

Spontaneous state switching in realistic mean-field model of visual cortex with heteroclinic channel

Nguyen Trong, Manh; Bojak, Ingo; Knösche, Thomas R

DOI:

[10.1186/1471-2202-12-S1-P175](https://doi.org/10.1186/1471-2202-12-S1-P175)

License:

Creative Commons: Attribution (CC BY)

Document Version

Publisher's PDF, also known as Version of record

Citation for published version (Harvard):

Nguyen Trong, M, Bojak, I & Knösche, TR 2011, Spontaneous state switching in realistic mean-field model of visual cortex with heteroclinic channel. in *BMC Neuroscience: Twentieth Annual Computational Neuroscience Meeting: CNS*2011*. vol. 12 (Suppl 1), P175, BMC Neuroscience, vol. 12 (Suppl 1), Twentieth Annual Computational Neuroscience Meeting, 2011, Stockholm, Sweden, 23/07/11. <https://doi.org/10.1186/1471-2202-12-S1-P175>

[Link to publication on Research at Birmingham portal](#)

Publisher Rights Statement:

This is an open access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/2.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Checked July 2015

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

POSTER PRESENTATION

Open Access

Spontaneous state switching in realistic mean-field model of visual cortex with heteroclinic channel

Manh Nguyen Trong^{1,2*}, Ingo Bojak³, Thomas R Knösche¹

From Twentieth Annual Computational Neuroscience Meeting: CNS*2011
Stockholm, Sweden. 23-28 July 2011

Spontaneous switching between cortical states in the visual cortex of cat was reported by Kenet *et al.* [1]: a succession of spatial activation patterns normally associated with visual input was observed even in the absence of external input. Using a Wilson-Cowan network, Blumenfeld *et al.* [2] proposed a model for this phenomenon that generated multistability by applying unstructured noise. Here we use the biologically realistic

mean-field model of Jansen & Rit [3], together with the heteroclinic channel theory proposed by Rabinovich *et al.*, cf. Ref. [5], to propose a mechanism how such spontaneous switching between states could occur independent of extrinsic noise.

A hypercolumn in V1 is made up of orientation preference columns (OPC), which selectively respond to specifically oriented stimuli. Our model of an OPC con-

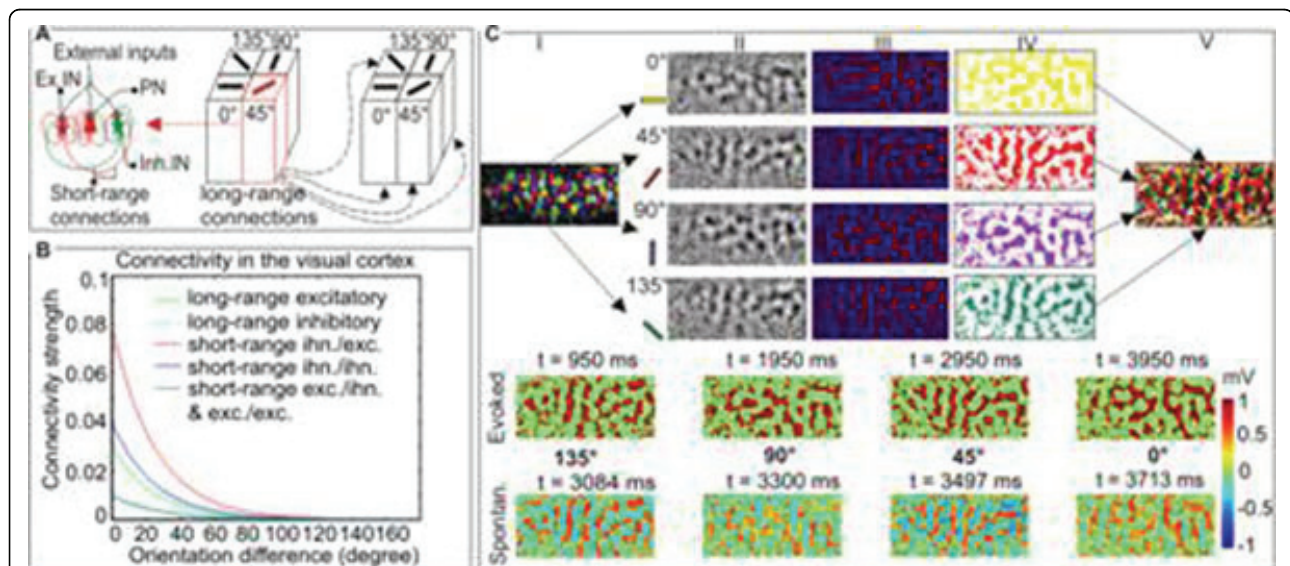


Figure 1 A. Basic model setup. B. Assumed decay of connectivity with orientation difference [4]. C. Spatial layout of OPCs and examples of the simulated evoked and spontaneous activity.

