

Symposium in Honour of  
Prof. Dr. Dr. h.c. mult. Hermann Haken  
Institute for Advanced Studies Delmenhorst  
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## Synergetics in Psychology Phase Transitions and Critical Instabilities in Human Change Processes

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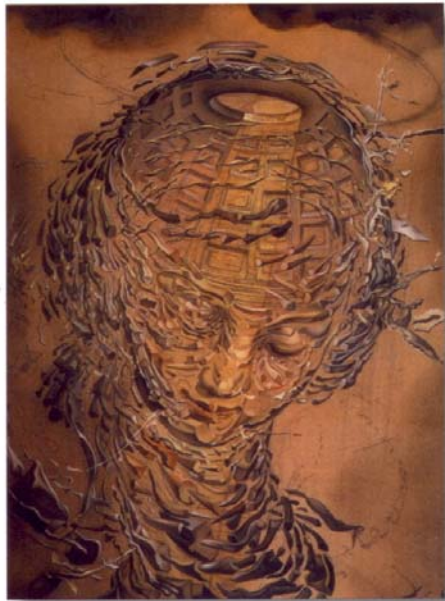


Hermann Haken  
Günter Schiepek



# Synergetik in der Psychologie

Selbstorganisation verstehen und gestalten



HOGREFE 

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**Synergetics has been  
arrived in psychology**

**- and transforms it**

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# Synergetics has successfully applied to many topics in psychology

## General psychology

- Motoric coordination
- Perception
- Decision making
- Memory
- Learning
- Creativity and innovation
- Individual and collective speech acquisition
- Dynamics of emotions
- The emergence of phenomenal consciousness
- The dynamics of the „self“

## Developmental Psychology

- Child development
- Assimilation and accommodation of schemata

## Social psychology

- Dyadic interaction (client-therapist, mother-child)
- Attitude change
- Group dynamics
- Stability and instability of collective behavior

## Clinical psychology

- Etiology of mental disorders
- Mental disorders as dynamical diseases
- Psychotherapy (definition, process-outcome-research, feedback and monitoring)

