

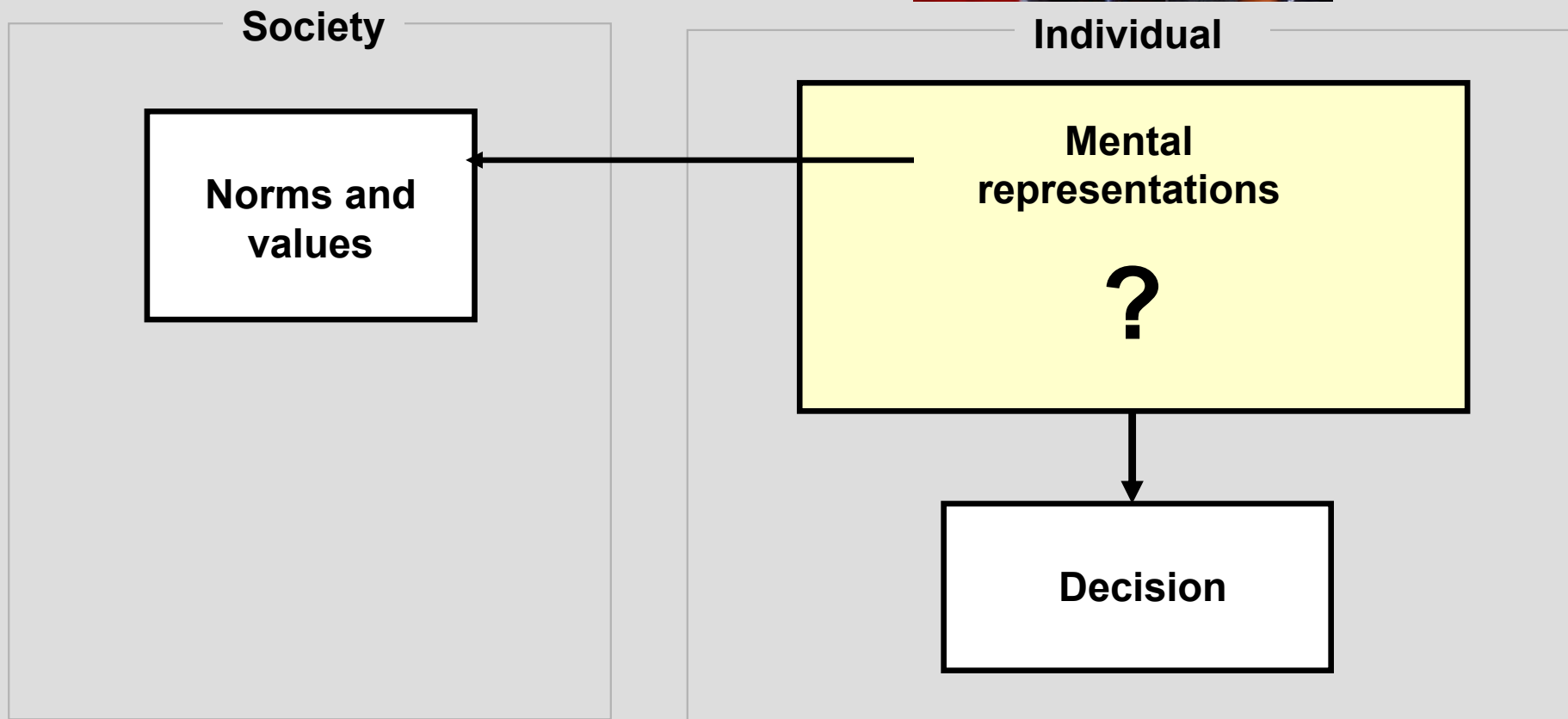
# Moral judgment competence reflected in right prefrontal cortex

*Kristin Prehn*

*Konstanz, July 2009*



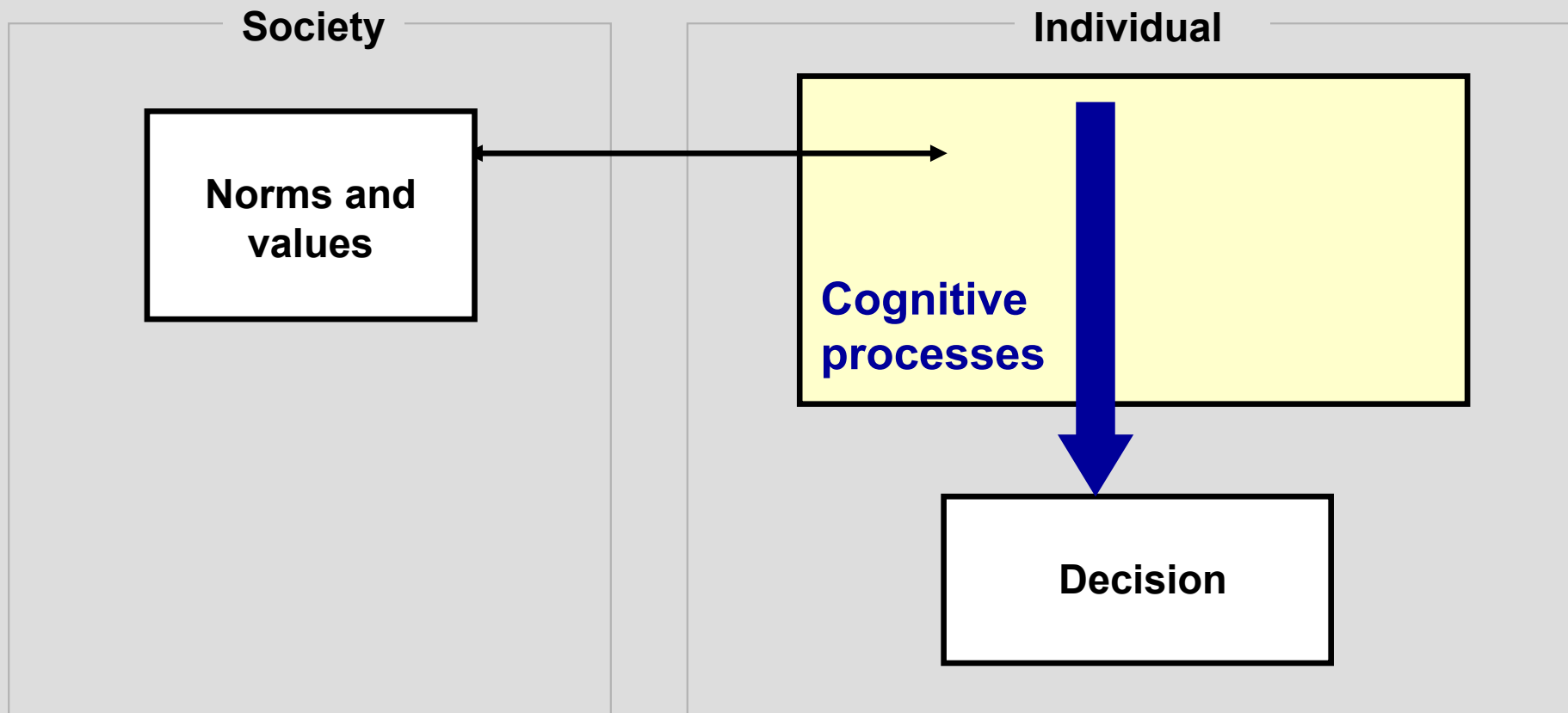
# Moral judgment and decision making



# Competing theories

## 1. Moral reasoning from a cognitive-developmental point of view

(Piaget, 1965; Kohlberg, 1969)



