Report from 2015 OHBM Hackathon (HI)

# Self-Organization and Brain Function

**Project URL:** http://brainhack.org/self-organization-and-brain-function

J. P. Pfannmöller[1*], R. Mesquita[2], L.C.T. Herrera[2] and Daniela Dentico[3]

## 1 Introduction

Self-organization is a fundamental property of complex systems, describing the order spontaneously arising by the local interactions of the system components not mediated by top-down inputs. Though, self-organizing systems typically possess a large number of components and exhibit complex dynamics, their evolution is deterministic and governed by a small number of order parameters. This property was used to model the self-organization of the ocular dominance columns of the striate cortex in patterns of neighboring stripes [1], which respond preferentially to inputs from the left or the right eye. In this model the self-organization across ocular dominance and orientation preference layers was coupled, were both layers were modeled with the Swift-Hohenberg equation [2]. We reduce the model complexity by including only the cortical dominance layer and investigate the parameter dependency of the self-organization with a Matlab implementation.

## 2 Approach

The Swift-Hohenberg equation [2] was used to model the self-organization of the ocular dominance columns. There are two order parameters in this equation, the first one determines the spatial wavelength $\lambda$ of the stripes and the second one the branchiness $\epsilon$ of the pattern. $\Delta$ is the Laplace operator.

$$\partial_t \psi(x, y, t) = [\epsilon - (\Delta + \frac{4\pi^2}{\lambda^2})^2] \cdot \psi - \psi^3 \tag{1}$$

The algorithm used to generate the results has been modified from an open source script. The Swift-Hohenberg equation was solved by applying periodic boundary conditions after a Fourier transform to k space, which simplifies the computation of the solution.

## 3 Results

Figures (a), (b) and (c) show the temporal evolution of the solution to the Swift-Hohenberg equation for random initial conditions (a), constant $\epsilon$ and time increasing from (a) to (c). In (c), (d) and (e) three solutions with different $\epsilon$ are shown. The branchiness increases with $\epsilon$ from (c) to (e). The wavelength $\lambda$ was set to the same value in all figures and the pattern in (d) is similar to the ocular dominance layers found in the visual cortex.

## 4 Conclusions

A simple model suffices to study basic properties of ocular dominance self-organization. Possibly, a combination of models for self-organization in neighboring cortical layers would allow to investigate even higher organizational principles of the cortex [1], e.g. the coordination between ocular dominance layers, orientation layers, and cytochrome oxidase.

**Availability of Supporting Data**

More information about this project can be found at: http://brainhack.org/self-organization-and-brain-function. Further data and files supporting this project are hosted in the *GigaScience* repository https://github.com/Brainhack-Proceedings-2015/Pfan_HBM_SOBF.

**Competing interests**

None

**Author's contributions**

JPP, RM, LCTH, and DD performed the project and wrote the report.

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[*]Correspondence: pfannmoelj@uni-greifswald.de

[1]Functional Imaging Unit, Center for Diagnostic Radiology, University Medicine Greifswald, Greifswald, Fleischmann Strasse 8, 17475, Germany

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

**Author details**
[1]Functional Imaging Unit, Center for Diagnostic Radiology, University Medicine Greifswald, Greifswald, Fleischmann Strasse 8, 17475, Germany. [2]Institute of Physics, University of Campinas, Campinas, Rua Sérgio Buarque de Holanda 777, 13083-859, Brazil. [3]Waisman Center, University of Wisconsin, Madison, 1500 Highland Ave, WI 53705, USA.

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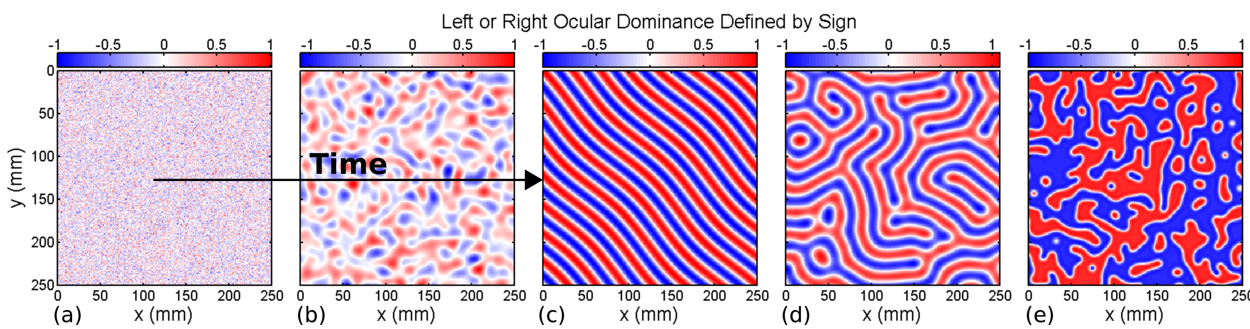


**Figure 1** Examples for the temporal evolution of the solution to the Swift-Hohenberg equation for different branchiness parameter $\epsilon$. (a) Random initial conditions for the solution of the equation. (b) Formation of the pattern. (c) Striped pattern for negligible branchiness $\epsilon$. (d) Complex stripes for medium $\epsilon$. (e) No pattern for large $\epsilon$.