## Management / organizational psychology



## Most of psychological phenomena are characterized by specific synergetic features

Order / order parameters

Pattern formation

Enslaving of system components

Critical instabilities

Order transitions (non-equilibrium phase transitions) and  
quasi-attractors

Hierarchies of order parameters

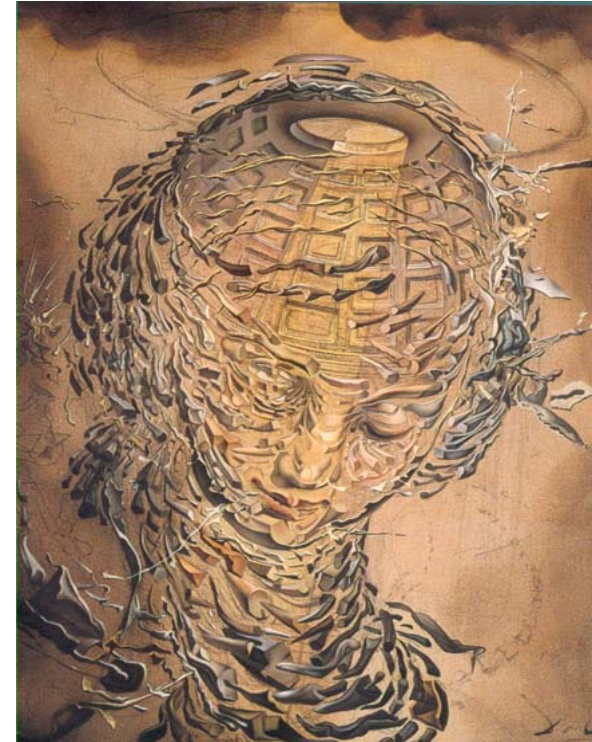
Symmetry breaking

Circular causality

Hysteresis

Coordination (competition or cooperation) of order  
parameters

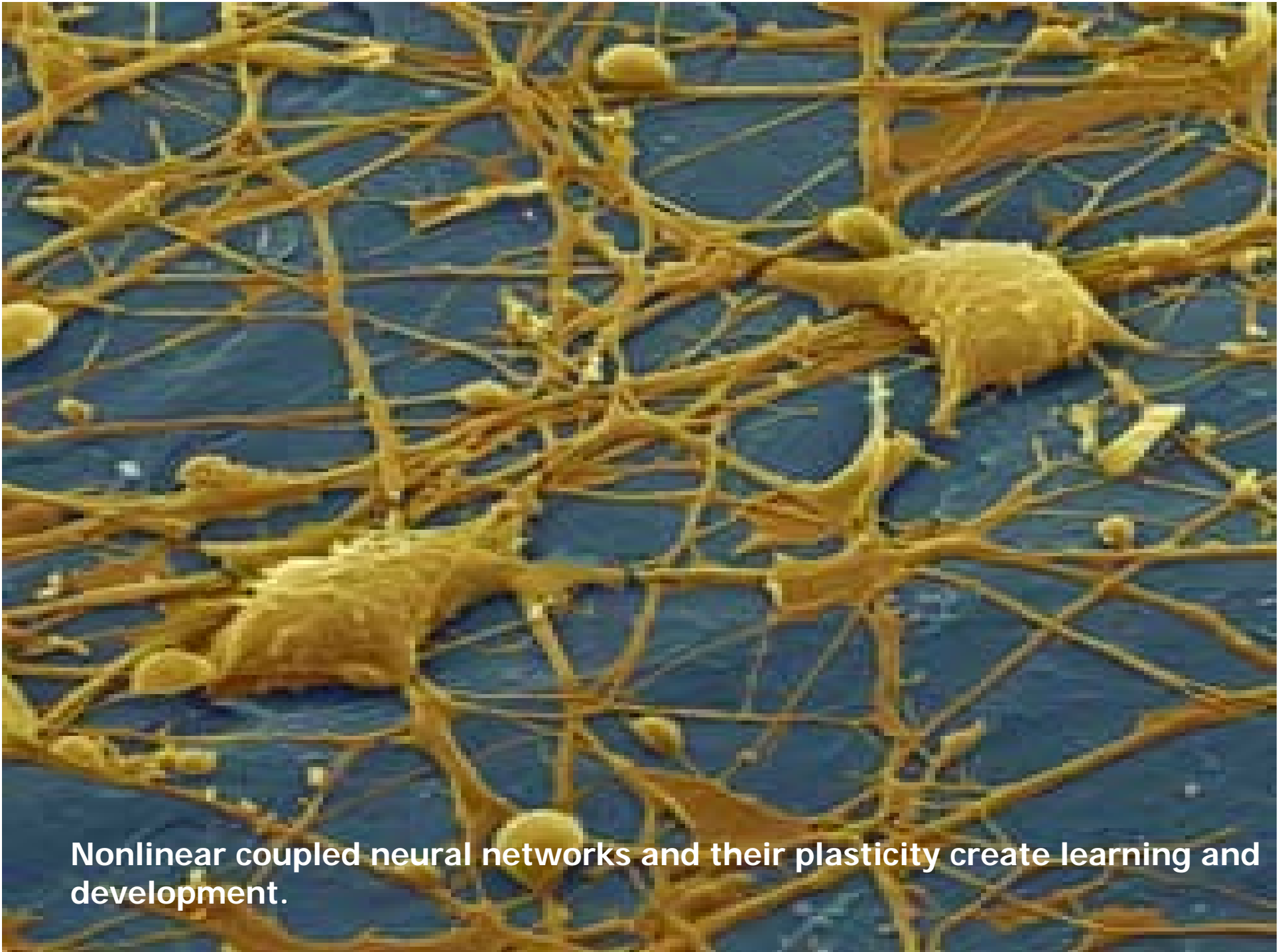
Multistability



## What psychology has got from synergetics

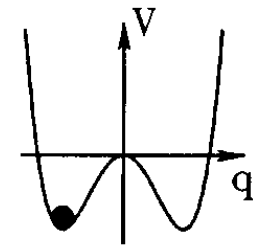
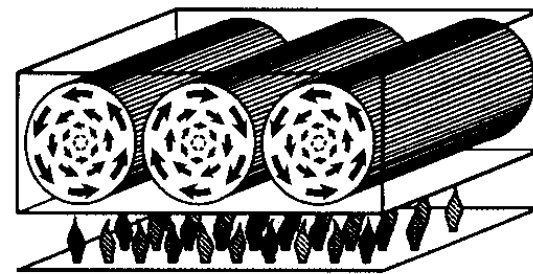
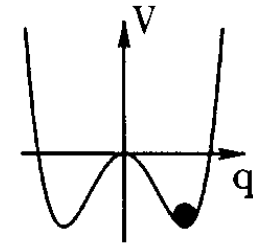
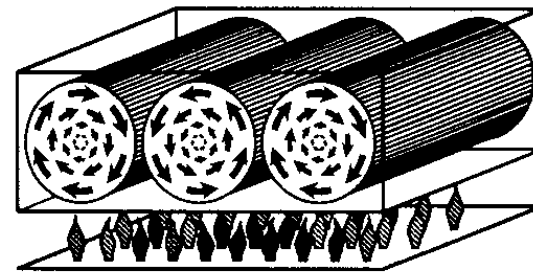
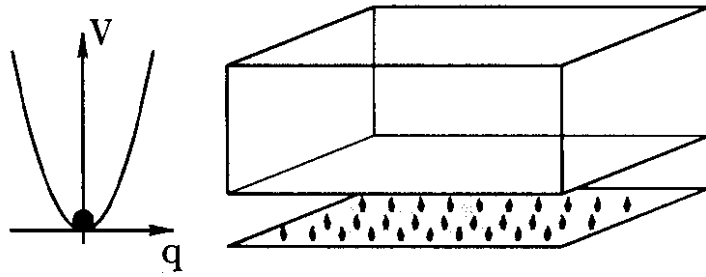


- Psychology got back its own history
- The concept of „time“ and dynamics
- Thinking in complexity
- A fruitful theory and research paradigm
- A specific „imago hominis“ accentuating autonomy as well as synchronization and cooperation

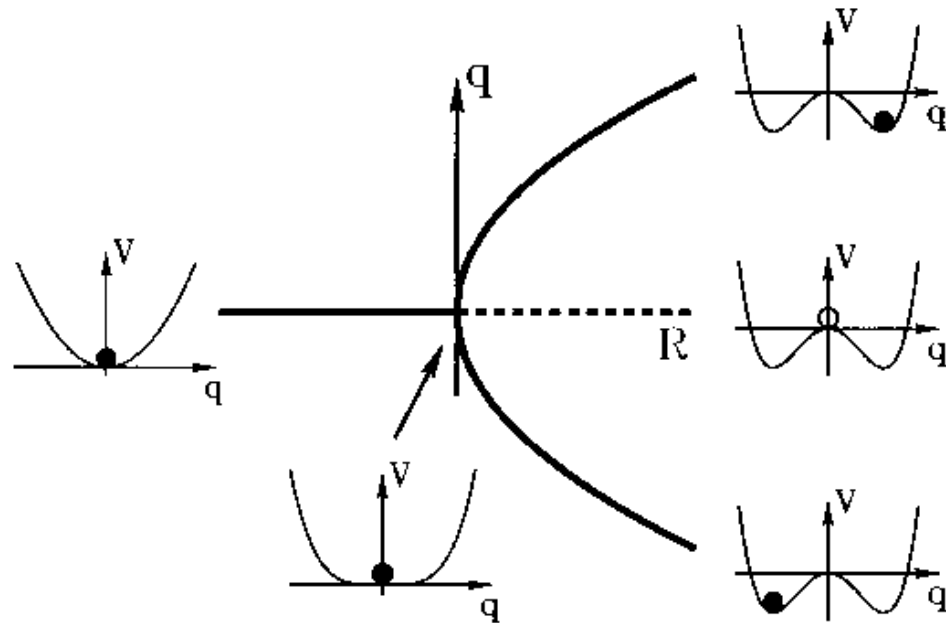


**Nonlinear coupled neural networks and their plasticity create learning and development.**

# Rayleigh-Bénard-Instability



## Symmetry breaking or bifurcation diagram



Bifurcation diagram and corresponding potential landscapes

$V$ : potential

$q$ : dynamic state of the system (order parameter)

$R$ : control parameter

*Kelso (1995)*



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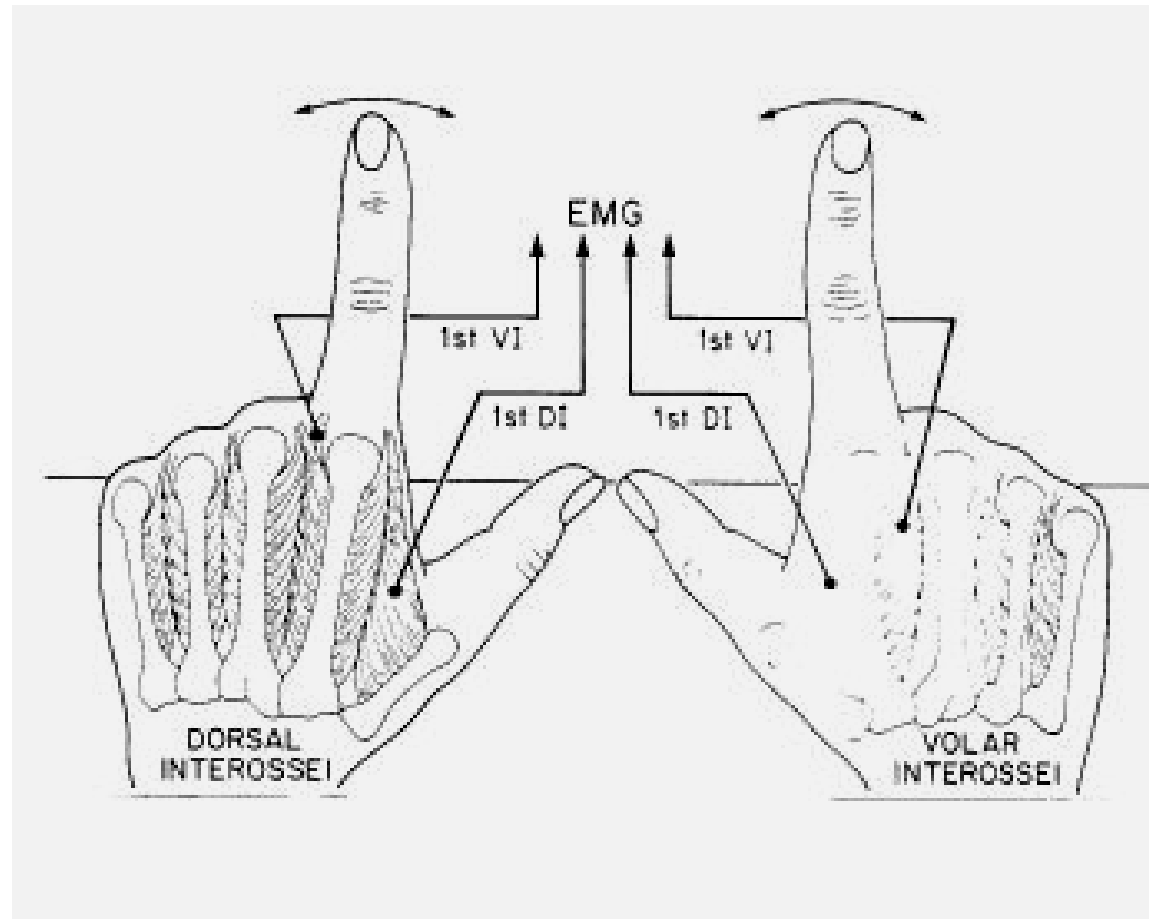
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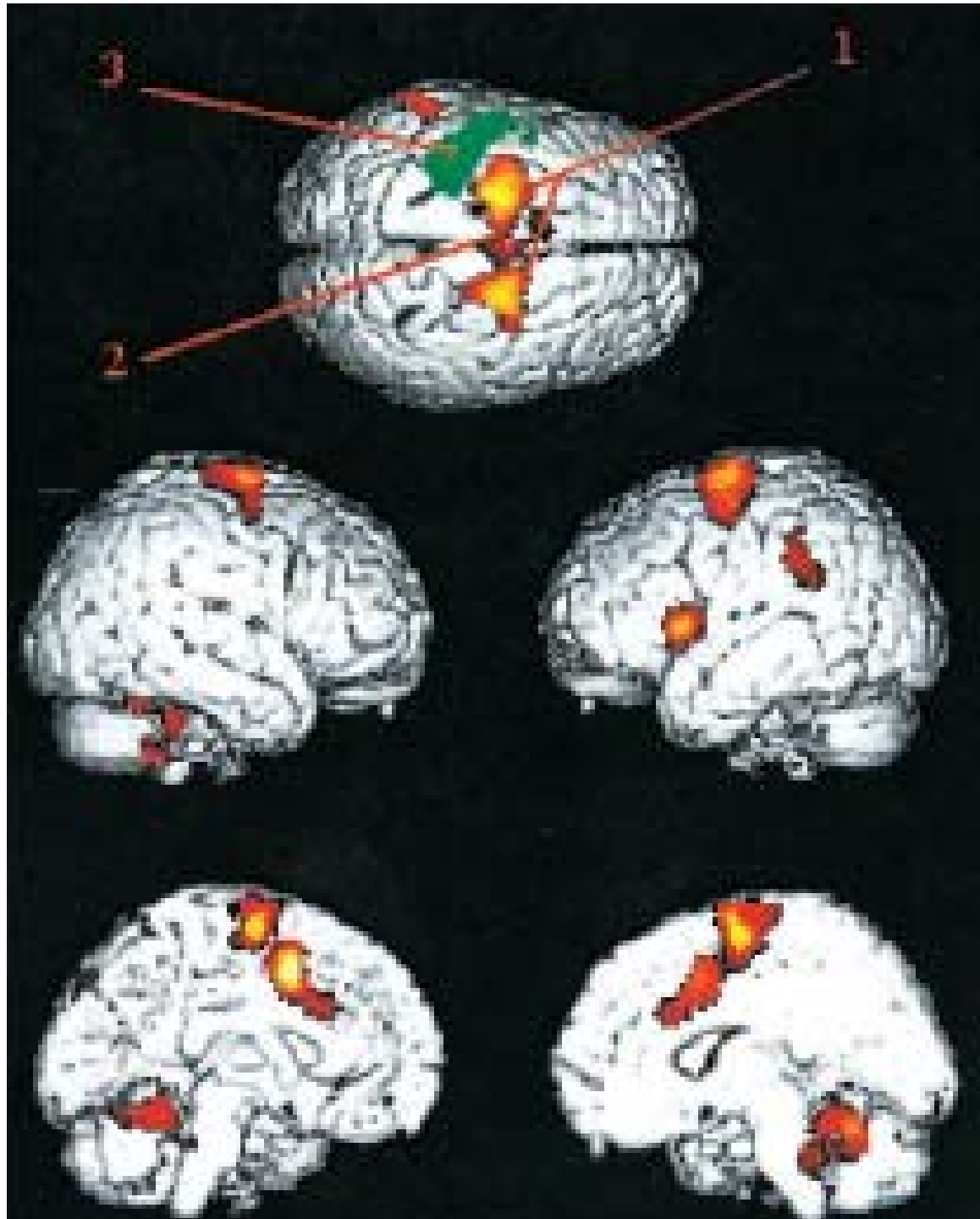