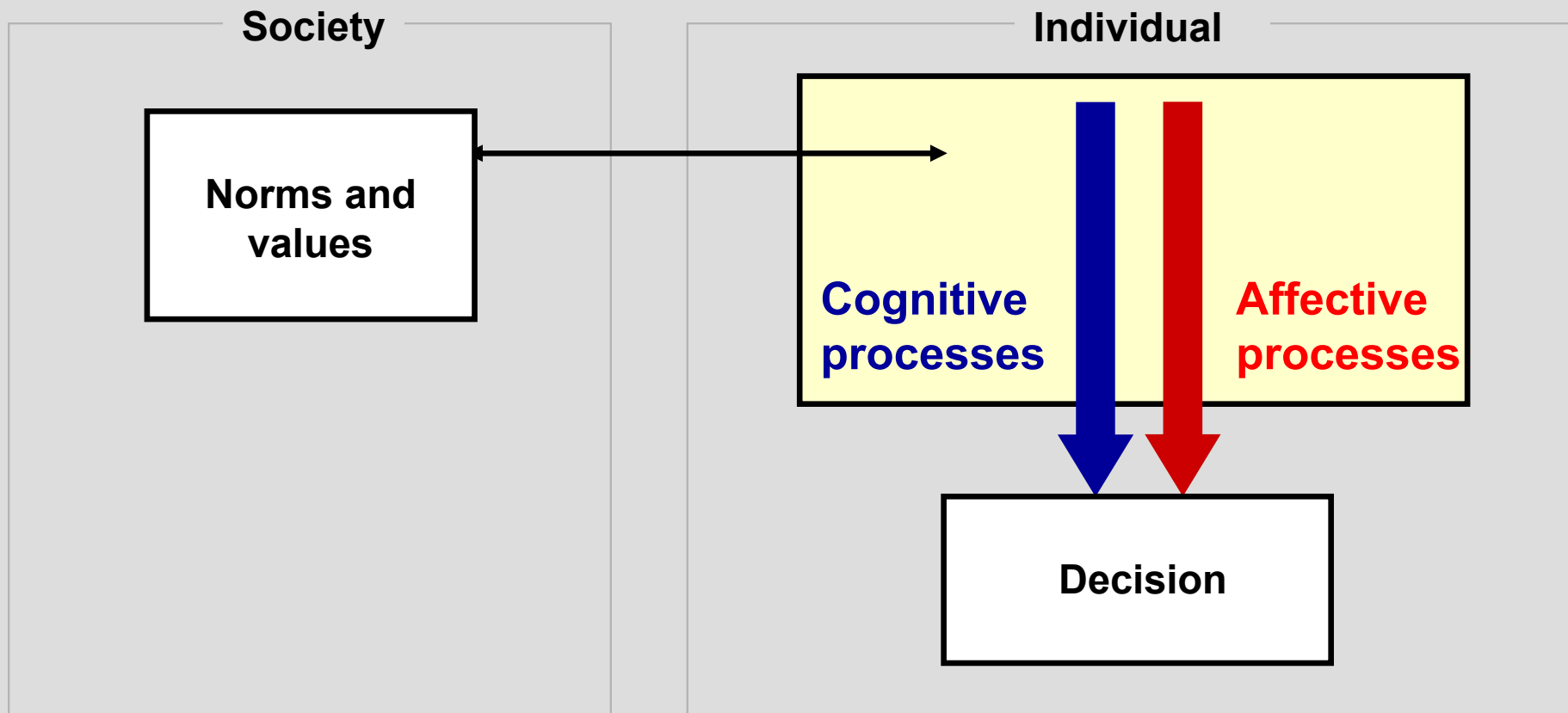
# Competing theories

## 1. Moral reasoning from a cognitive-developmental point of view

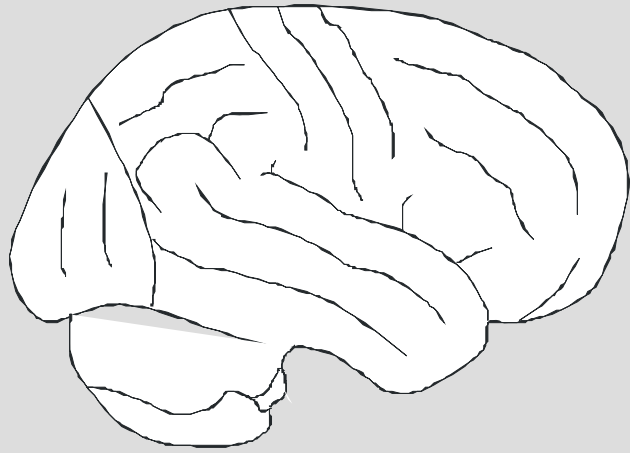
(Piaget, 1965; Kohlberg, 1969)

## 2. Intuition and moral emotions

Social Intuitionist model (Haidt, 2001); Moral emotions (Haidt, 2003); Moral grammar theory (Hauser, 2006; Mikhail, 2007)



# Cognitive Neuroscience



**Neurobiological mechanisms underlying cognition and behavior**

**Methods:**

- *Lesion data***
- *Neuroimaging studies***
- *Studies investigating information processing in clinical samples***

# Lesion studies

## First evidence for a neurobiological basis of morality

- **Phineas Gage (Harlow, 1848; Damasio et al., 1994)**
    - Preserved basic cognitive abilities
    - Irresponsible and inappropriate behavior
    - Impaired decision making in real life
    - Limited ability to experience emotions
  - **More recent case studies:**
    - OFC (Camille et al., 2004)
    - VMPFC (Koenigs et al., 2007)
  - **Lesions acquired in early childhood also prevent acquisition of factual knowledge about accepted standards of moral behavior (Anderson et al., 1999)**
- ⇒ *Very few cases with mostly very large and heterogeneous lesions*

