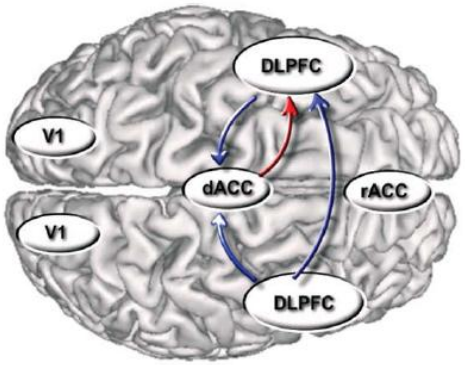

Fronto-Cingulate Effective Connectivity in Obsessive Compulsive Disorder: A Study With fMRI and Dynamic Causal Modeling

Schlösser, R.G.M., Wagner, G., Schachtzabel, C., Peikert, G., Koch, K., Reichenbach, J.R., & Sauer, H.

Presentation by Amadeus Magrabi

University of Osnabrueck, WS 2010/2011

Course: Neural Network Plasticity Analysis with fMRI Data

Human Brain Mapping, 31, 1834–1850 (2010)

Overview

Obsessive-Compulsive Disorder (OCD)

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The Neural Basis of OCD

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Experimental Idea

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Method

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Results

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DCM Analysis

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Conclusions

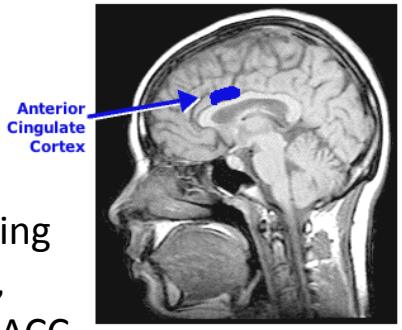
Obsessive-Compulsive Disorder (**OCD**)

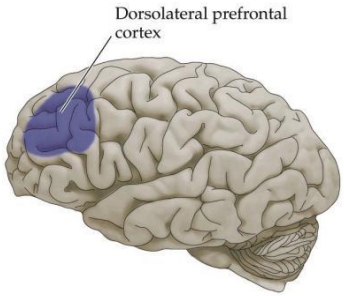
- Typical pattern: An extreme fear of something (obsession) leads to overly cautious, often repetitive, behaviors (compulsions).

- diagnosed by a structured clinical interview checking DSM IV-criteria
- #4 of most common mental disorders
- OCD in everyday life: *"You're so obsessive-compulsive!"*
  ➔ People who are very careful, plan everything, like to follow strict rules, ...

The Neural Basis of OCD?

- A widespread model of cognitive control proposes a fronto-cingulate system: (Cohen et al., 2000)
  - The dorsal anterior cingulate cortex (**dorsal ACC**) is an *error-/conflict-detector*
  - The dorsolateral prefrontal cortex (**DLPFC**) can *exert control* to resolve this conflict (e.g. by inhibiting what is irrelevant and amplifying what is relevant), and is „informed“ about the conflict by the dorsal ACC





- Theory of OCD in this model:
  - patients have an increased conflict sensitivity ➔ overactive dorsal ACC
  - supported by fMRI-studies (e.g. Maltby et al., 2005; Ursu et al., 2003)

Experimental idea: Further test the theory by using Dynamic Causal Modeling (DCM) to investigate the effective connectivity in the fronto-cingulate system, not just activation in isolated regions.

Main Hypotheses

1) OCD-patients have an overactive dorsal ACC during conflict processing.

2) There is a stronger connectivity between the dorsal ACC and the DLPFC in OCD-patients.

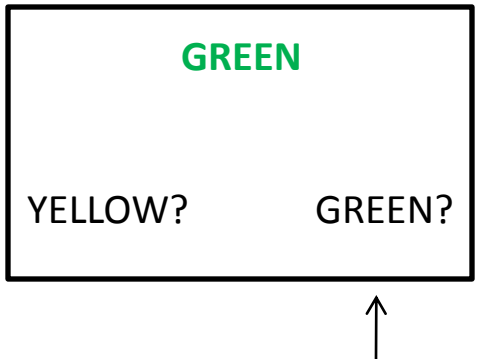
Ingredients for Experiment

1) MRI scanner

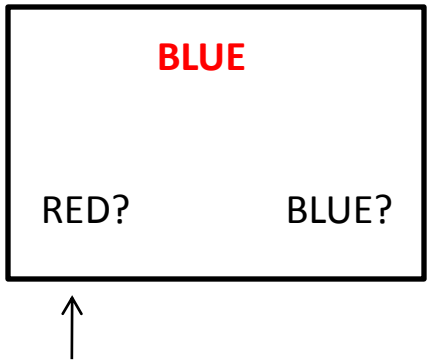
2) 21 OCD-patients and 21 healthy controls (**IV 1**)

3) Popular cognitive control task: The Stroop task (**IV 2**)

Congruent Condition (*no control required*)



Incongruent condition (*control required*)



4) A set of DCM models to test the data against (presented later)

How was the performance of the OCD-patients in the Stroop task, compared to the healthy controls?