# Order transition in the motoric system with hysteresis

## The Haken-Kelso-Bunz-Model

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## Activated areas in motoric order transitions

Traget areas for the Transcranial magnetic stimulation (TMS)

- 1 premotoric cortex
- 2 supplementary motoric area
- 3 primary sensumotoric cortex

Method: H2 15O-PET

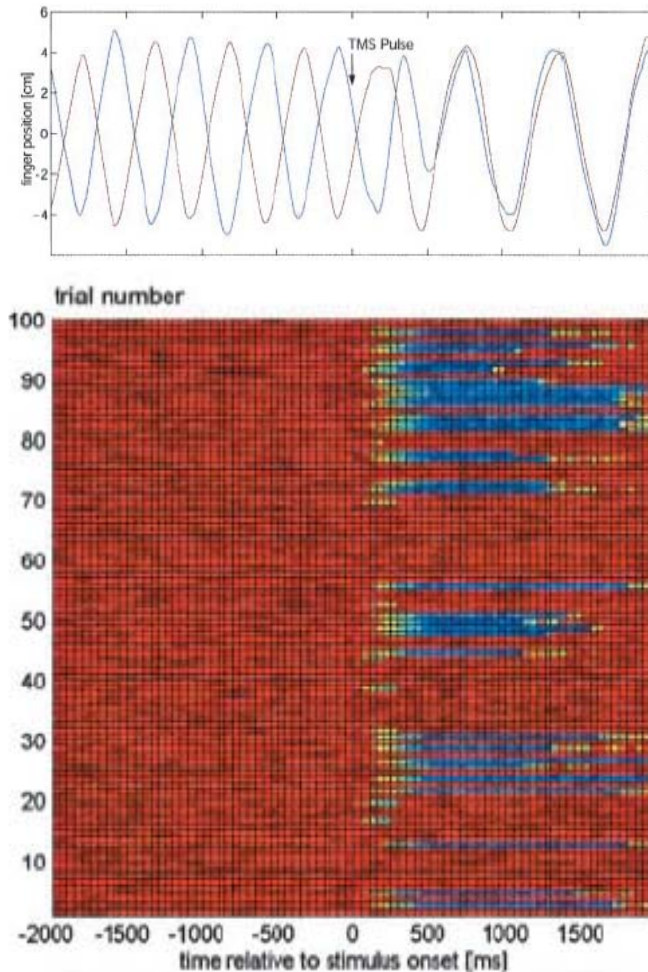
rCBF

Red/yellow: Areas with significant interaction between motoric pattern transitions and movement frequency (control parameter)

Green: no such interaction, but brain activation correlates with movement frequency

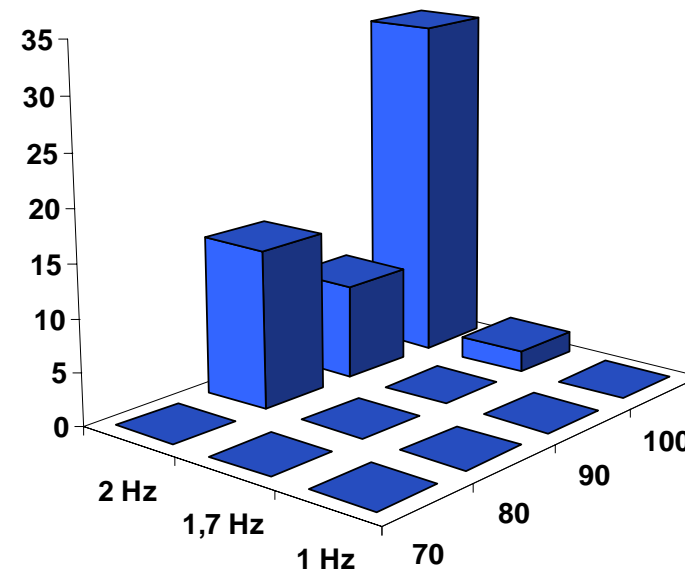
Meyer-Lindenberg et al. (2002).  
Transitions between dynamical states of differing stability in the human brain. PNAS, Vol. 99, No. 17, 10948

