

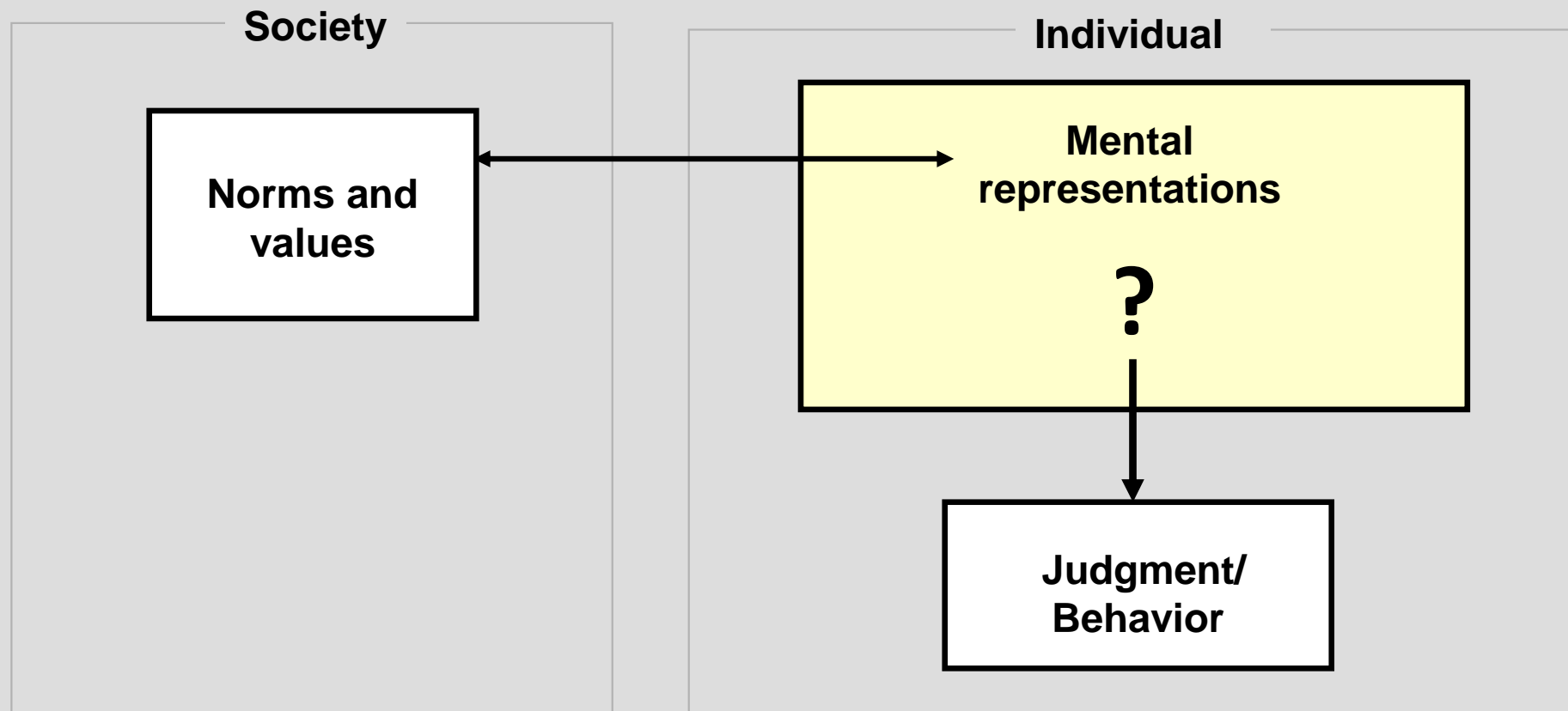
***Neural correlates of  
moral judgment &  
moral judgment competence***