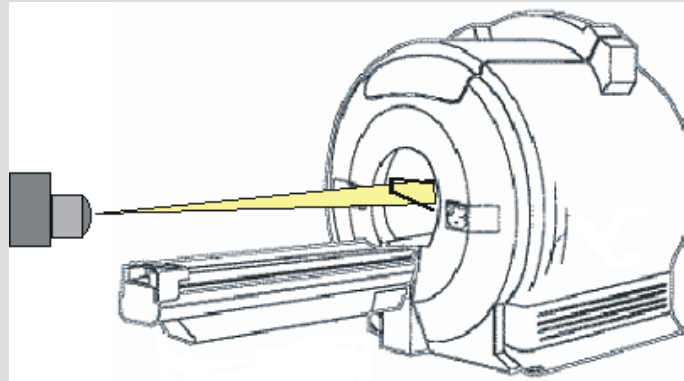


From Damasio et al., 1994

# Functional magnetic resonance imaging

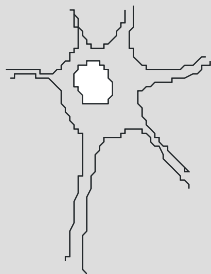
## Investigating moral decision making in the intact human brain

(1) Stimulus presentation

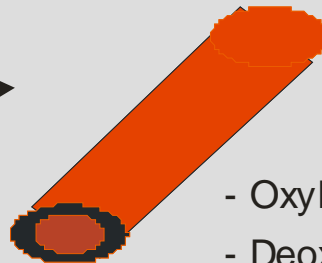


Detection by the MRI scanner

(2) Neural activity



(3) Hemodynamic response



- Oxyhemoglobin increases
- Deoxyhemoglobin decreases

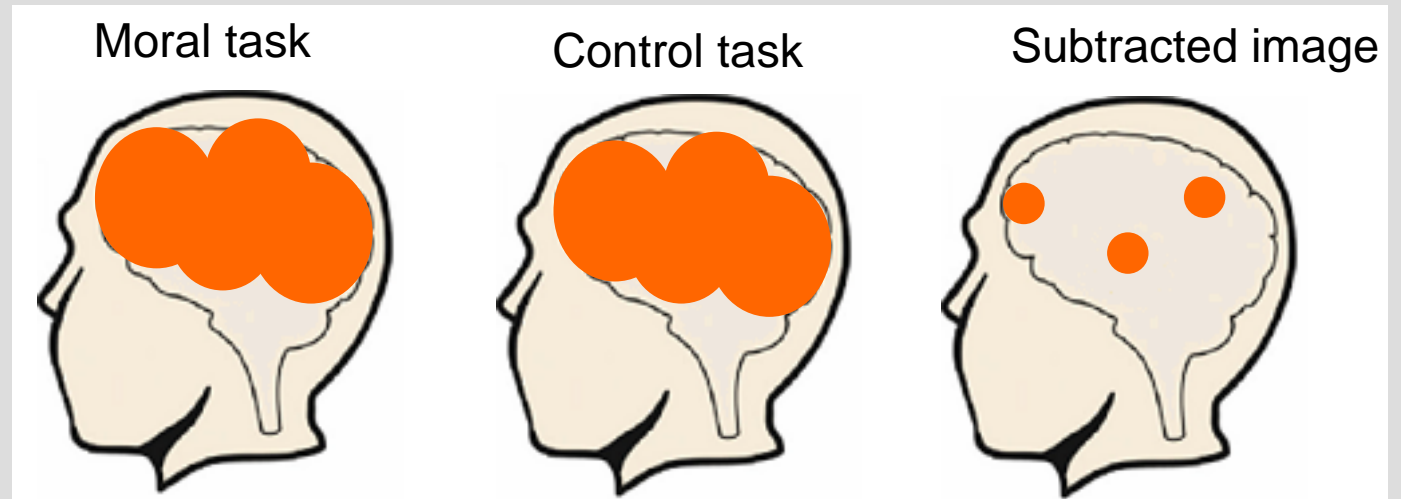
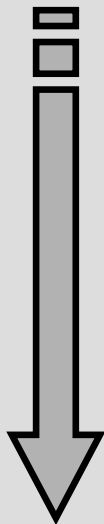




# Functional magnetic resonance imaging

## Some methodological considerations

### 1. Subtraction logic



### 2. Tasks and experimental paradigms have to be carefully designed

(eliminating confounding variables)

### 3. Complex cognition

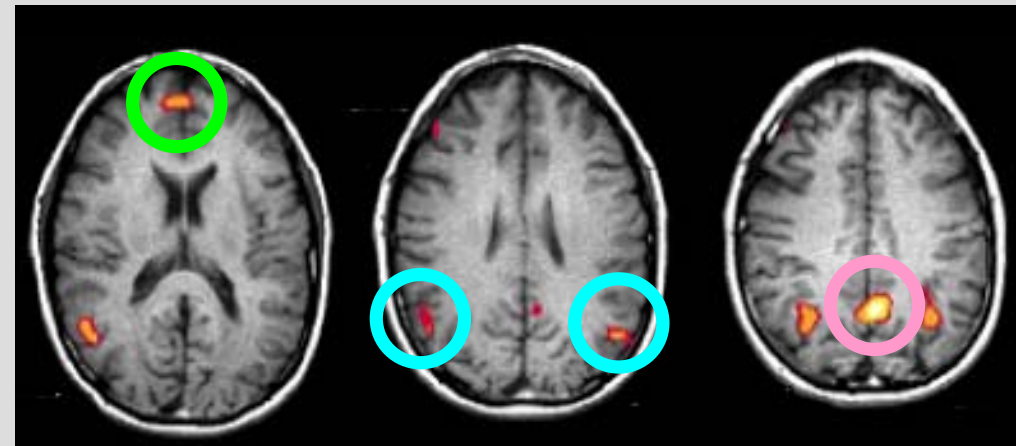
⇒ No “moral center” in the brain

⇒ Distributed and overlapping functional neural networks

# Neural correlates of moral decision making

- **Different Tasks and Materials**

(Reviews: Greene & Haidt, 2002; Moll et al., 2003, 2005; Goodenough & Prehn, 2004; Prehn & Heekeren, in press)



from Greene et al., 2001:

- **Functional network:**

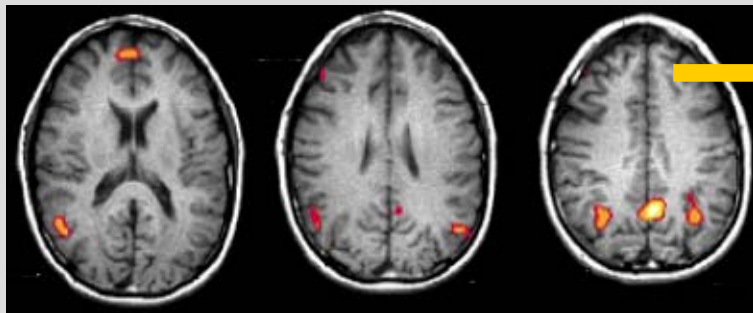
***Cognition + Emotion***

VMPFC

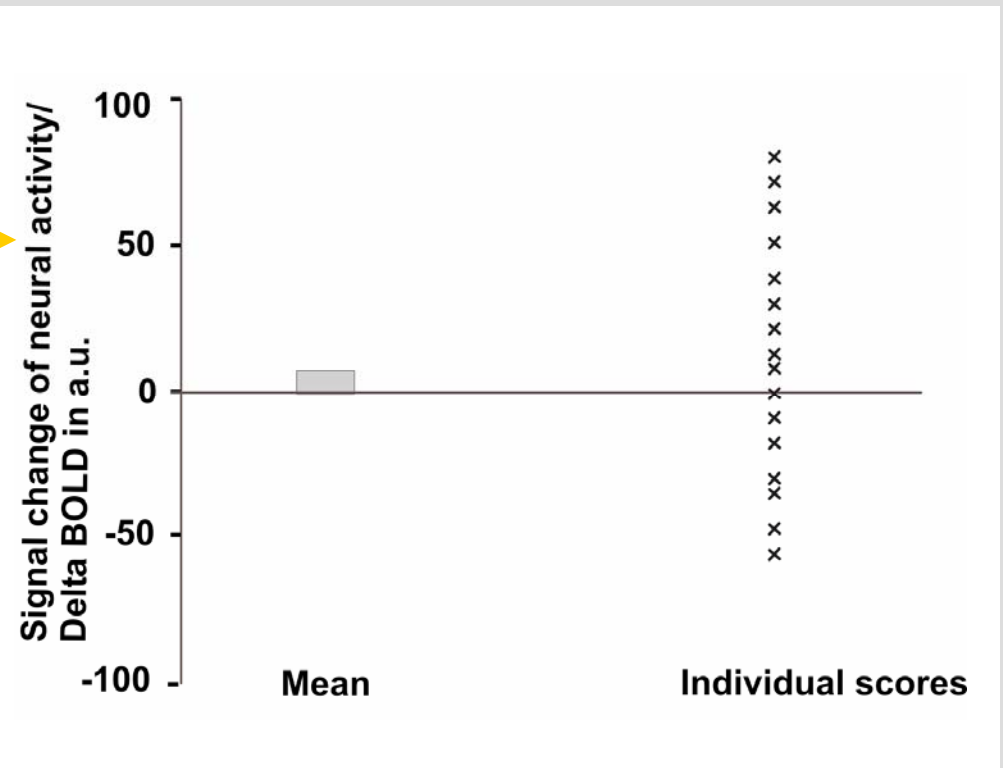
PCC

PSTS

# Individual differences approach

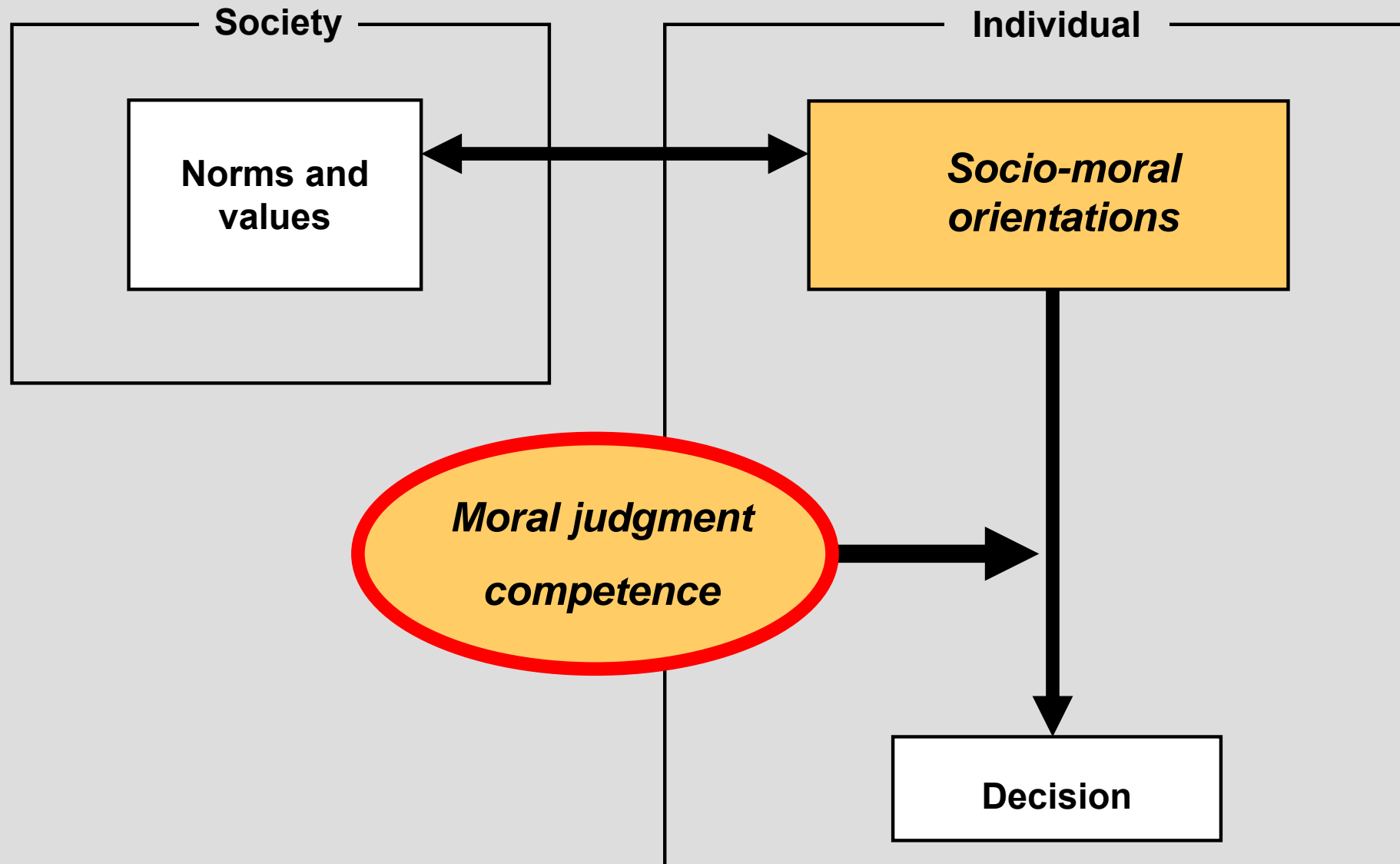


from Greene et al., 2001:



*One man's noise is  
another man's data...*

# Individual differences in moral decision making



# Present study

## Aim and hypothesis

### To investigate:

**Neural correlates of moral judgment competence and how the neural correlates of moral decision making are modulated**



### Hypothesis:

**Covariation of moral competence with neural activity in prefrontal cortex**

(e.g., Miller et al., 2000, 2002; Greene et al., 2004, Bunge, 2004, etc.)

# Present study

## Task and sentence material

	Moral decision making
Violation	<p>X uses public transportation.</p> <p>He smashes the window.</p>
Non-violation	<p>X uses public transportation.</p> <p>He looks out of the window.</p>

# Present study

## Task and sentence material

	Moral decision making	Grammatical decision making
Violation	X uses public transportation. He smashes the window.	X uses public transportation. He look* out of the window.
Non-violation	X uses public transportation. He looks out of the window.	X uses public transportation. He looks out of the window.