# Order transition in motoric coordination – from parallel to antiparall movement



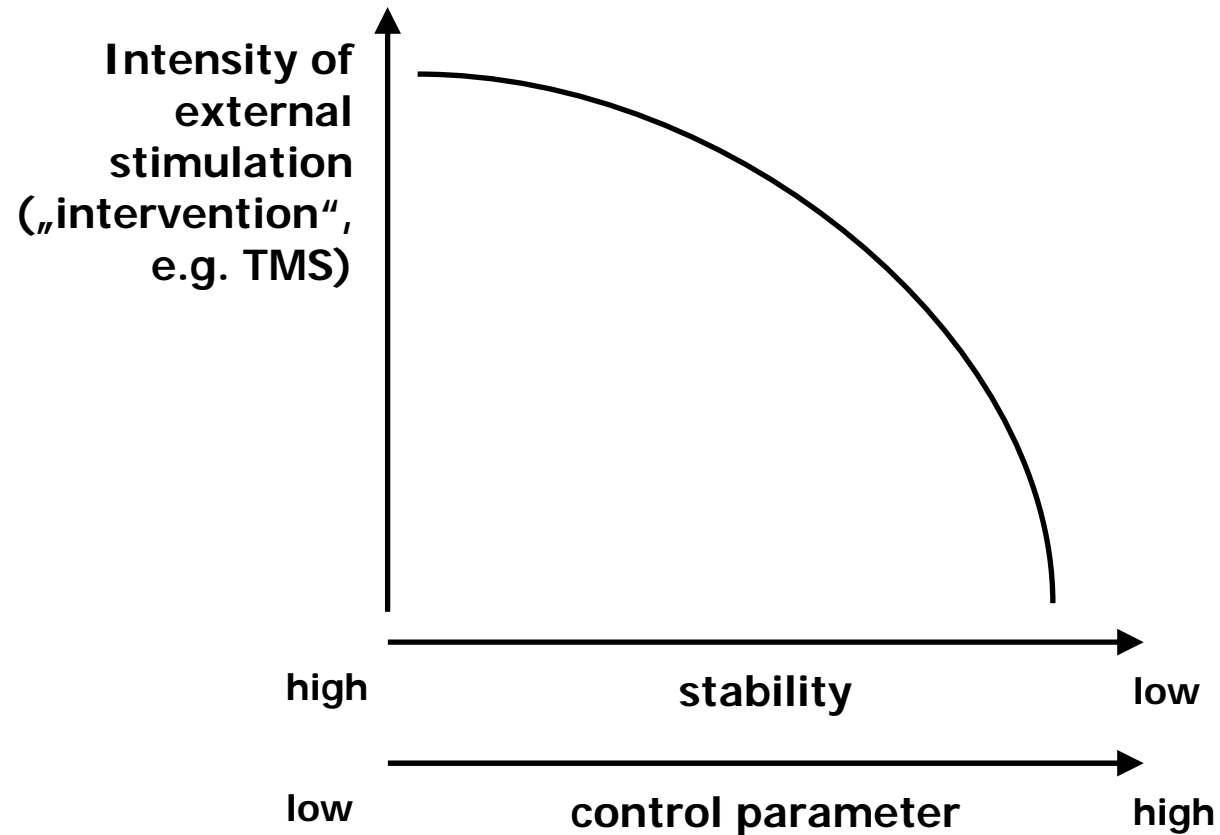
Only in a destabilized state order transitions can be triggered (in this case by TMS-pulses), but not in each trial.

Meyer-Lindenberg et al. (2002). Transitions between dynamical states of differing stability in the human brain. PNAS, Vol. 99, No. 17, 10948.

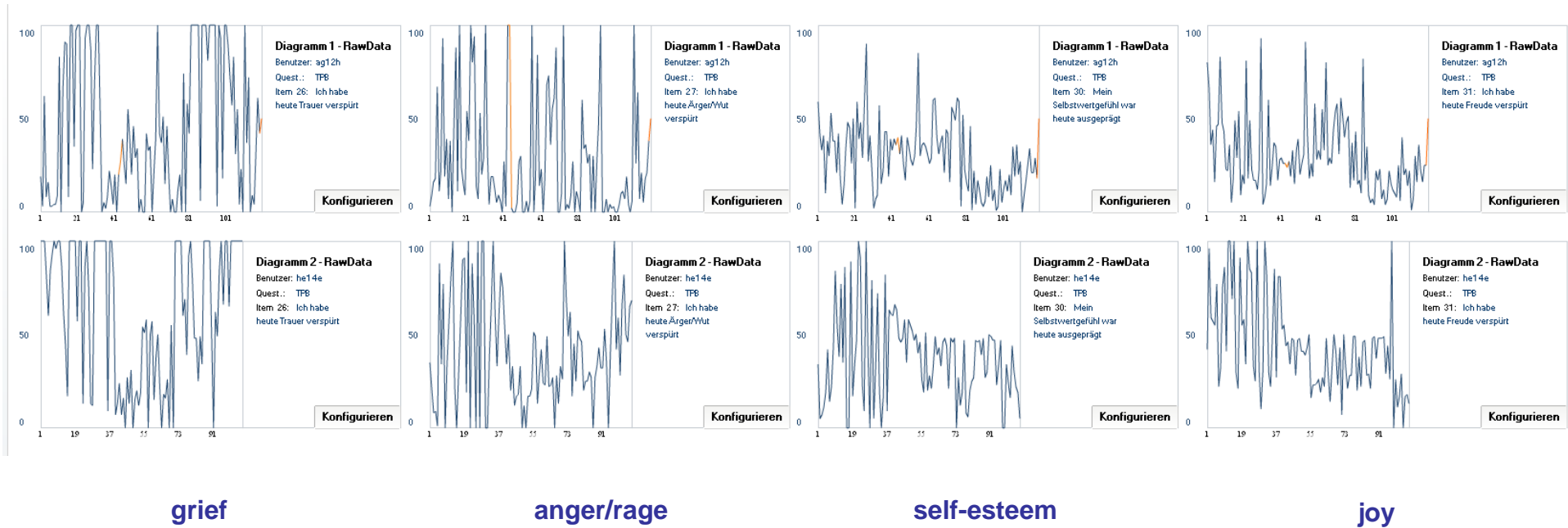


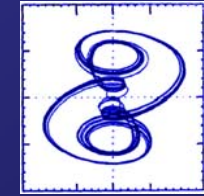
**Hypothetical relations between degree of stability, change of control parameter(s), and intensity of external stimulation triggering change: explaining the effect of minimal or no interventions**

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# Nonlinear and nonstationary dynamics in time series from daily ratings on the Therapy Process Questionnaire by an Internet-based device (Synergetic Navigation System)