*Kristin Prehn*

# Outline

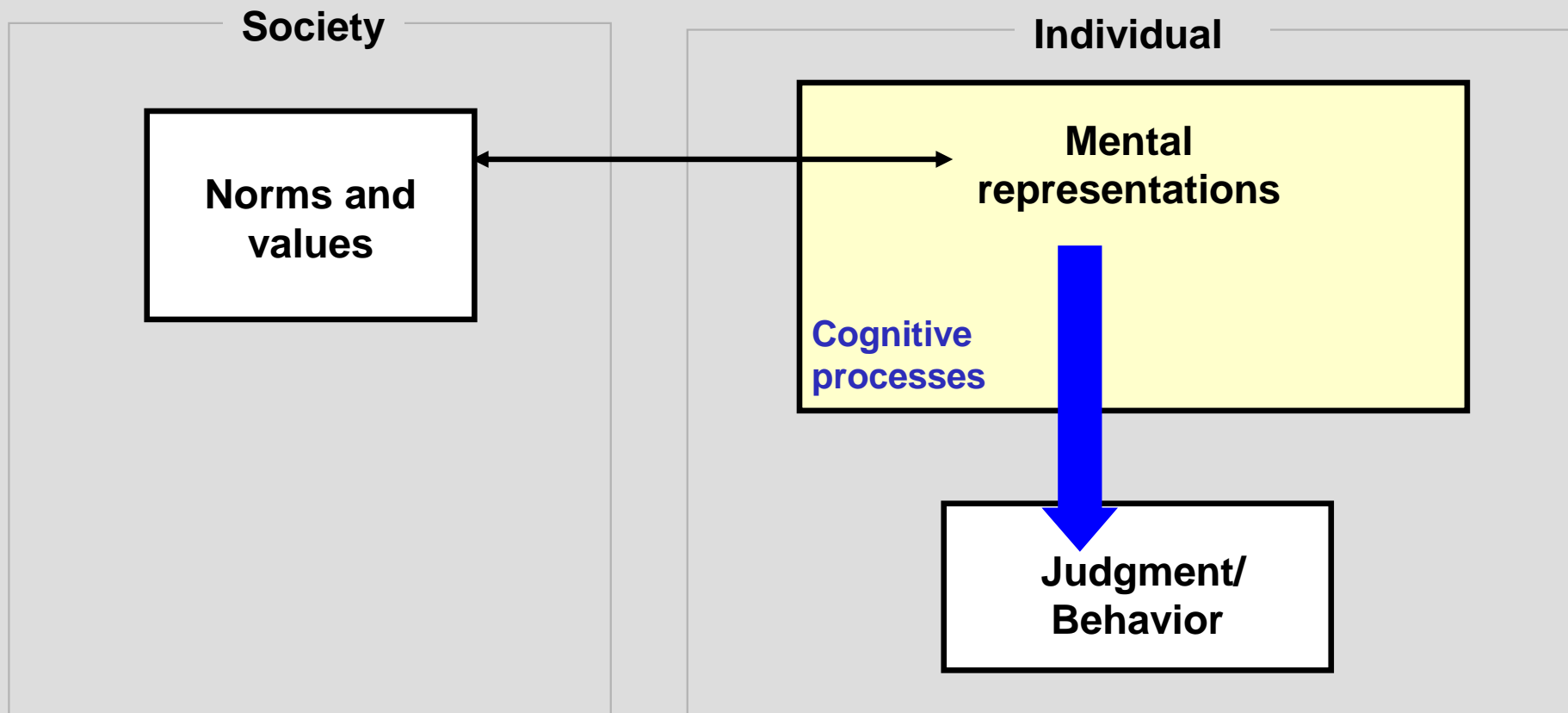
1. ***Psychological models on moral judgment and behavior***
2. ***Introduction to neuroscientific methods***
  - ***Lesion studies give first evidence for a neurobiological basis of morality***
  - ***Neuroimaging (fMRI)***
  - ***Neurostimulation as an attempt to modulate activity in the “moral brain”***
3. ***Findings on neural correlates of moral judgment and behavior***
  - ***Competing emotional and cognitive subsystems***
  - ***Social cognitive processes and mental state reasoning***
  - ***The influence of individual differences in moral judgment competence***

# 1. Psychological models on moral judgment and behavior



# 1. Psychological models on moral judgment and behavior

Moral reasoning from a cognitive-developmental  
perspective (Kohlberg, 1969)