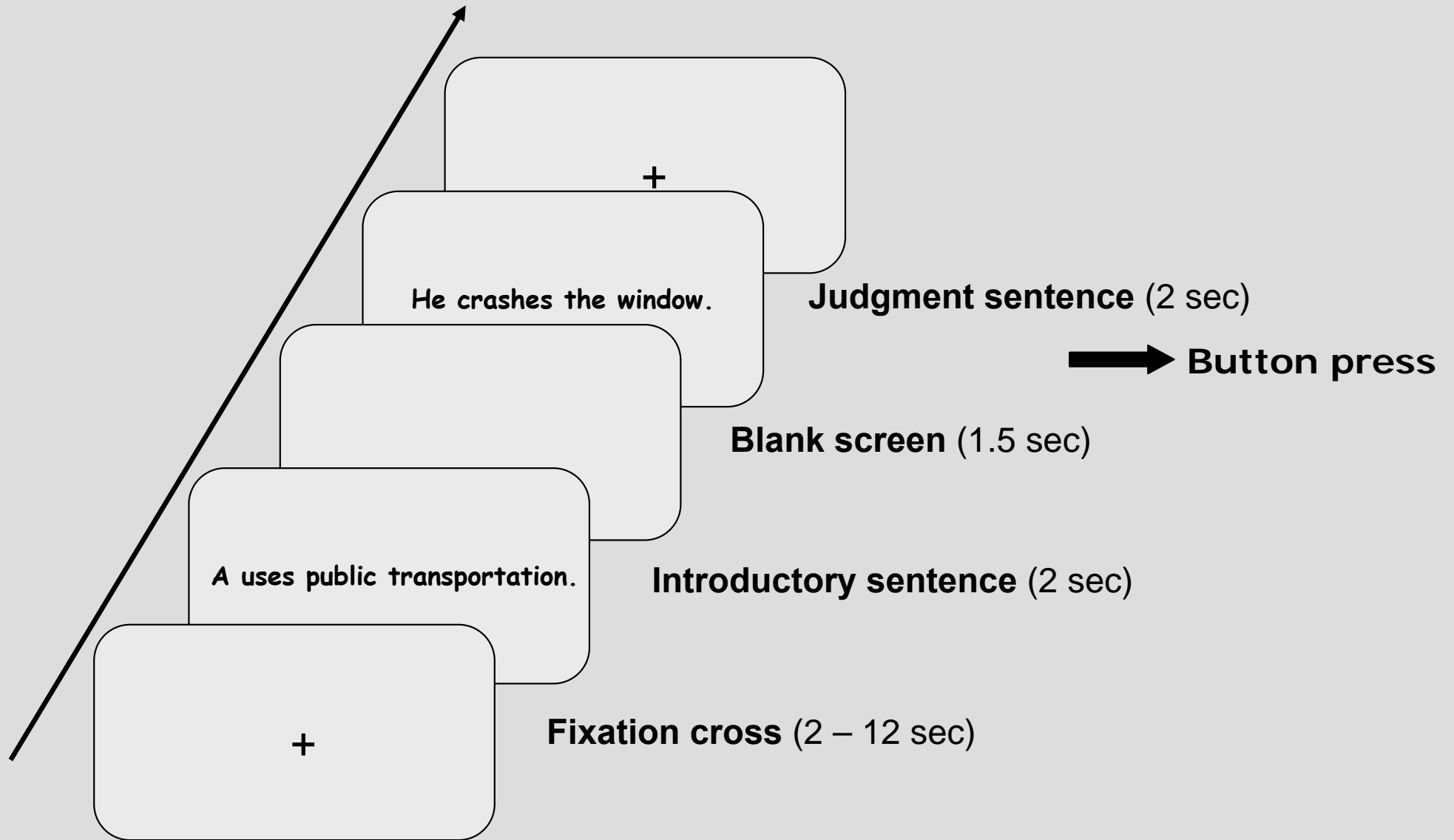
Prehn et al., 2008

- Matched for number of syllables and word frequencies
- Validated in a questionnaire-based investigation (n = 80)
- Presented in a mixed blocked/ event-related design

# Present study

## Experimental procedure

- **Mixed blocked event-related design**





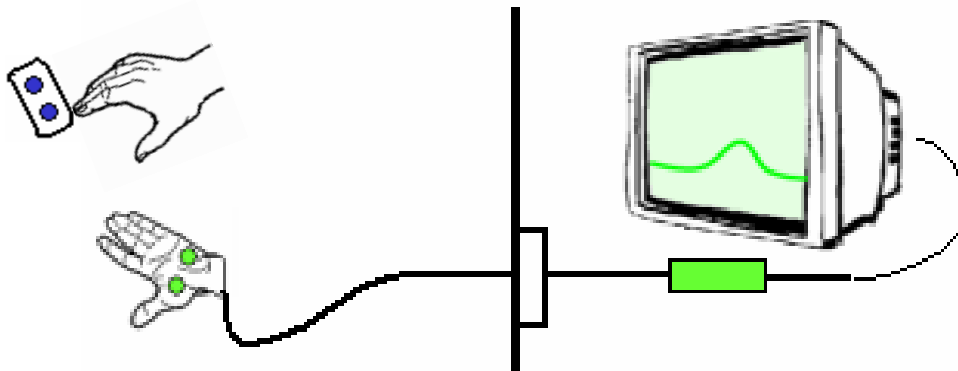
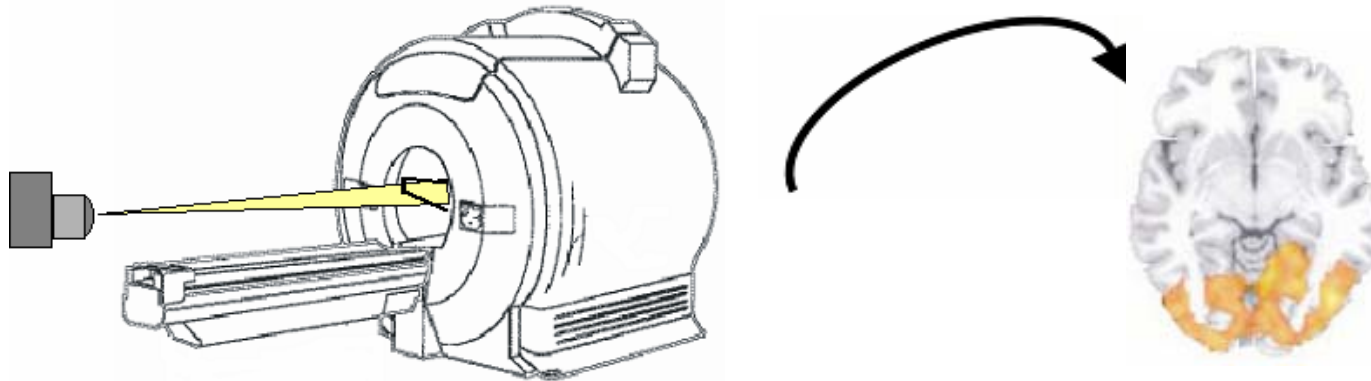
# Present study