# Complexity Resonance Diagrams

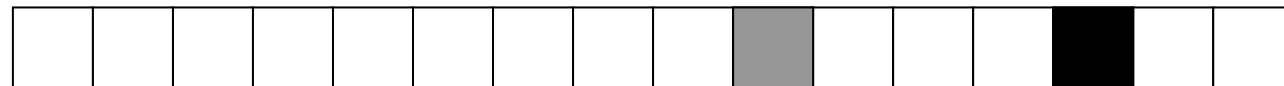
significance test

not significant

significant on  
5% level

significant on  
1% level

complexity  
value



time

# Complexity Resonance Diagram

Questionnaire ▶

Data Analysis ▼

Raw Data / Dynamic Complexity

Synopsis

Recurrence Plot

**Complexity Resonance Diagram**

Correlation Matrices

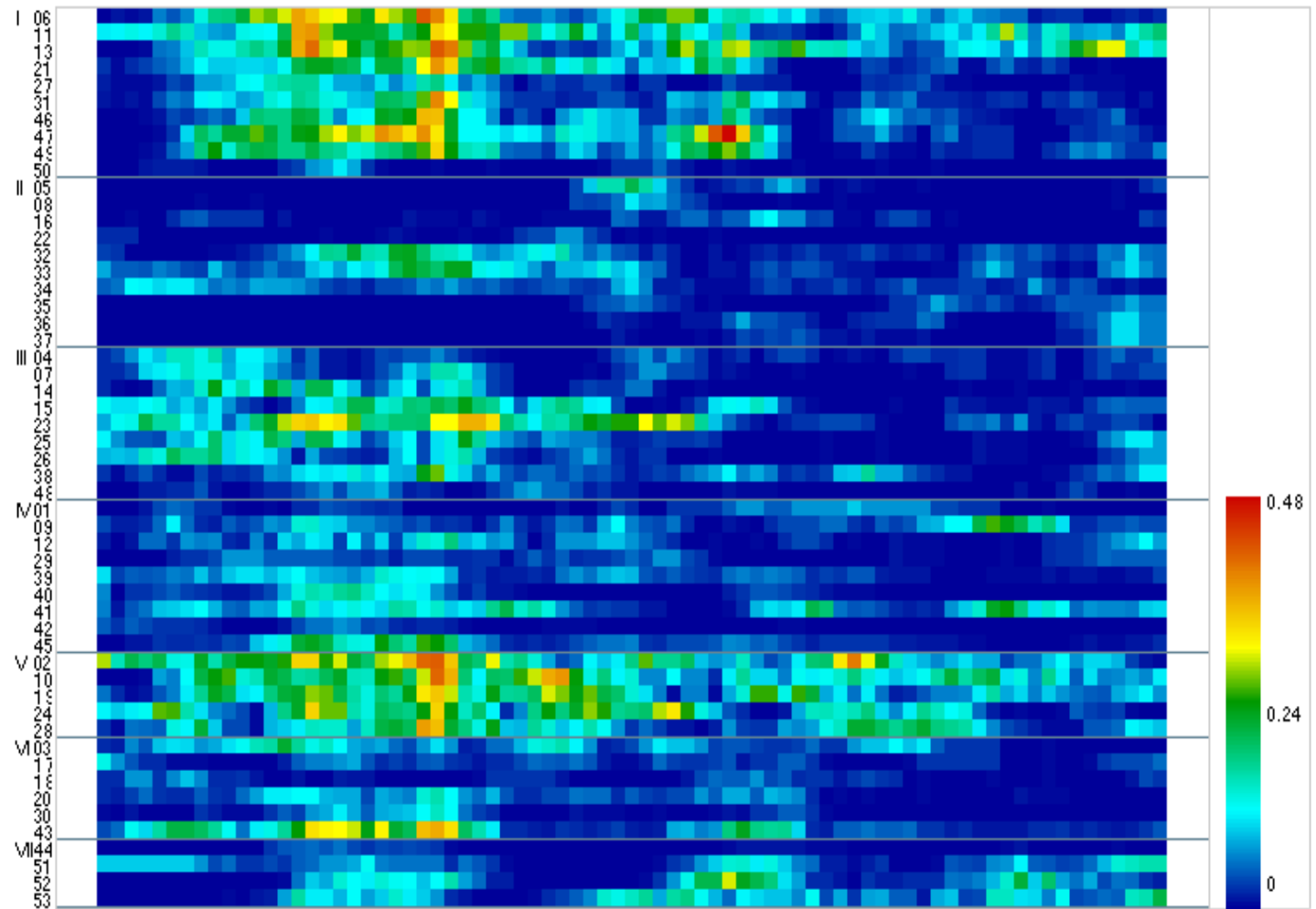
Evaluation

Administration ▶

Data Import / Export ▶

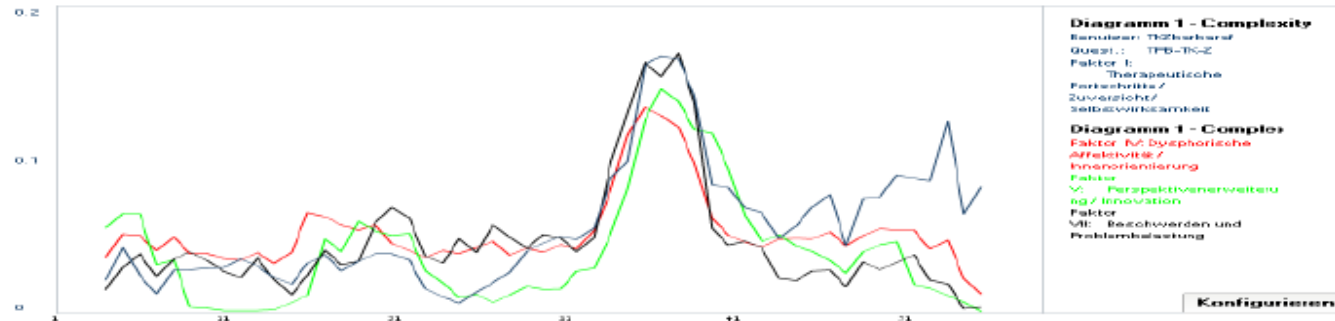
Execute

Config



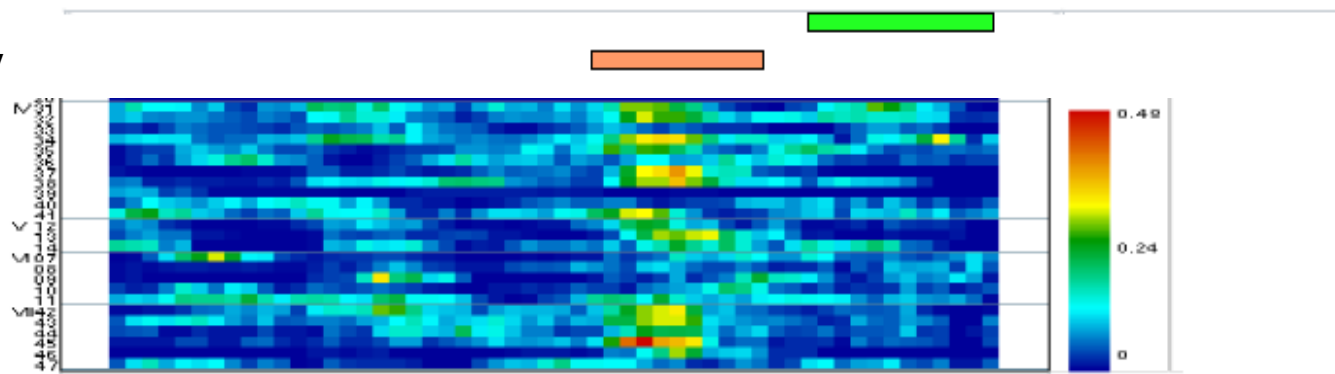
# Therapy process of an OCD-patient in a day treatment center

Dynamic Complexity

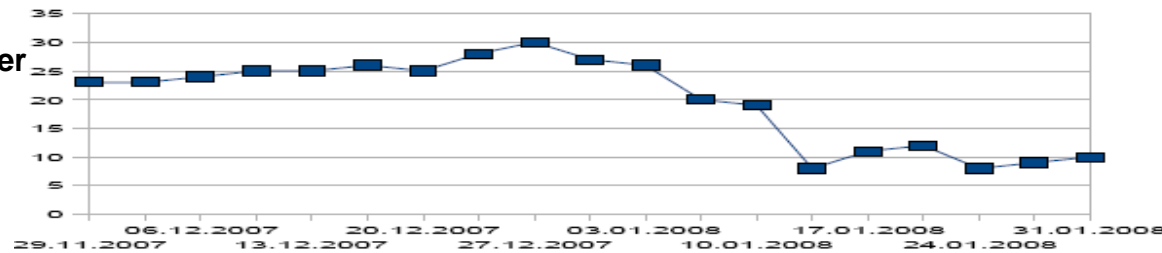


Flooding

Crit. Instability

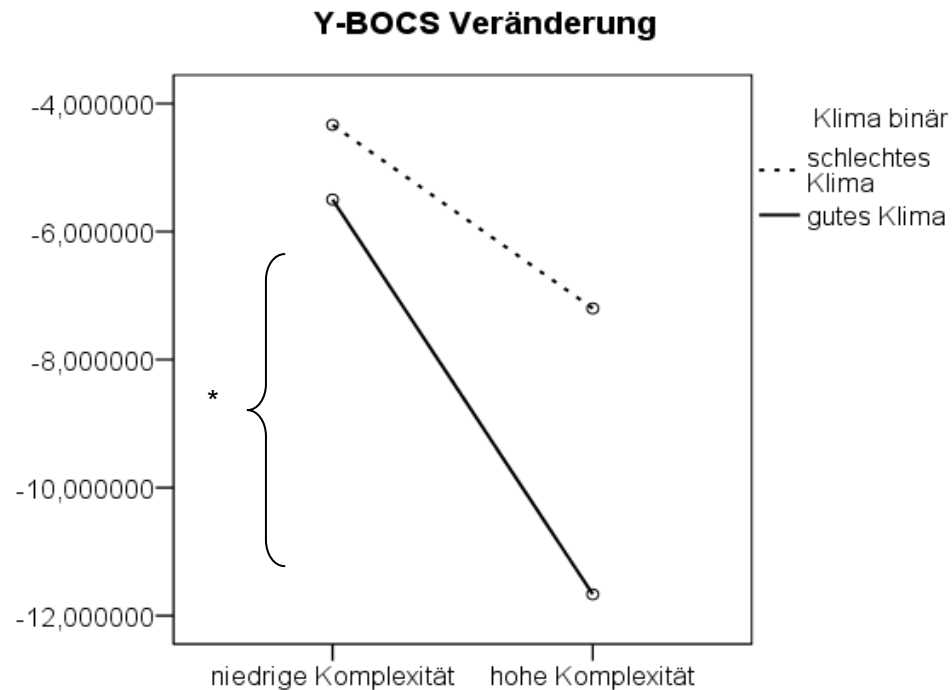


Y-BOCS (two times per week)