* Correspondence: nguyen@cbs.mpg.de

¹Max Planck Institute for Human Cognitive and Brain Sciences, 04103
Leipzig, Germany

Full list of author information is available at the end of the article

sists of 3 neuronal populations: pyramidal neurons (PN) and excitatory (Ex. IN) / inhibitory interneurons (Inh. IN), see Fig. 1A. Their connectivity decays exponentially with orientation difference, see Fig. 1B. These decays, and the spatial layout shown in Fig. 1C(I,II), are derived from the data of Gilbert & Wiesel [4]. The interactions between the OPCs are described by integral differential equations:

$$\Theta(\mathbf{V}(r, t)) = -K \int_R \mathbf{W}(r, \tilde{r}) S(\mathbf{V}(r, t)) d\tilde{r} + \mathbf{I}^{ext}(r, t)$$

[Θ : 2nd order differential operator, \mathbf{V} : membrane potentials, \mathbf{W} : connectivity, \mathbf{S} : sigmoid function, \mathbf{I} : input, \mathbf{K} : gain]

Evoked activity was simulated by applying input to a specific hypercolumn, yielding patterns that are very similar to the OPC distribution maps - compare Fig. 1C (Evok.) with 1C(IV,V). Importantly however, even without any external stimulus the system spontaneously switches from one state to another, see Fig. 1C(Spon.). In state space the system evolves in a heteroclinic channel, made up by the trajectories near a chain of saddle points (representing the OPCs) and associated unstable separatrices. The inhibitory connectivity governs this sequence of activation. Imposing noise on this connectivity can introduce randomness into the sequence of activation.

In this study we have combined mean-field and heteroclinic channel theory in order to describe the experimental observation of spontaneous state switching [1]. In contrast to Ref. [2], we do not need to impose unstructured noise to create multistability here. Furthermore, manipulations of our inhibitory connectivity matrix can vary the resulting sequence of states, e.g., in order to accommodate expectations about the next stimulus.

Author details

¹Max Planck Institute for Human Cognitive and Brain Sciences, 04103 Leipzig, Germany. ²Institute for Biomedical Engineering and Informatics, Technical University of Ilmenau, 98693 Ilmenau, Germany. ³Donders Centre for Neuroscience, Radboud University Medical Centre, 6500 HB Nijmegen, The Netherlands.

Published: 18 July 2011

References

1. Kenet T, Bibitchkov D, Tsodyks M, Grinvald A, Arieli A: Spontaneously emerging cortical representations of visual attributes. *Nature* 2003, **425**:954-956.
2. Blumenfeld B, Bibitchkov D, Tsodyks M: Neural network model of the primary visual cortex: from functional architecture to lateral connectivity and back. *J Comput Neurosci* 2006, **29**:219-241.
3. Jansen BH, Rit VG: Electroencephalogram and visual evoked potential generation in a mathematical model of coupled columns. *Biol Cybern* 1995, **73**:357-366.

4. Gilbert CD, Wiesel TN: Columnar specificity of intrinsic horizontal connections and corticocortical connections in cat visual cortex. *J Neurosci* 1989, **9**:2432-2442.
5. Afraimovich VS, Rabinovich MI, Varona P: Heteroclinic contours in neural ensembles and the winnerless competition principle. *Int J Bifurcat Chaos* 2004, **14**:151-158.

doi:10.1186/1471-2202-12-S1-P175

Cite this article as: Trong et al.: Spontaneous state switching in realistic mean-field model of visual cortex with heteroclinic channel. *BMC Neuroscience* 2011 **12**(Suppl 1):P175.

Submit your next manuscript to BioMed Central and take full advantage of:

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