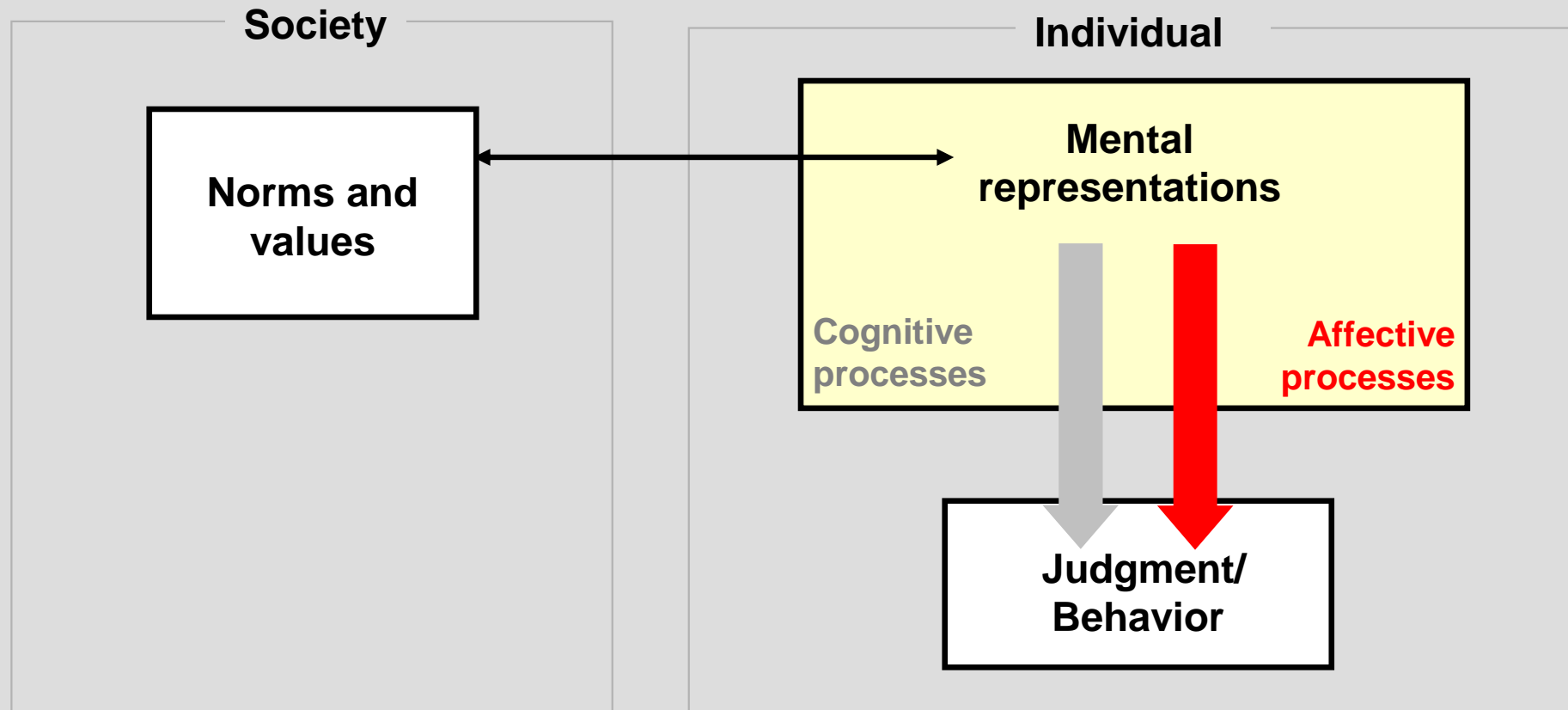
# 1. Psychological models on moral judgment and behavior

Violence inhibition mechanism (Blair, 1995)

Social intuitionist model and moral emotions (Haidt, 2001, 2003)

Universal moral grammar theory (Hauser, 2006; Mikhail, 2007)

Moral foundations theory (Haidt & Joseph, in press)



## 2. Neuroscientific methods

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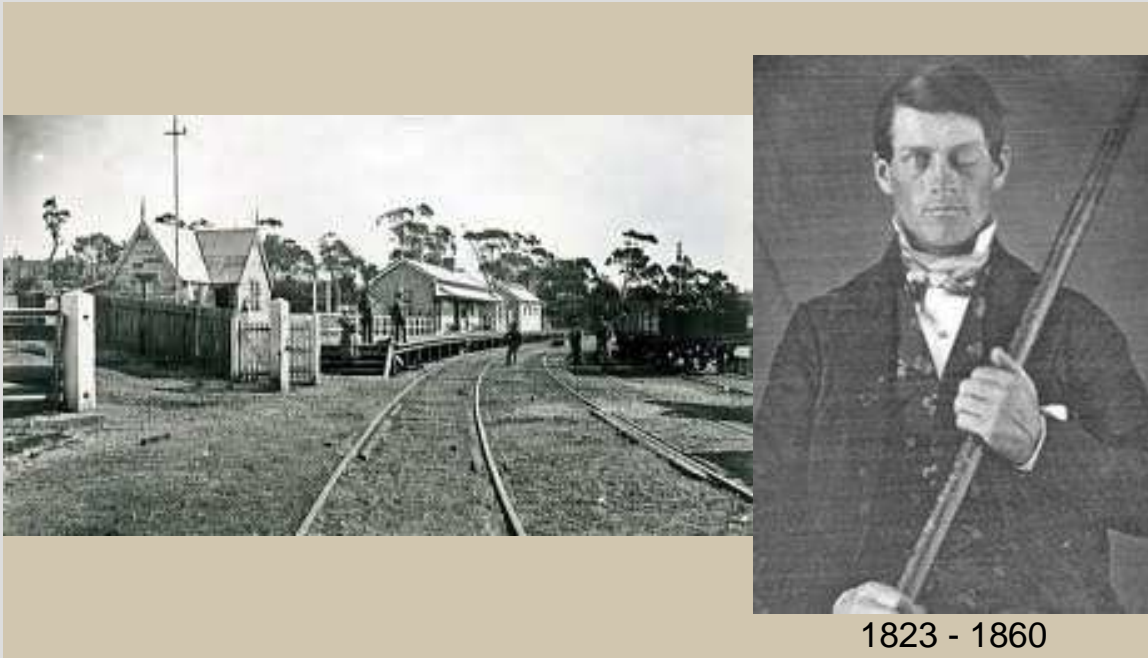
*... as one possibility*