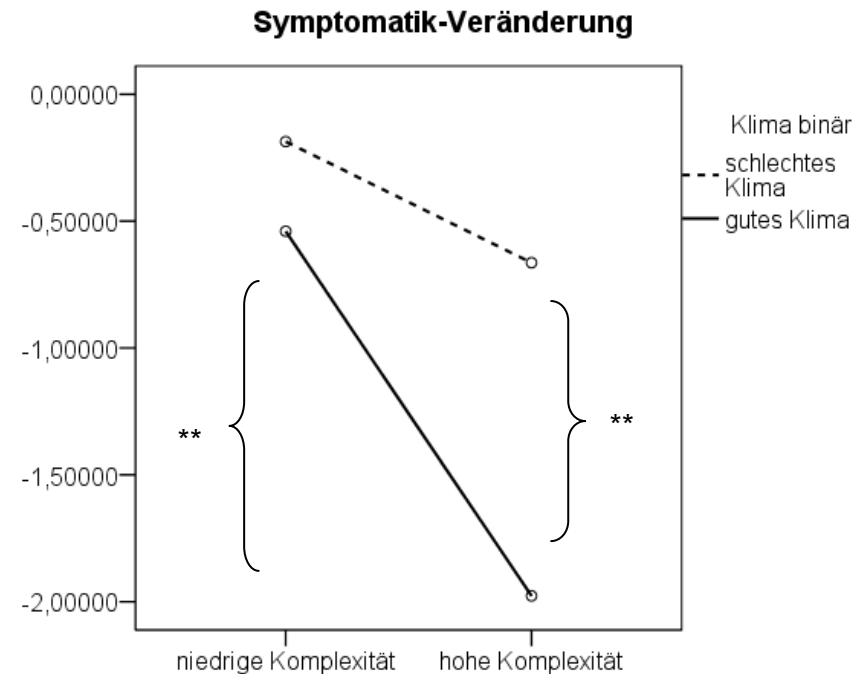


## The contribution of the ward atmosphere (stability of the boundary conditions) and local dynamic complexity (critical instability) to the therapy effect



**Interaction between ward atmosphere (stable boundary conditions) and local complexity (degree of critical instability).**

Y-axis: reduction of Y-BOCS-score



**Interaction between ward atmosphere (stable boundary conditions) and local complexity (degree of critical instability).**

Y-axis: reduction of symptom severity (TPQ-scale)

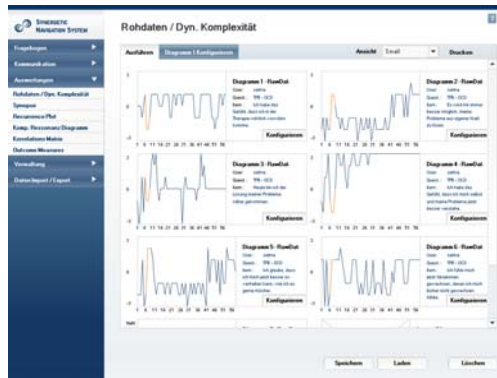


## SNS-based feedback in a psychotherapy session



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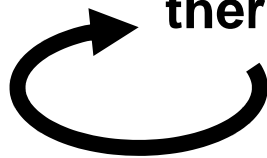
identification of patterns  
without the quality of qualia

adaptive indikation:  
data-driven decisions on interventions

confidence

theory- based reconstruction  
of ongoing processes

**therapist**



the classic interactional  
and self-referential loops

confirmation of the therapeutic progress

confidence

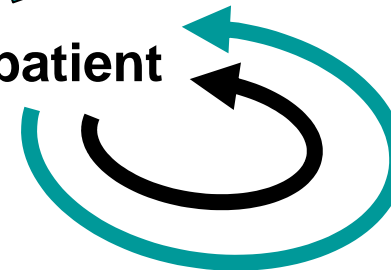
valid feedback

enhanced motivation

experience of self-efficacy

enhanced self-regulation of  
behavior and emotions

**patient**



differentiated  
self-awareness  
of mental states

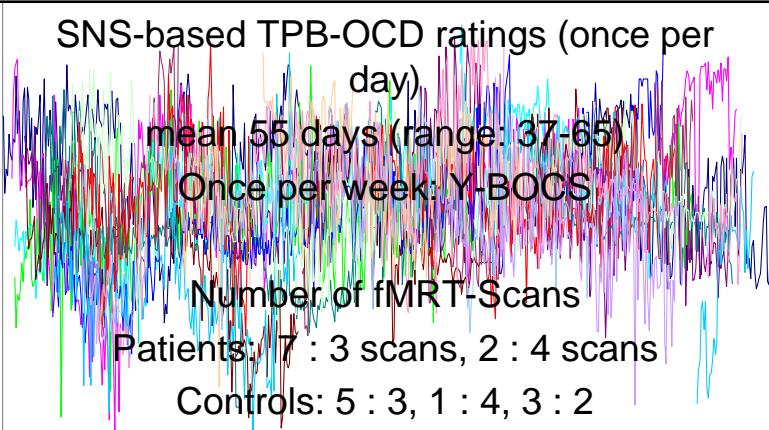
perception of  
emotions, emotional learning

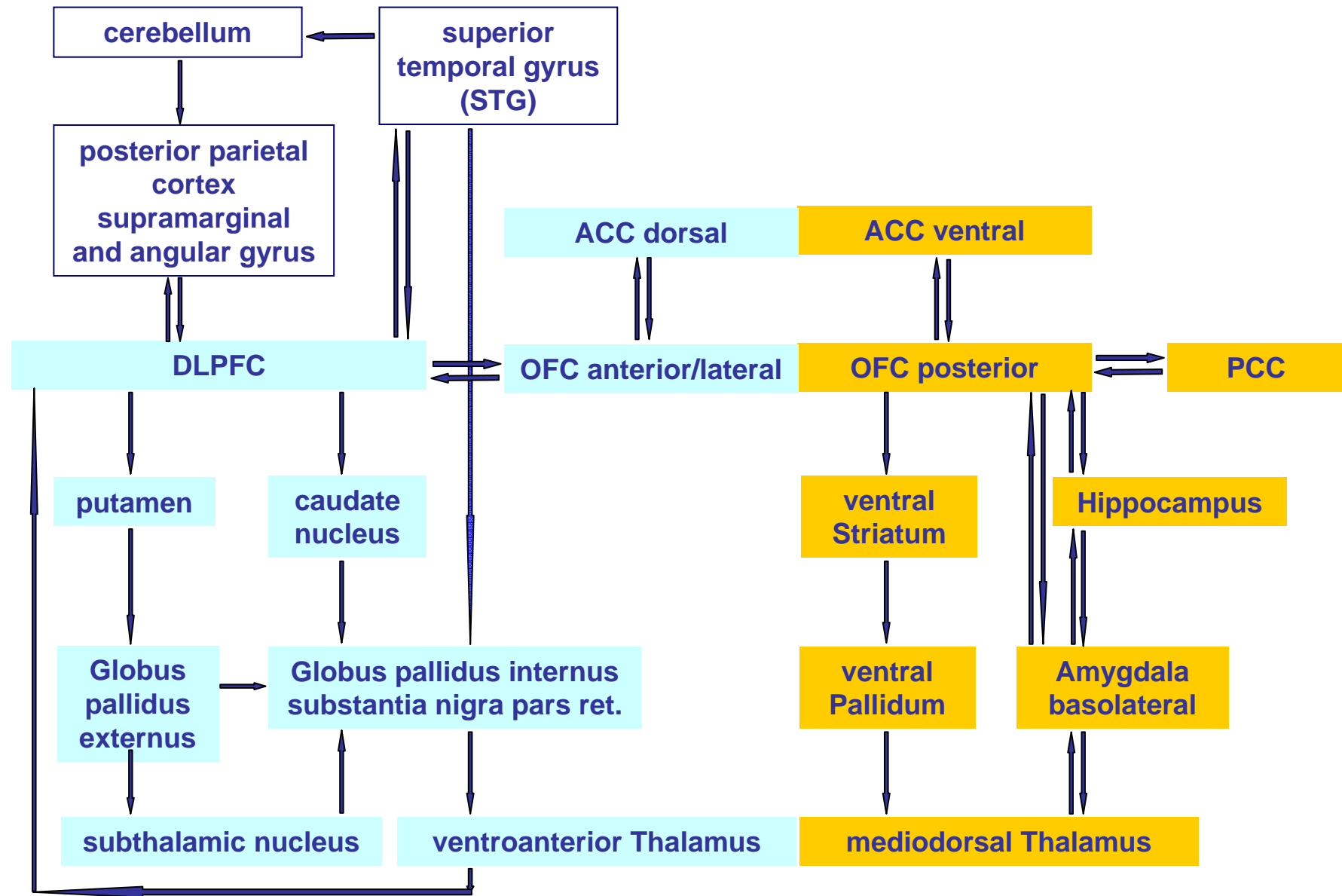
# Design of the OCD-Study on Order Transitions