- A slower and less accurate
- B: slower and more accurate
- C: faster and less accurate
- D: faster and more accurate

Results

Behavioral Results:

- reaction times of OCD patients significantly higher than those of healthy controls
  - the accuracies of OCD patients were higher than those of healthy controls, but this effect was not significant
- Usual Stroop results: reaction times significantly higher and accuracies significantly lower in the incongruent condition

fMRI Results:

- the '*incongruent > congruent*'-contrast revealed significant activity in „an extended fronto-cingulate network including the dorsal ACC, left VLPFC, and left DLPFC"
- the '*OCD > healthy control*'-contrast revealed significant activity in „a predominantly fronto-cingulate network including the dorsal ACC and right DLPFC"
  - the dorsal ACC and right DLPFC also show significant activity if we just consider the incongruent condition

Main Hypotheses

1) OCD-patients have an overactive dorsal ACC during conflict processing.

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But not all results were motivated by the hypotheses... (don't try do read all that)

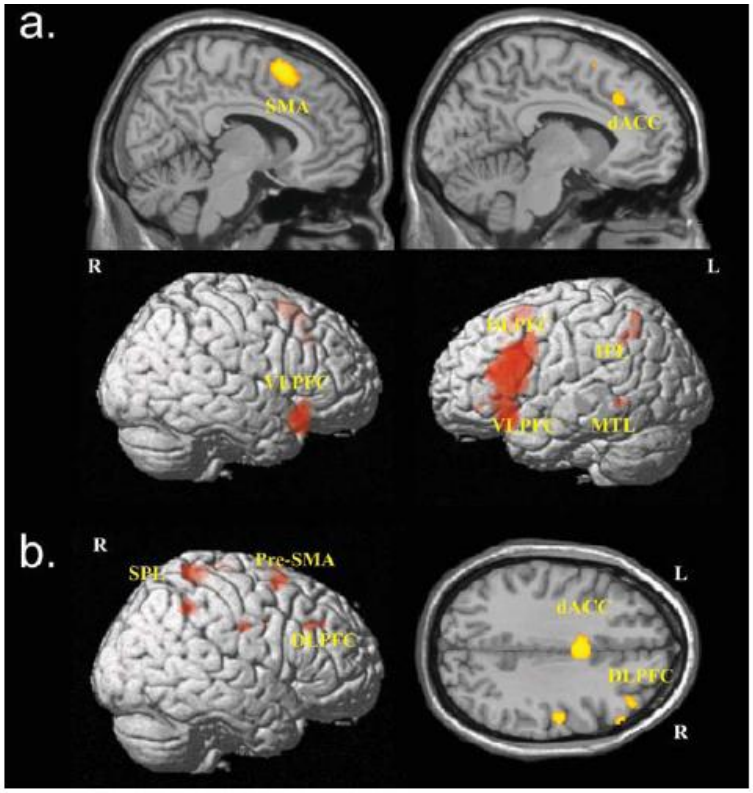


Figure 2.
Significant areas for (**a**) main effects of task (incongruent > congruent condition; $P < 0.05$, FWE corrected) and (**b**) main effect of group (OCD patients > healthy controls, $P < 0.001$, $k = 12$ voxels). [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