## Experimental procedure

- **n = 23**  $\Rightarrow$  young, healthy, right-handed women, same level of education

- **Functional magnetic resonance imaging (1,5 T Siemens Vision)**

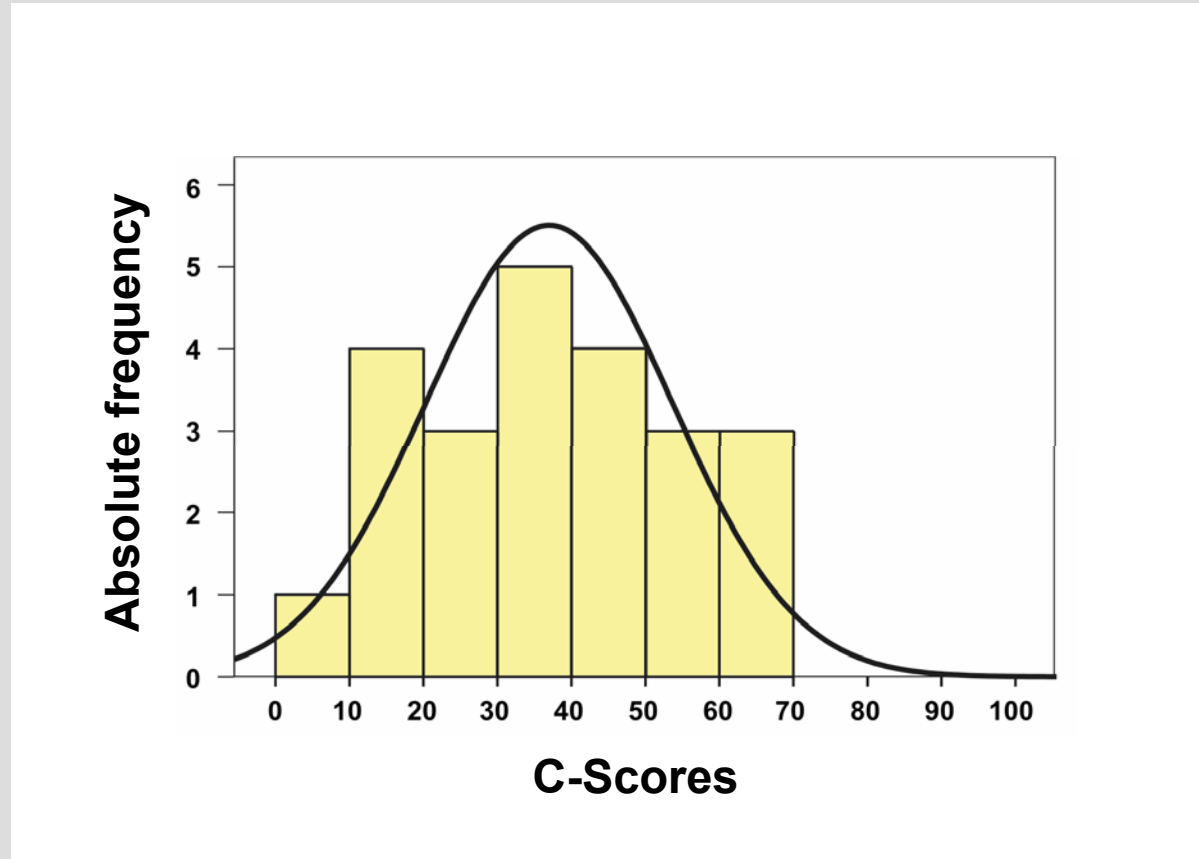
TE: 40 msec; TR: 2500 msec; flip angle: 90°; FOV: 256 mm; matrix: 64 x 64; voxel size: 4 x 4 x 4 mm; 26 slices



- **Behavioral data:**  
Response times, error rates
- **Skin conductance level**