## The Dynamics of Change Processes During the Psychotherapy of Obsessive Compulsive Disorder

**N = 9 patients, 5 female, 4 male, AM age 31,9, with one exception drug naive OCD (F42.2), 8 out of 9 washing/contamination fear, with one exception no comorbidity (1 subject F34.1)**

**N = 9 healthy controls, 5 female, 4 male, AM age 30,9, similar education level**

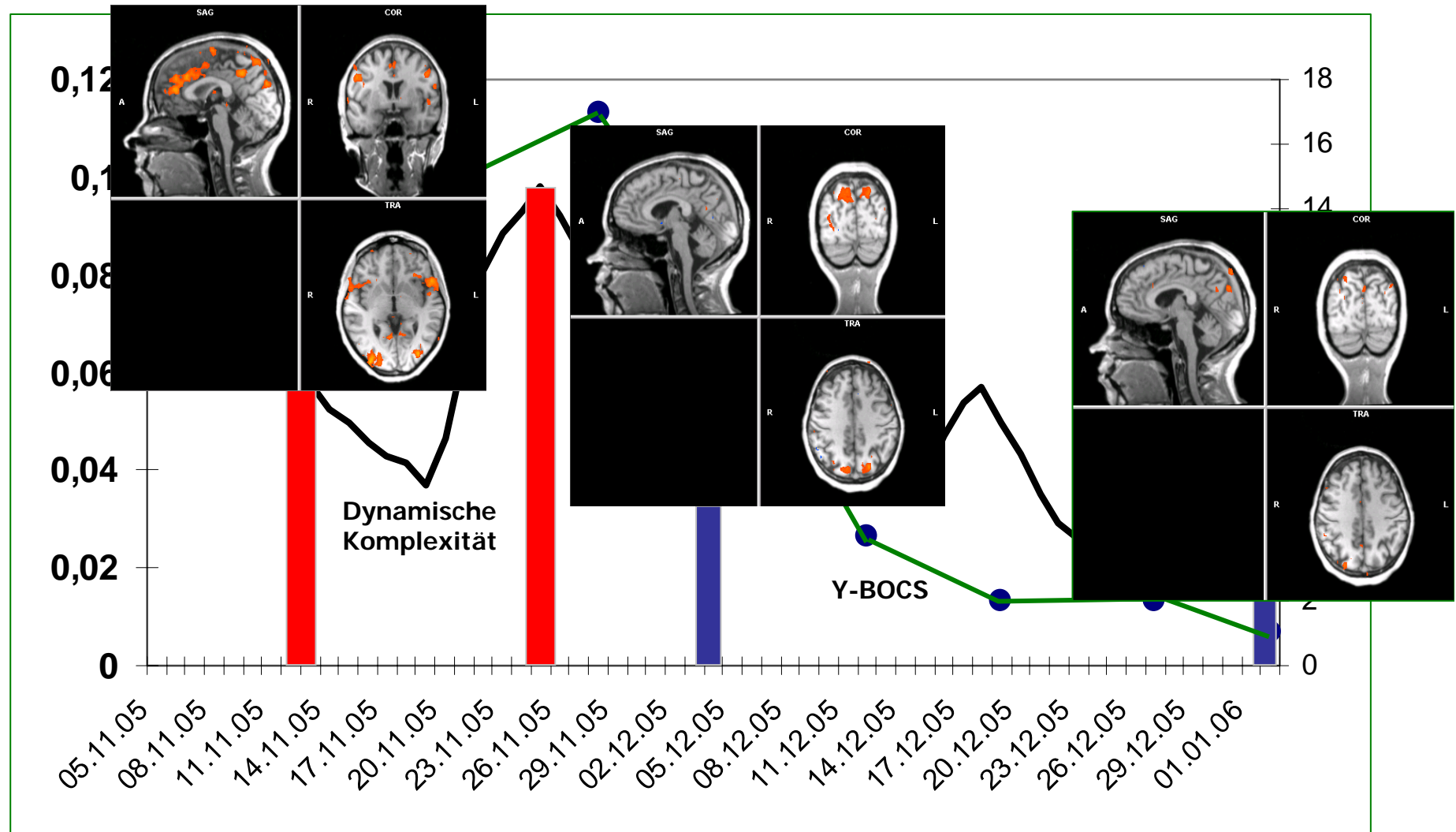
<i>Pre</i>	<i>During treatment</i>	<i>Post</i>
<ul style="list-style-type: none"> <li>• Y-BOCS</li> <li>• BDI</li> <li>• SCL-90-R</li> <li>• Inkongruenz-FB</li> <li>• TPB-basiertes Symptomrating</li> </ul>	<p>SNS-based TPB-OCD ratings (once per day)</p>  <p>mean 55 days (range: 37-65)</p> <p>Once per week: Y-BOCS</p> <p>Number of fMRT-Scans</p> <p>Patients: 7 : 3 scans, 2 : 4 scans</p> <p>Controls: 5 : 3, 1 : 4, 3 : 2</p>	<ul style="list-style-type: none"> <li>• Y-BOCS</li> <li>• BDI</li> <li>• SCL-90-R</li> <li>• Inkongruenz-FB</li> <li>• TPB-basiertes Symptomrating</li> </ul>