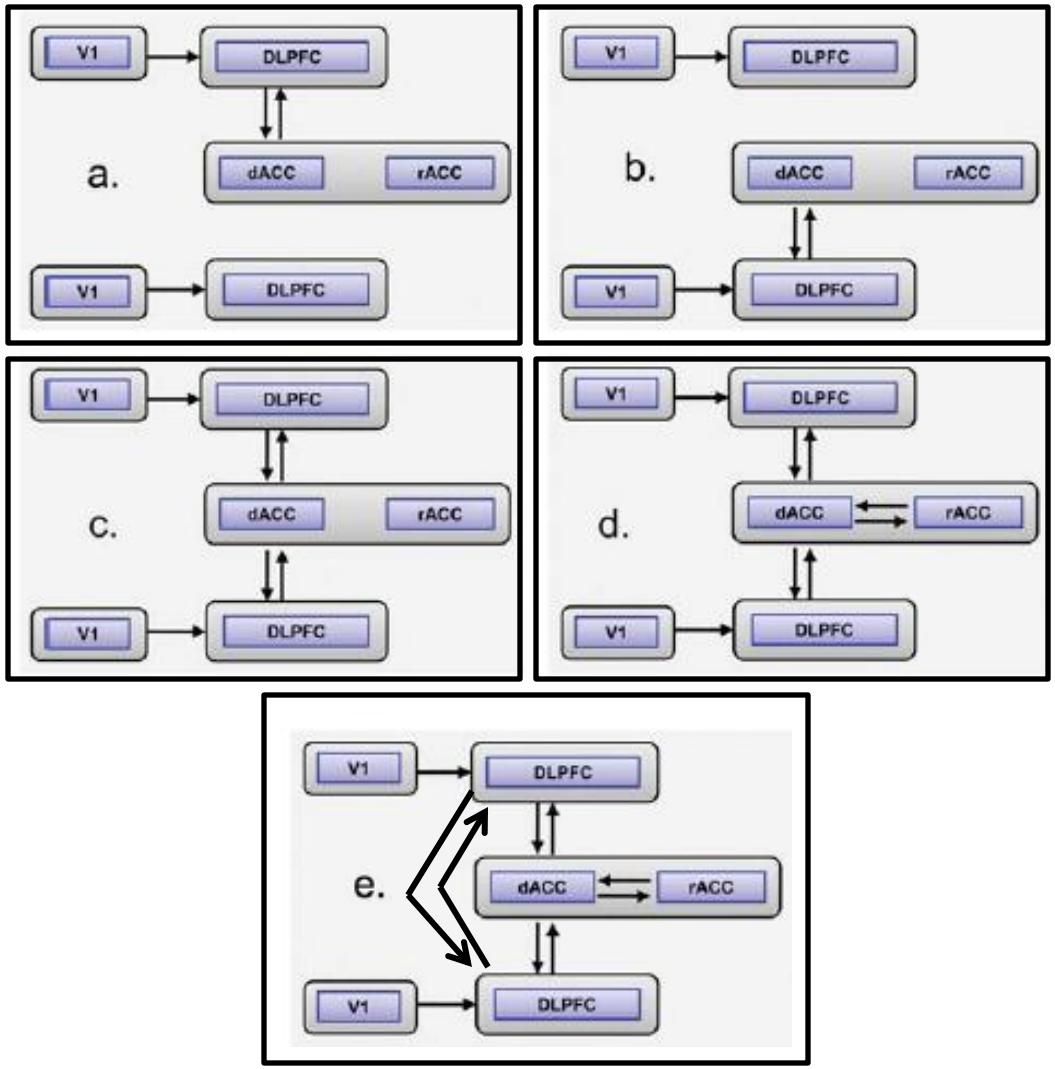
TABLE I. Talairach coordinates of activation maxima (SPM{*T*} value) for the main effect of task ($P < 0.05$ FWE corrected) and main effect of group as well as the planned comparison OCD > HC ($P < 0.001$, uncorrected)

Region of activation	L/R/M	BA	Talairach coordinates *x*	*y*	*z*	*k*	*T* value
Main effect of task (Incongruent > congruent)							
Superior frontal gyrus	M	6	−6	12	58	409	7.5
dACC	M	32	8	26	36		5.4
Middle frontal gyrus	L	9/46	−44	20	18	2252	7.6
Inferior frontal gyrus	L	47	−34	24	−10		6.8
Inferior frontal gyrus	R	47	34	20	−24	407	6.9
Inferior parietal lobule	L	40	−32	−52	42	166	5.7
Middle temoral gyrus	L	37	−54	−48	−6	27	5.2
Main effect of group (OCD > HC)							
Superior frontal gyrus	R	6	26	8	62	57	3.98
Superior frontal gyrus	L	6	−14	6	70	79	3.86
Middle frontal gyrus	R	46	54	26	32	14	3.51
Middle frontal gyrus	R	9	38	34	34	12	3.35
dACC	M	24	−2	2	34	105	4.02
Precentral gyrus	L	4	−24	−24	70	519	4.24
Precentral gyrus	R	6	50	−12	32	35	3.75
Superior parietal lobule	R	7	16	−46	68	243	4.07
Inferior parietal lobule	R	40	40	−46	46	74	3.96
Task by group interaction							
OCD > HC; Incongruent > congruent							
DLPFC	R	9/46	40	34	36	23	3.5
	L	9	−56	10	26	23	3.5
HC > OCD; Incongruent > congruent							
Occipital lobe	L	19	−34	−64	14	47	3.5
OCD > HC, incongruent condition only							
Middle frontal gyrus	R	9/46	40	34	36	199	4.2
dACC	M	24	−2	2	34	171	4.1
Precentral gyrus	L	4	−24	−24	70	108	3.7
Superior parietal lobule	R	7	6	−42	66	167	3.8
Inferior parietal lobule	R	40	42	−48	46	69	3.9
Superior frontal gyrus	R	6	24	8	62	58	4.1
Superior frontal gyrus	L	6	−22	4	66	29	3.6

