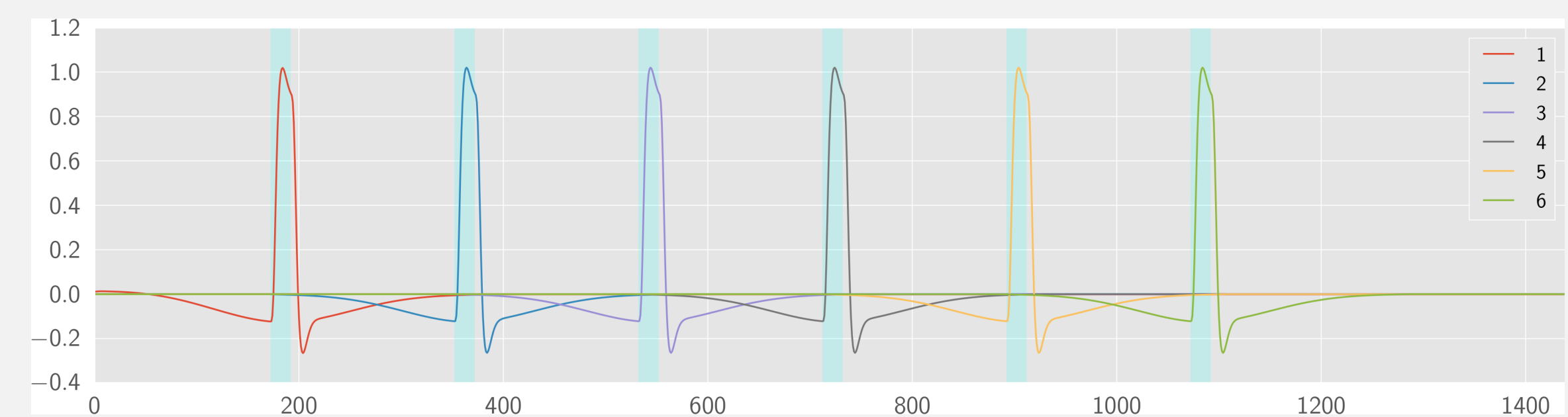


Figure 3: Band-pass filtered pulse-train-resolved first-level design model, with pulse trains represented in cyan.

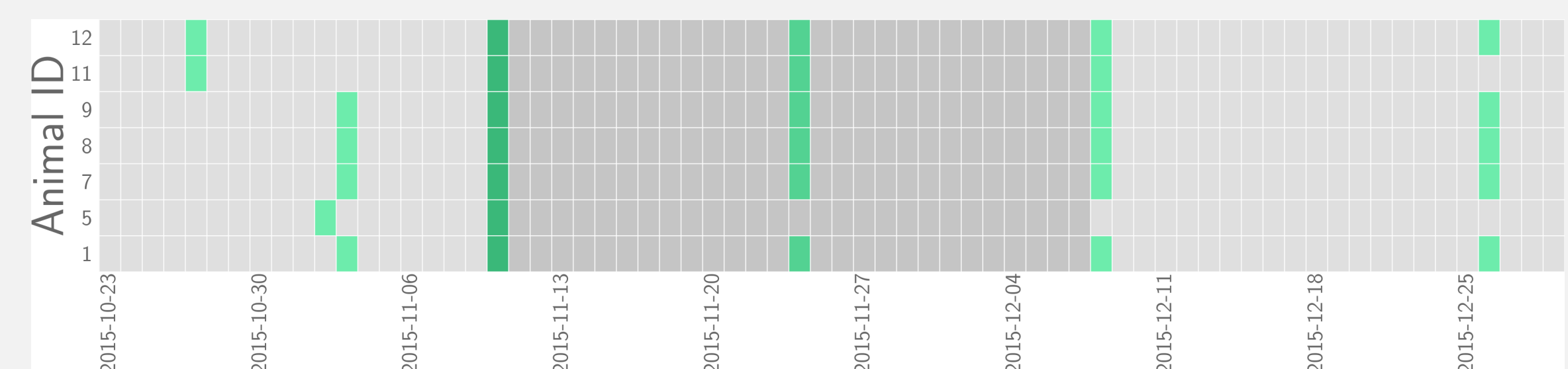


Figure 4: Animal cohort treatment and measurement timetable. Opto-fMRI scan dates are tinted turquoise. Treatment-free days are shaded light gray, chronic (i.p.) fluoxetine administration days medium gray, and acute (i.v.) fluoxetine administration days dark gray.

Acute Fluoxetine Effects

Preliminary results from the comparison of the first two measurement sessions (as seen in figure 4) indicate that the uncorrected response to optogenetic stimulation across all trains (depicted individually in figure 3) is stronger and more widespread immediately after acute fluoxetine administration than in the drug-naïve mouse. It is important to note that the results seen in figure 7 need further statistical elaboration.