- *To investigate/ disentangle the underlying processes*
  - *To test the different theoretical models*

## 2. Neuroscientific methods

### Lesion studies

- **Phineas Gage:** First evidence for a neurobiological basis of morality



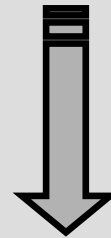
from Damasio et al., 1994

- **“Acquired sociopathy”** (Harlow, 1848; Damasio et al., 1994):
  - Irresponsible and inappropriate social behavior
  - Impaired decision making in everyday social life
  - Limited ability to experience emotion

## 2. Neuroscientific methods

### Lesion studies

- More recent lesion studies also report that damage to the prefrontal cortex (especially ist ventromedial and orbitofrontal portions) leads to deficits in moral emotions, social behavior, and moral decision making
  - **VMPFC** (e.g., Koenigs & Tranel; Koenigs et al., 2007)
  - Camille et al., 2004: Patients with **OFC** lesions show defective ability to anticipate negative consequences and experience regret



*... only few cases with mostly very large and heterogeneous lesions*



# 2. Neuroscientific methods

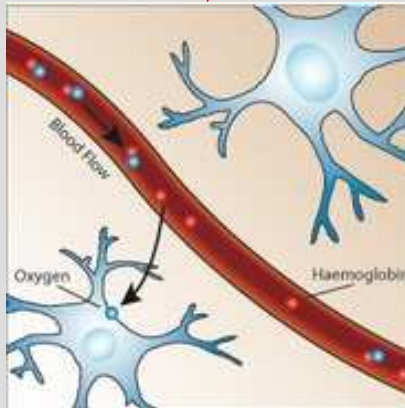
## Functional magnetic resonance imaging (fMRI)