DCM analysis: The models

General properties of the models:

- left and right V1 have been used as input regions
- the rostral ACC has been included to enable comparisons with previous studies on major depression (we won't discuss it further)
- motivated by the literature, the DLPFC gets input from V1, but not the ACC
- other regions like the VMPFC probably also play a role, but the authors wanted to maintain a low complexity level



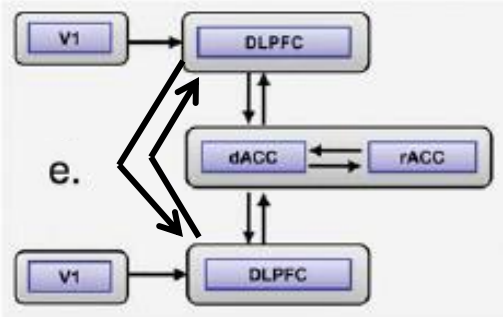
Which model is a priori likely to win Bayesian Model Selection?

- A the most complex model
- B: the most simple model
- C: the model with the best name
- D: no model in particular

DCM Results

- Bayesian Model Selection revealed that the most complex model, model 5, fits best (both for OCD-patients and healthy controls)
  - this is not obvious a priori, because Bayesian Model Selection identifies the model with the best balance between *fit* and *complexity*

- None of the intrinsic connections showed significant group differences



Main Hypotheses

1) OCD-patients have an overactive dorsal ACC during conflict processing.

2) ~~There is a stronger connectivity between the dorsal ACC and the DLPFC in OCD-patients.~~

?

DCM Results

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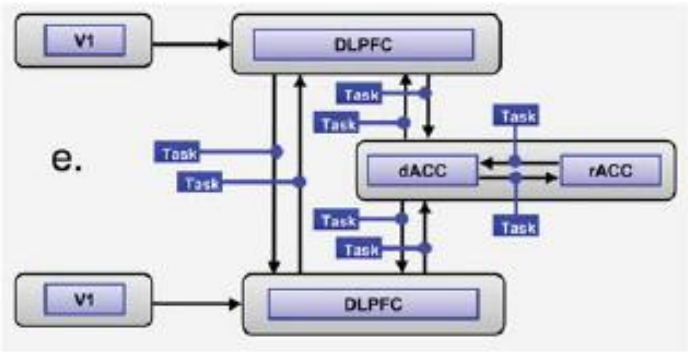
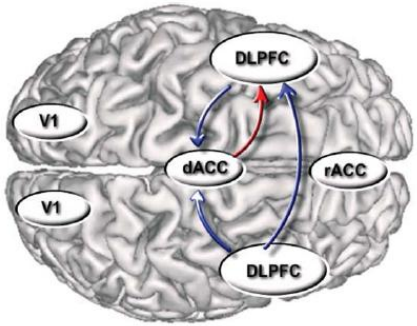


- None of the intrinsic connections showed significant group differences

- They added task-related modulators (*bilinear interaction terms*) to assess the influence of conflict (congruent vs. incongruent condition) on the connections
  - ➔ task-related modulation of the connection from the dorsal ACC to left DLPFC was significantly stronger in OCD patients



Main Hypotheses

1) OCD-patients have an overactive dorsal ACC during conflict processing.

2) There is a stronger connectivity between the dorsal ACC and the **left** DLPFC in OCD-patients**, when the connections include task-related modulation.**

Conclusions

Questions?
Remarks?
Comments?

1) OCD-patients have an overactive dorsal ACC during conflict processing.

2) There is a stronger connectivity between the dorsal ACC and the **left** DLPFC in OCD-patients**, when the connections include task-related modulation.**

OCD-patients do not have a different neural network with a different structure, but the intensity of functional connectivity parameters is different.

The results are compatible with Cohen's elegant model of the fronto-cingulate system, but arguing that the model is *supported* would probably be an overstatement.