# Present study

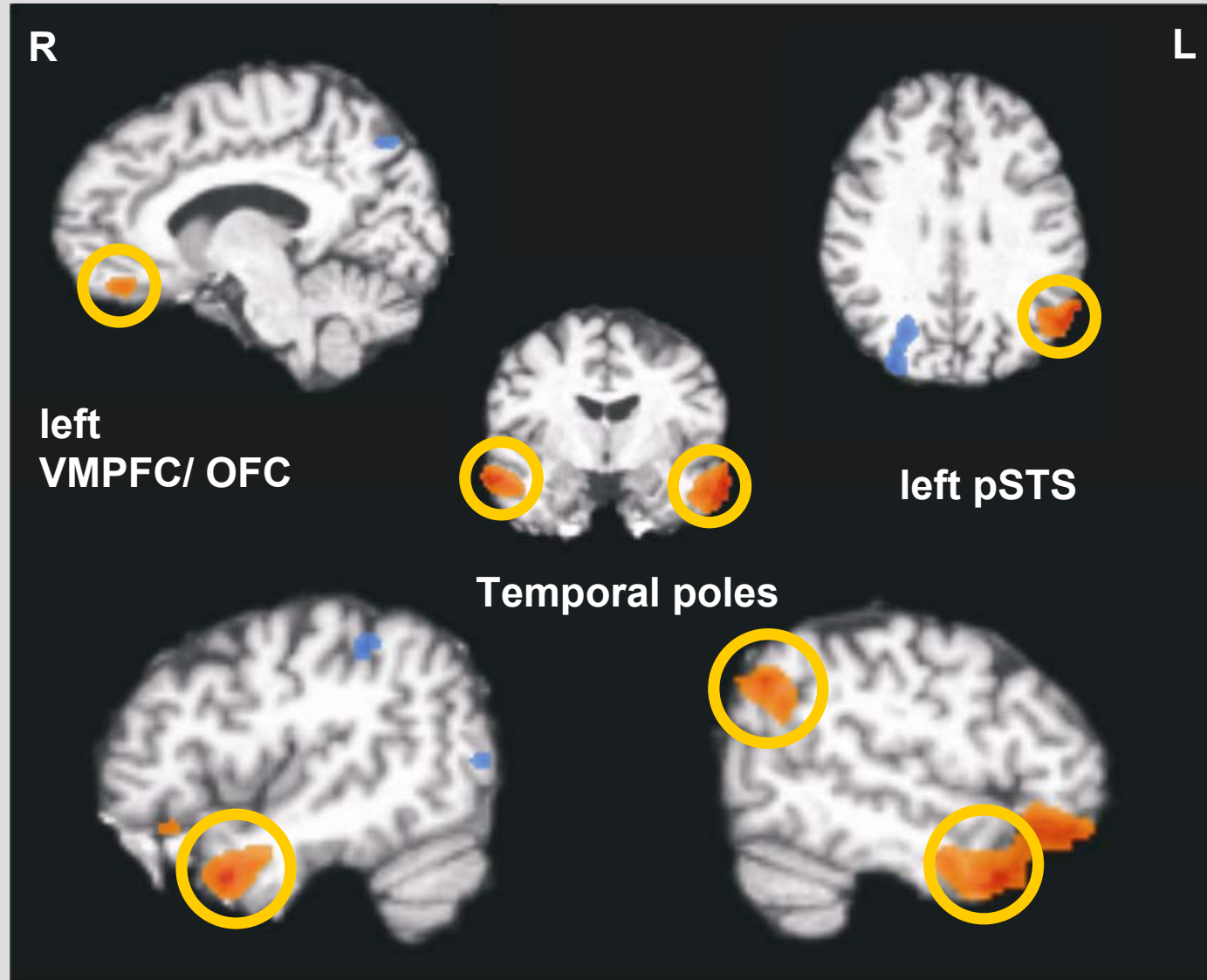
## Individual moral judgment competence



**36.93 [mean]  $\pm$  16.67 [SD] => Normally distributed**

# Present study

## Results 1



Moral  
decision making  
>  
Grammatical  
decision making

Random effects analysis,  $p < 0.05$ , corr.

# Present study

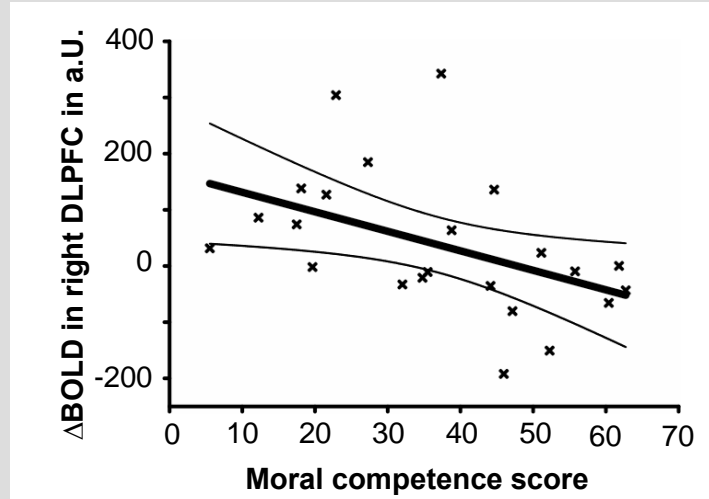
## Results 2

Right DLPFC  
(BA 45/46)

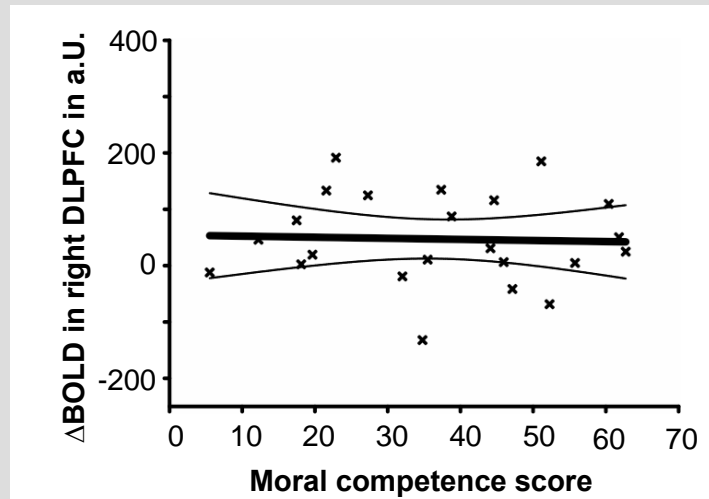


$p < 0.05$ , corrected

Moral decision making:  $r = - .47^*$



Grammatical decision making:  $r = - .05$



# Present study

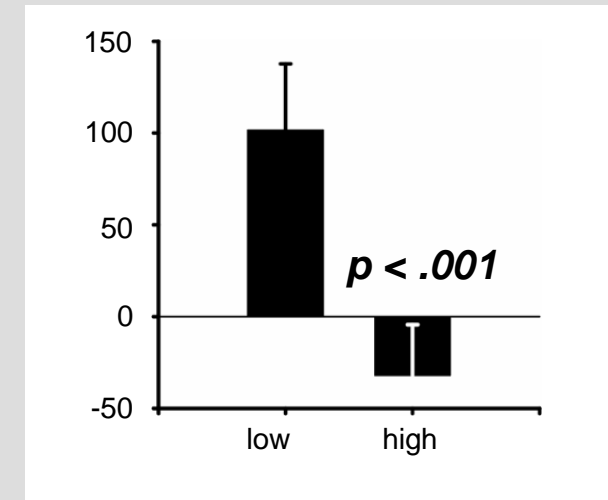
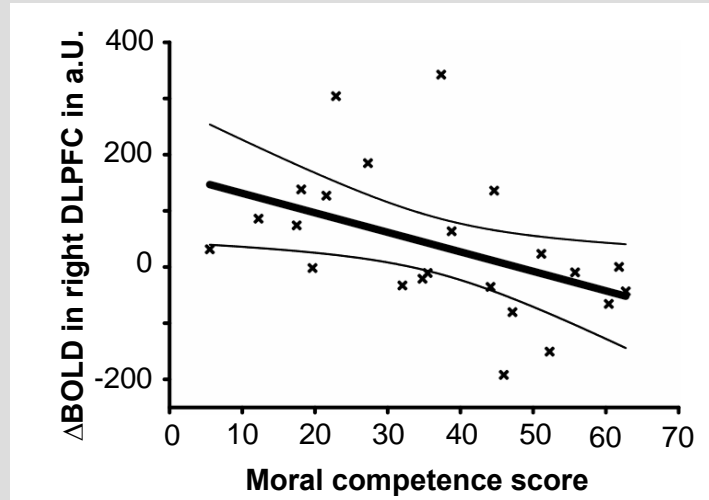
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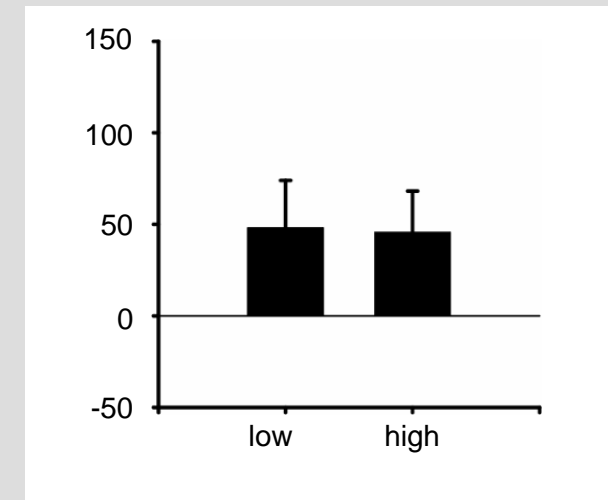
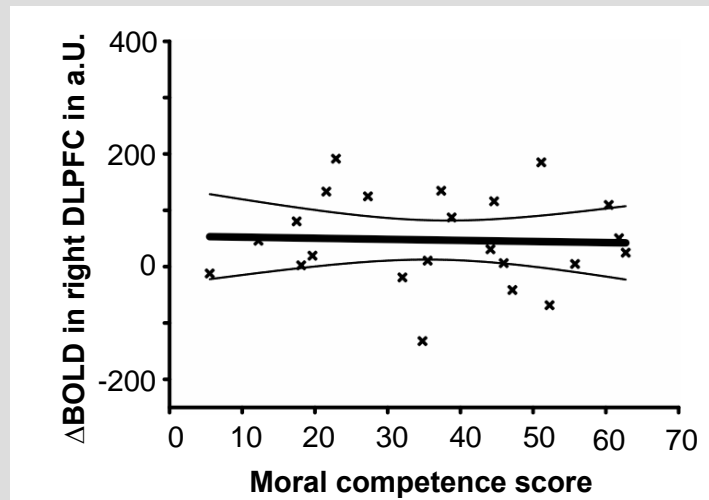