### A) Stimulus presentation

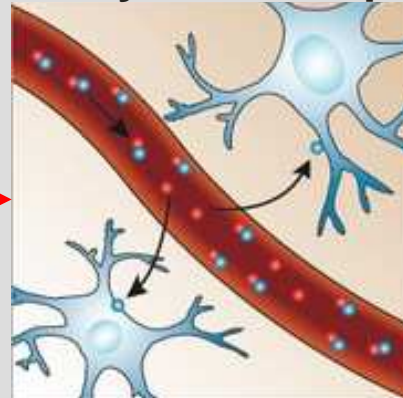


Detection by the MRI scanner

### B) Neural activity



### C) Hemodynamic response



- Oxyhemoglobin increases
- Deoxyhemoglobin decreases

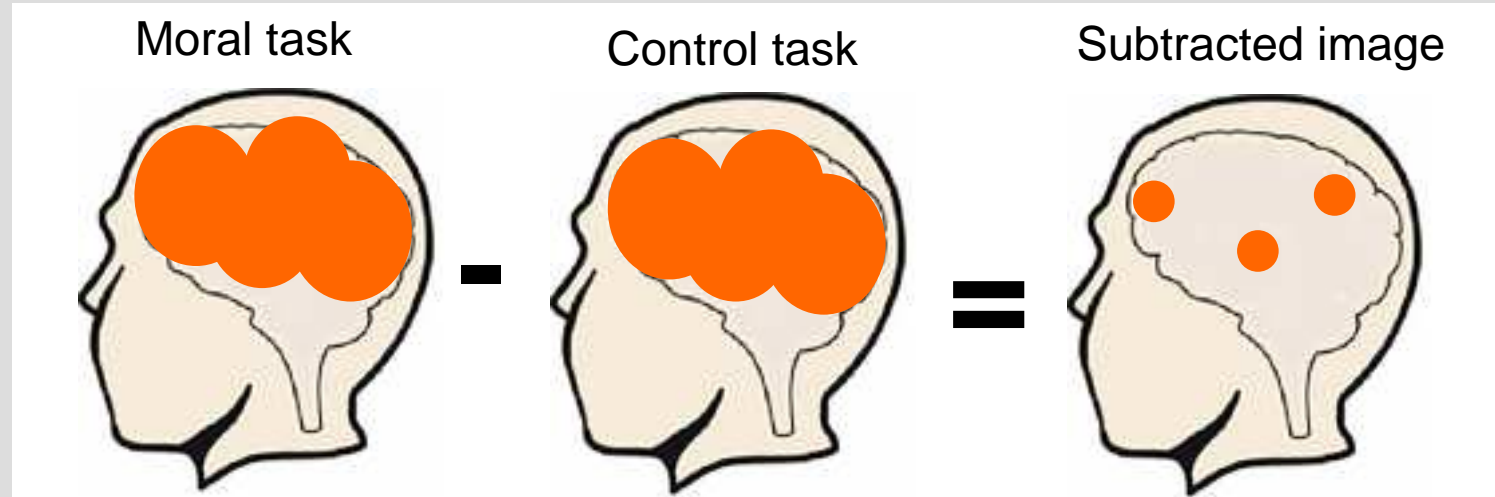
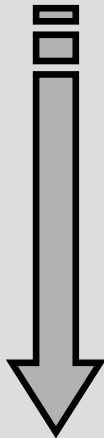


Blood-oxygen level dependent signal (BOLD-signal)

## 2. Neuroscientific methods

### Functional magnetic resonance imaging (fMRI)

#### A) Subtraction logic



#### B) Tasks and experimental paradigms have to be carefully designed (eliminating confounding variables)

**Different tasks and materials** (for reviews see: Greene & Haidt, 2002; Moll et al., 2003, 2005; Goodenough & Prehn, 2004; Prehn & Heekeren, 2009)

#### C) Complex representations

- ⇒ No “moral center” in the brain
- ⇒ Distributed and overlapping functional neural networks

## 2. Neuroscientific methods

### Neurostimulation

*... because correlation does not imply causation*



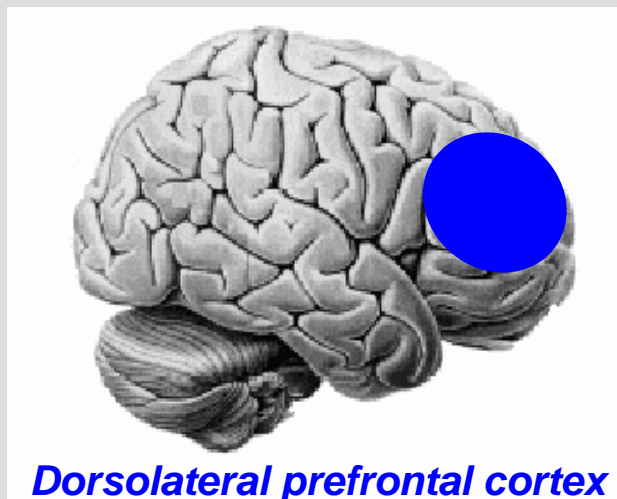
## 2. Neuroscientific methods

### Neurostimulation

- **Transcranial magnetic stimulation (TMS):**

- Magnetic pulses induce weak electric currents in the cortical brain tissue
- Electric current either elicit an action potential that leads to a nerve impulse (high frequent TMS) or inhibits its elicitation (low frequent TMS, “*virtual lesion approach*“)

- [The study by Knoch et al., 2006:](#)



- Ultimatum Game
- Disruption of the right (but not the left) DLPFC reduced the subject’s willingness to reject their partner’s unfair offers (no “altruistic punishment“)
- Subjects were still able to judge unfair offers as unfair right DLPFC implementation of fairness-related behavior



## 2. Neuroscientific methods

### Neurostimulation

- **Transcranial direct current stimulation (tDCS):** Increases/ decreases cortical excitability and changes the likelihood of action potentials



- **Fecteau et al., 2007:** *Anodal stimulation* over right DLPFC reduces risk-taking during decision making
- **Karim et al., 2010:** *Cathodal stimulation* of anterior PFC improves deceptive behavior (better lying skills, reduced skin conductance responses, less feelings of guilt)