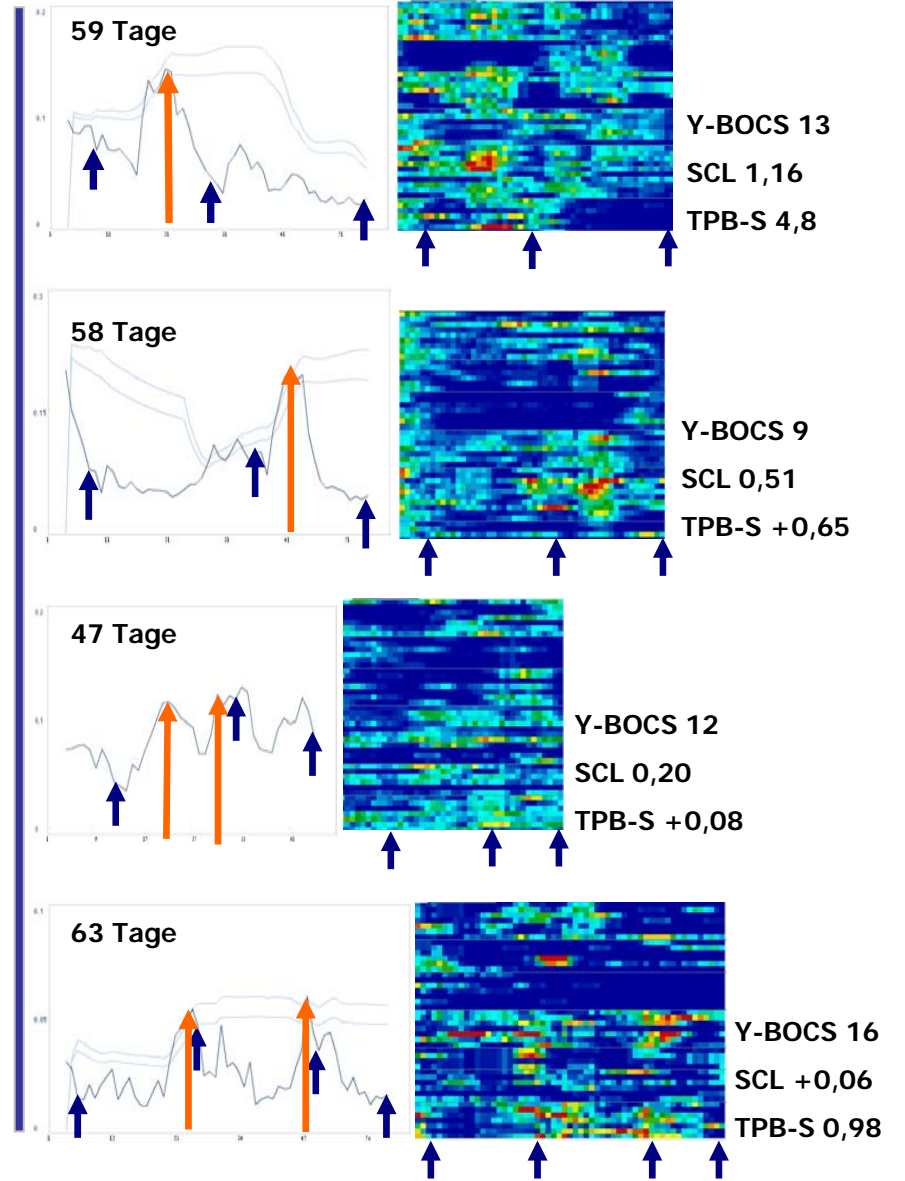
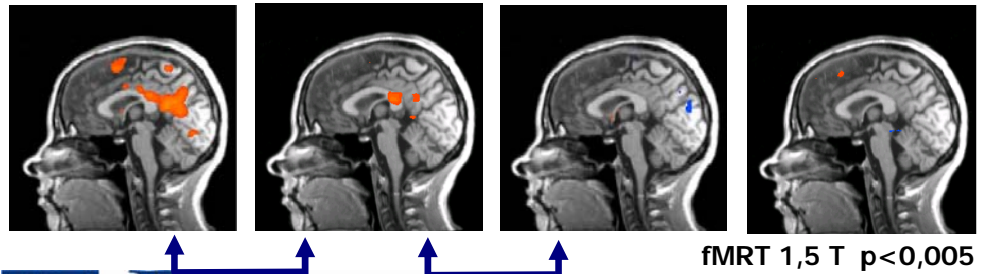
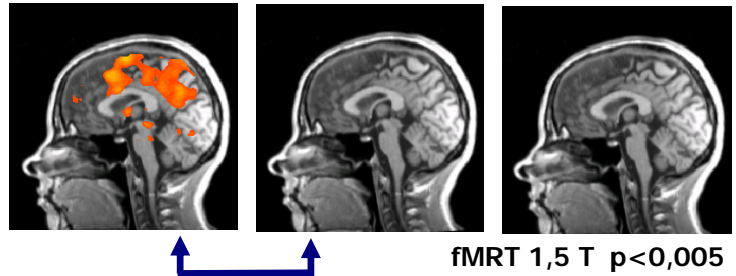
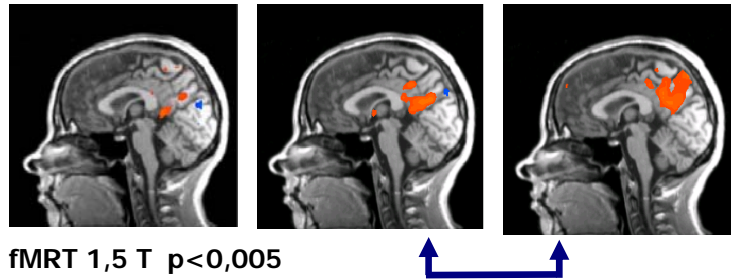
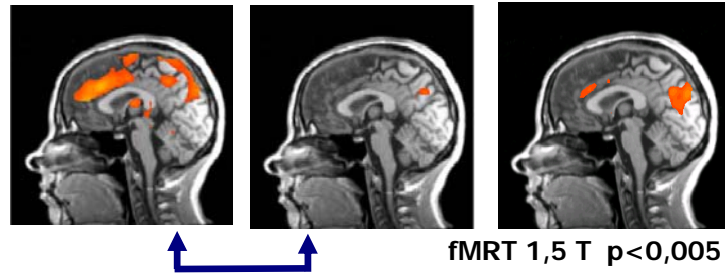


„cognitive“ dorsolateral prefrontal-striatal loop  
decreased during executive functions

„affective“ ventral orbitofrontal-striatal loop  
increased during emotional processing

# Single case: dynamics of the Y-BOCS, dynamic complexity and brain activity

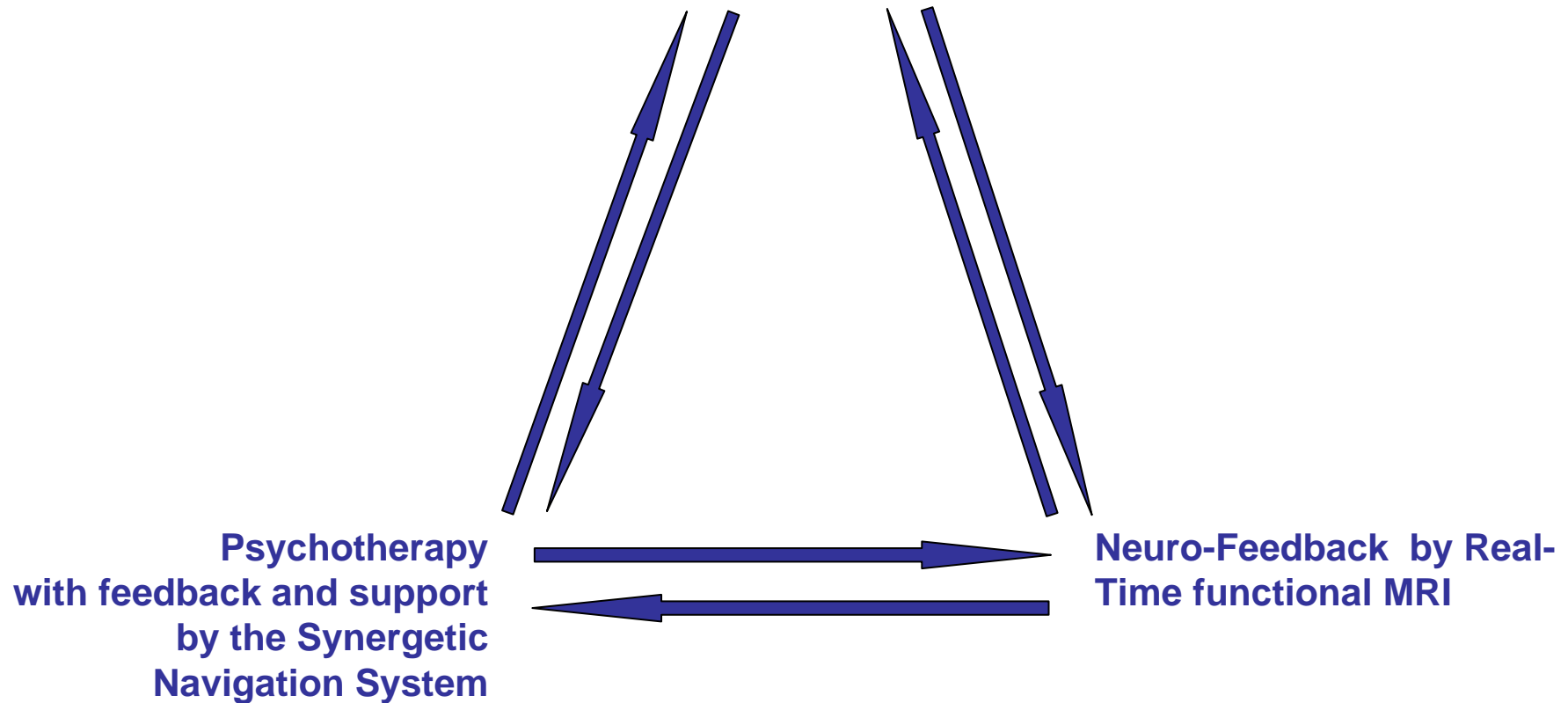




ISPP > Neutral  
Patients Windach/Munich



## Neuromodulation by noninvasive brain stimulation using principles from synergetics and synaptic plasticity



The future of synergetics in an integrated neuro-psychological systems medicine