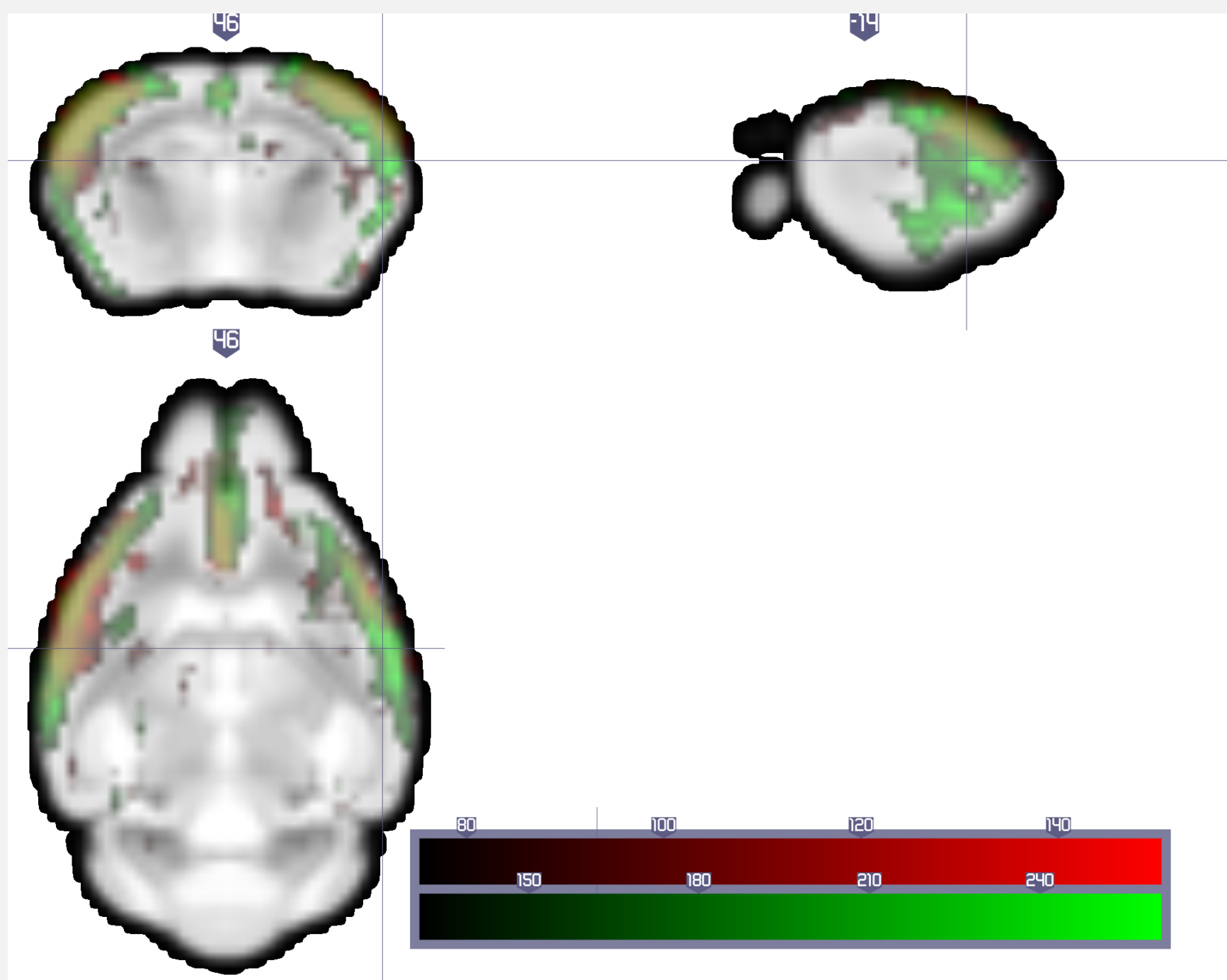


Figure 7: Contrast for all stimulation train parameter estimates for the pre-drug-administration session (red) and the acute fluoxetine administration session (green). Note the considerably different scales.

References

- [1] P. Marjamäki.
IMAGING OF DOPAMINE AND SEROTONIN TRANSPORTERS - Pre-Clinical Studies with Radiotracers for Positron Emission Tomography.
PhD thesis, Turun Yliopisto University of Turku, 2011.
- [2] S. O. Ögren, T. M. Eriksson, E. Elvander-Tottie, C. D'Addario, J. C. Ekström, P. Svenningsson, B. Meister, J. Kehr, and O. Stiedl.
The role of 5-Ht1A receptors in learning and memory.
Behavioural Brain Research, 195(1):54–77, Dec 2008.