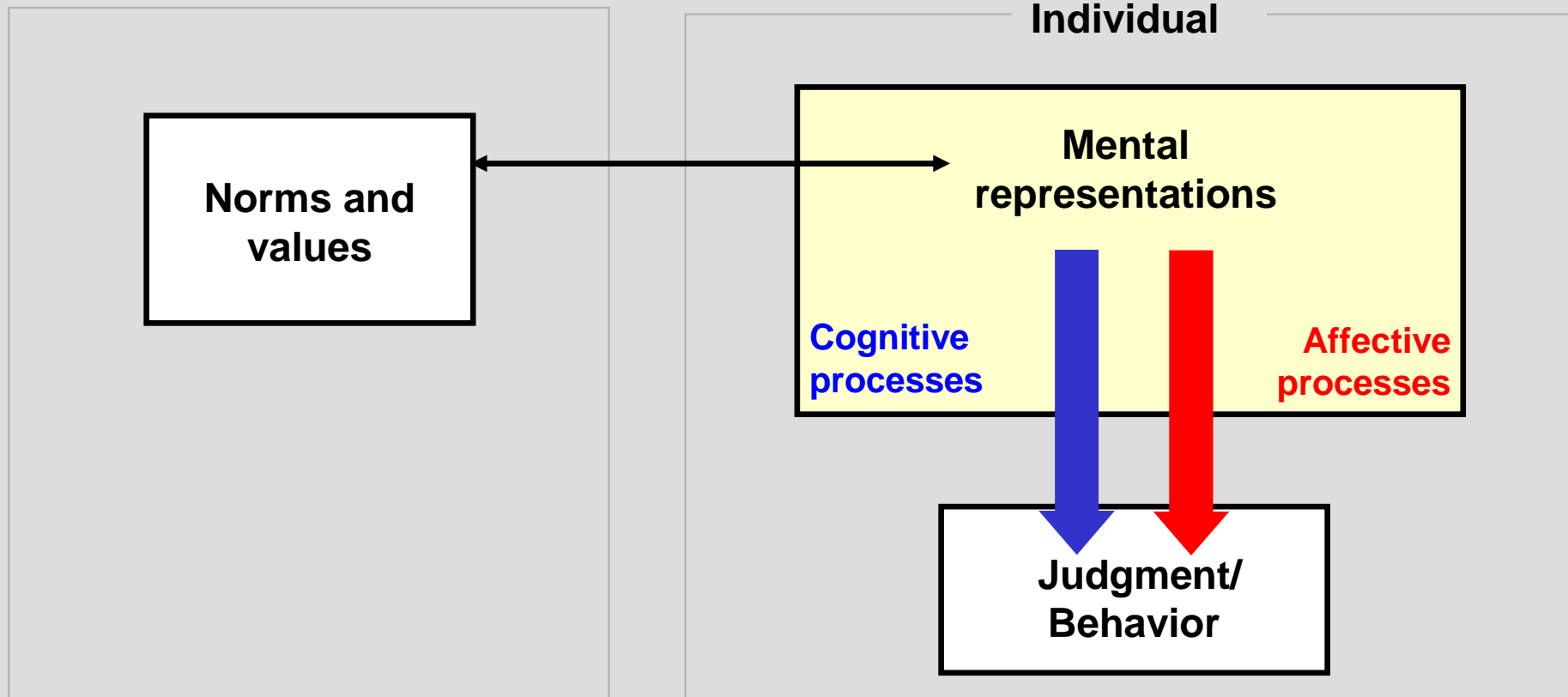
# 3. Neural correlates of morality

## Competing emotional and cognitive subsystems

*... 2 lines of research*

Society