$p < 0,05$ , corrected

Moral decision making:  $r = - .47^*$



Grammatical decision making:  $r = - .05$

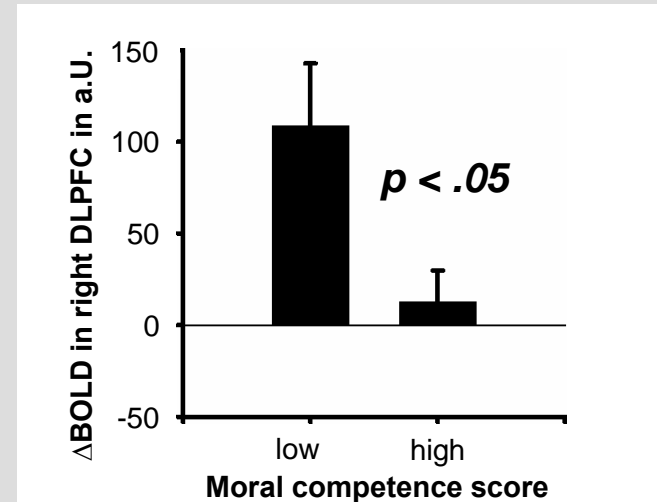
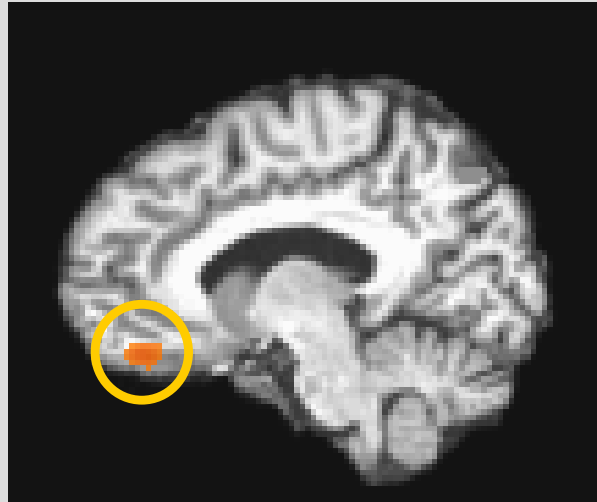


# Present study

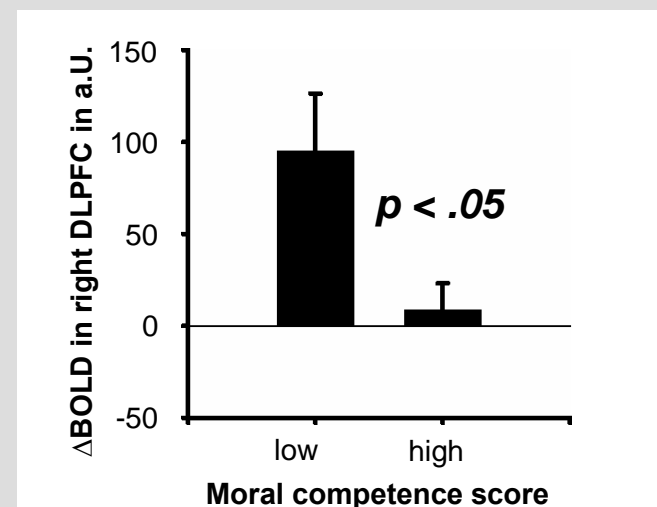
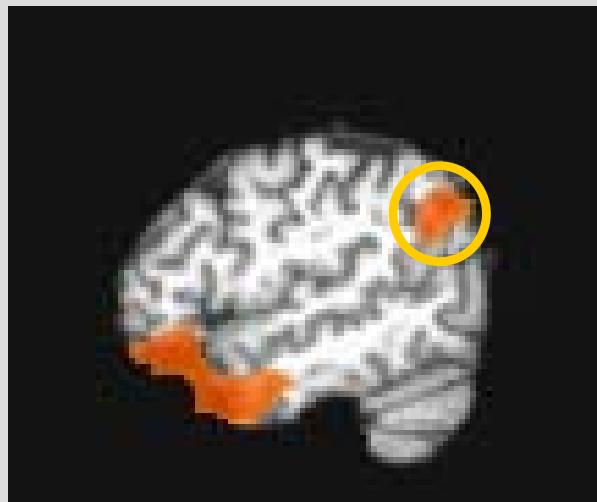
## Results 3

Specifically during identification of social norm violations:

- Left VMPFC



- Left PSTS



# Present study

## Discussion

- **Replication of a functional network contributing to moral decision making**
- **Neuronal correlate of individual differences in moral competence: Participants with lower moral competence recruited the right DLPFC/ VMPFC/ PSTS more than those with high competence**
  - **Right DLPFC: Higher processing demands during the controlled and consistent application of social norms**  
(Knoch et al., 2006; Knoch & Fehr, 2007; Richeson et al., 2003)
  - **VMPFC/ PSTS: Increased involvement of emotional and socio-cognitive processes**  
(see Amodio & Frith, 2006; Young et al., 2007)

# Next steps

## ToDo:

### From BIG QUESTIONS to SMALL STEPS

- **Investigating neural correlates of moral judgment competence during more complex moral decision making**  
(moral dilemmas during which a conflict between cognitive and emotional processing is induced)
- **Investigating effects of training and expertise**
- **Providing tools for clinical application (diagnosis and therapy of patients with antisocial personality disorder, psychopathy)**



# Generell discussion

- **Have we now found how moral judgment competence is represented in the brain?**
- **Can we say that our brain capacities determine our way to handle moral dilemmas?**

# Thanks!



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