NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

Computational Neuroscience: A Lecture Series from Models to Applications
Summer semester 2016 – Exam for course TUM EI7646, LMU P10.2
Date: 12.07.2016, 6:00 p.m., Location: LMU Main building, Room A017

- **First of all, please check the completeness of your documents: the exam consists of 11 pages printed on individual sheets.**
- **Please turn off all electronic devices and store them somewhere non-visible and non-reachable. You are not allowed to make use of them.**
- **Please have your student ID as well as a photo ID ready.**
- **Only writing materials are permitted (no calculators!).**
- **Write down your full name and your student ID (matr. nr.) on top of each sheet.**
- **In case you need more sheets of paper, please feel free to contact a proctor. Please do not forget to write down your full name and your student ID on the new sheet.**
- **Please put your answer below each question! Do not use a separate sheet of paper.**

Hiermit bestätige ich, dass ich vor Prüfungsbeginn darüber in Kenntnis gesetzt wurde, dass ich im Falle einer plötzlich während der Prüfung auftretenden Erkrankung das Aufsichtspersonal umgehend informieren muss. Dies wird im Prüfungsprotokoll vermerkt. Danach muss unverzüglich ein Rücktritt von der Prüfung beim zuständigen Prüfungsausschuss beantragt werden. Ein vertrauensärztliches Attest – ausgestellt am Prüfungstag – ist unverzüglich nachzureichen. Wird die Prüfung hingegen in Kenntnis der gesundheitlichen Beeinträchtigung dennoch regulär beendet, kann im Nachhinein kein Prüfungsrücktritt aufgrund von Krankheit beantragt werden. Wird die Prüfung wegen Krankheit abgebrochen, wird die Klausur als "nicht erschienen" gemeldet und – unabhängig von einem Rücktrittsantrag – nicht bewertet.

Non-official English translation – *Hereby I certify that I am instructed of the following before the start of the written exam: in case of a sudden onset of illness during the exam, it is my responsibility to inform one of the proctors. This will be noted down in the exam protocol. Subsequently, I have to request my withdrawal from the exam at the authorized examination office (Prüfungsamt). Moreover, I will be responsible to hand in an attest by the TUM/LMU fiduciary physicist – issued at the day of the exam. However, I cannot request my withdrawal from the exam in case I am fully aware of my impaired medical condition during the exam and decide to finish it regularly. In case of a termination due to illness, the outcome of the exam will be reported as "absent" ("nicht erschienen") and will not be affected by a request of withdrawal from the exam.*

München, den 12.07.2016

.....

(Signature)

Points (to be filled in by the examiner):

Question	1 [3 P]	2 [3 P]	3 [3 P]	4 [3 P]	5 [3 P]	6 [3 P]
Points						

Question	7 [3 P]	8 [5 P]	9 [4 P]	10 [3 P]	11 [4 P]	12 [4 P]
Points						

Σ **of 41 points – Final grade:**

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

1. (Neuroanatomy) **[3 P]**
What anatomical details characterize the (human) cortex?

2. (Neurophysiology) **[3 P]**
Membrane channels for ions usually change their conformation depending on specific gating factors. Please name the three basic factors that control the conformation of membrane channels, and shortly describe the mechanism that leads to the opening/closing of these channels.

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

3. (Hodgkin-Huxley Model) **[3 P]**

The Hodgkin-Huxley Model for a point-neuron consists of four coupled differential equations. To simplify the dynamics, one can reduce the dimensionality of the model from 4D to 3D. Which component of the model is altered, how is this done, and why is this possible?

4. (Synaptic dynamics and plasticity) **[3 P]**

In class, we discussed the study of Tsodyks and Markram (PNAS 1997). What are the main take-home messages concerning synaptic transmission, synaptic plasticity and constraints for neural coding?

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

5. (Collective properties of feedback networks) **[3 P]**
What is a Lyapunov (or "Energy") function and what can it be used for?

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

6. (Hippocampal dynamics) **[3 P]**

Please, describe the experimental evidence for the temporal sequential dynamics of place cells in the hippocampus during awake running and sleep.

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

7. (Spatial cognition) **[3 P]**

Inertial sensors, such as the otolith organs in the inner ear of vertebrates, cannot distinguish between gravity and linear acceleration. Nonetheless, we rarely misperceive linear accelerations as body tilt or vice versa.

(a) Give an example where we perceive linear acceleration as body tilt. [1 P]

(b) The problem is solved by our brain by taking into account other information from another sensory modality. In the absence of vision and sound, which sensory information is used? Which sensor is measuring it? [1 P]

(c) Which mechanism has been proposed for this case of multimodal sensor fusion? [1 P]

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

8. (Modeling perception) **[5 P]**

In perceptual discrimination experiments, two-alternative-forced-choice (2AFC) methods allow fitting a psychometric function to response data. What are the two most important parameters of the psychometric fit and what information do these parameters convey about the underlying perceptual estimate? What is the advantage of the 2AFC method over alternative methods such as method of adjustment?

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

9. (Human neuroimaging) **[4 P]**

How is whole-brain connectivity quantified using data from functional magnetic resonance imaging? Name one way in which this measure can then be analysed for whole-brain computational modeling? Give one successful application of whole-brain connectivity to a specific research question.

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

10. (Population coding) **[3 P]**

Please, explain the key principles of the concept of population coding and describe which parameters determine the coding precision of a population code. Which statistical measure can be used to quantify the coding precision of a population code?

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

11. (Cochlear implants) **[4 P]**

(a) Sketch into the axes below the behavior of the firing probability of a single auditory nerve fiber as a function of stimulation current for monophasic (or biphasic) electrical pulses in cochlear implants. Label the axes! [2 P]

(b) Label the firing threshold in your graph. [1 P]

(c) Briefly describe what are the T- and C-level in clinical cochlear implants. [1 P]

NAME: ..... MATR. NR.: .....

Bernstein Center for Computational Neuroscience Munich

12. (Neurotechnology) **[4 P]**

Camera vs Retina

(a) Briefly describe the working principle of a standard frame-based camera. [1.5 P]

(b) Now contrast that to the human retina: Name at least 3 retinal vision processing features that can not be found in conventional cameras. [1.5 P]

(c) Name and briefly describe a neuromorphic vision technology that implements one of those features. [1 P]