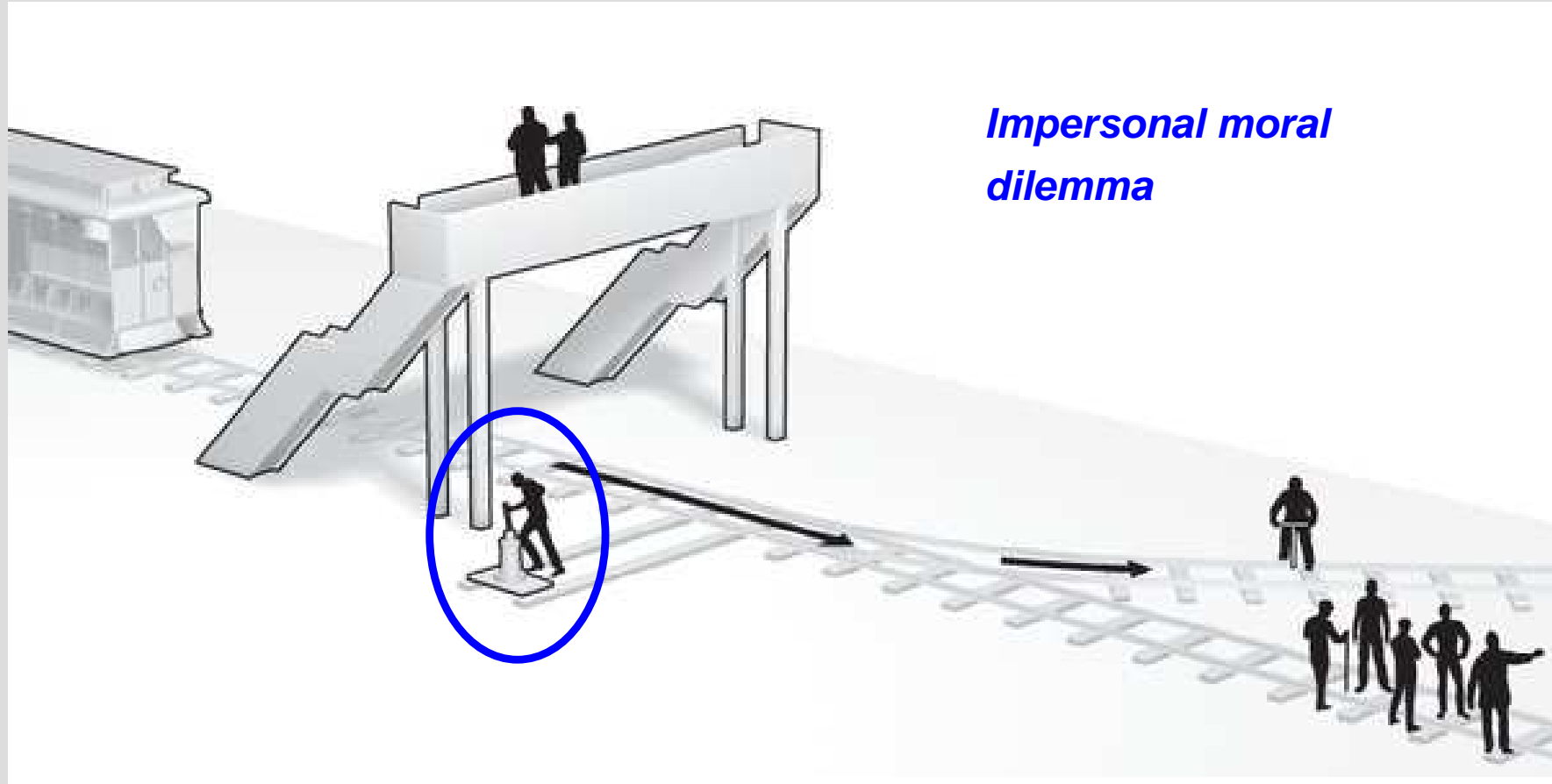
Individual



# 3. Neural correlates of morality

## Competing emotional and cognitive subsystems

Greene et al., 2001:

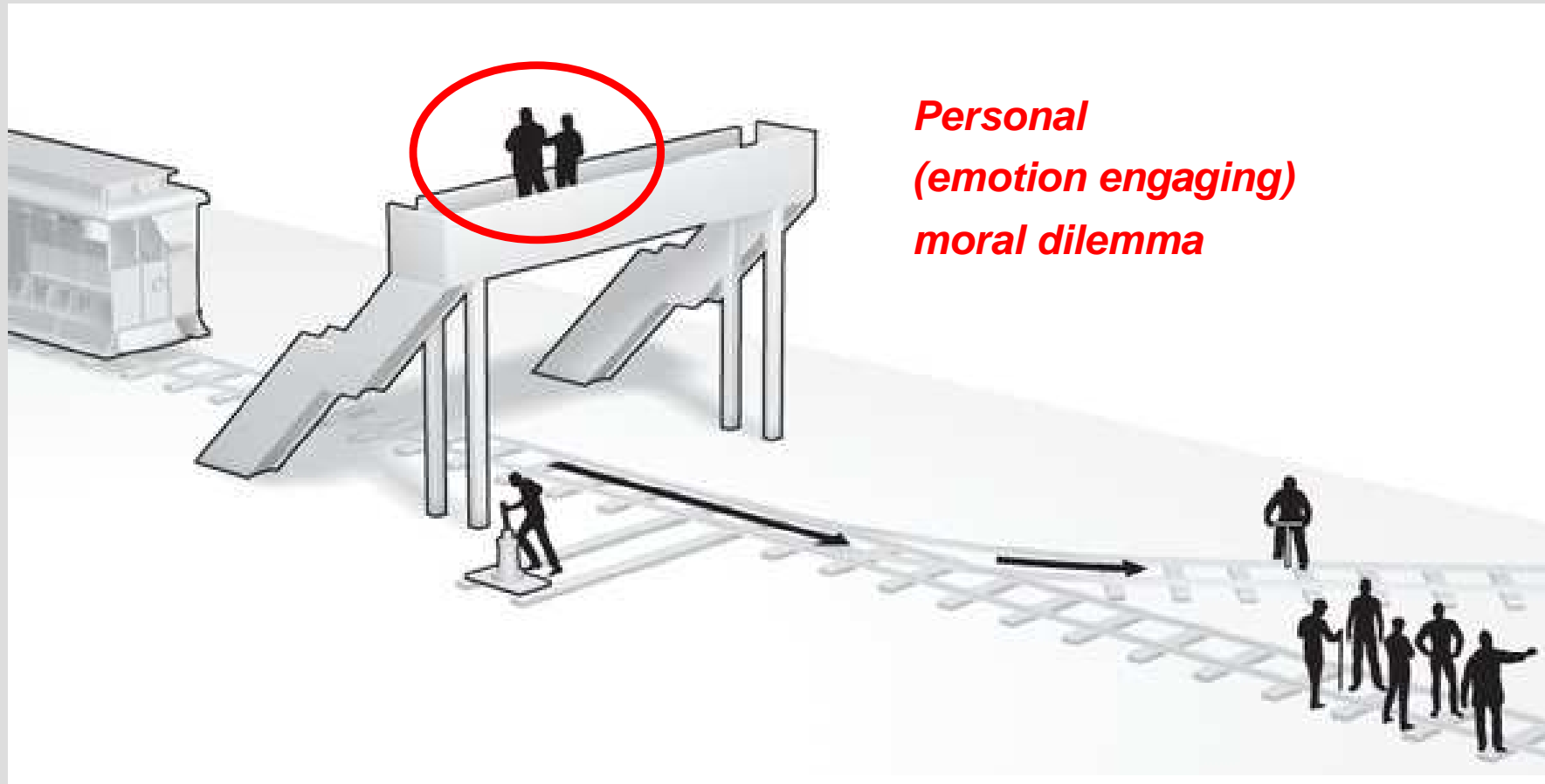


The New York Times, October 9, 2010; Illustration by Frank O'Connell

# 3. Neural correlates of morality

## Competing emotional and cognitive subsystems

Greene et al., 2001:



The New York Times, October 9, 2010; Illustration by Frank O'Connell

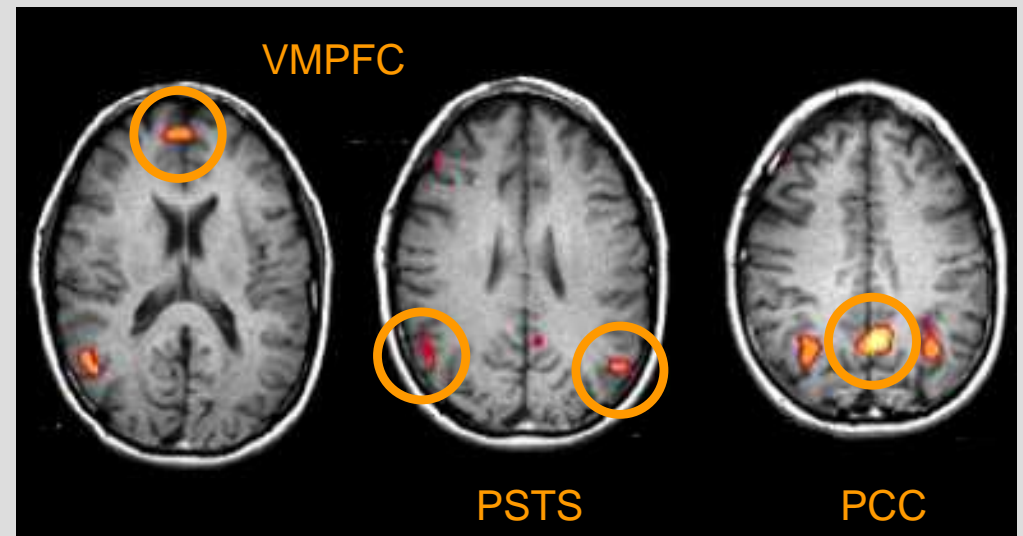
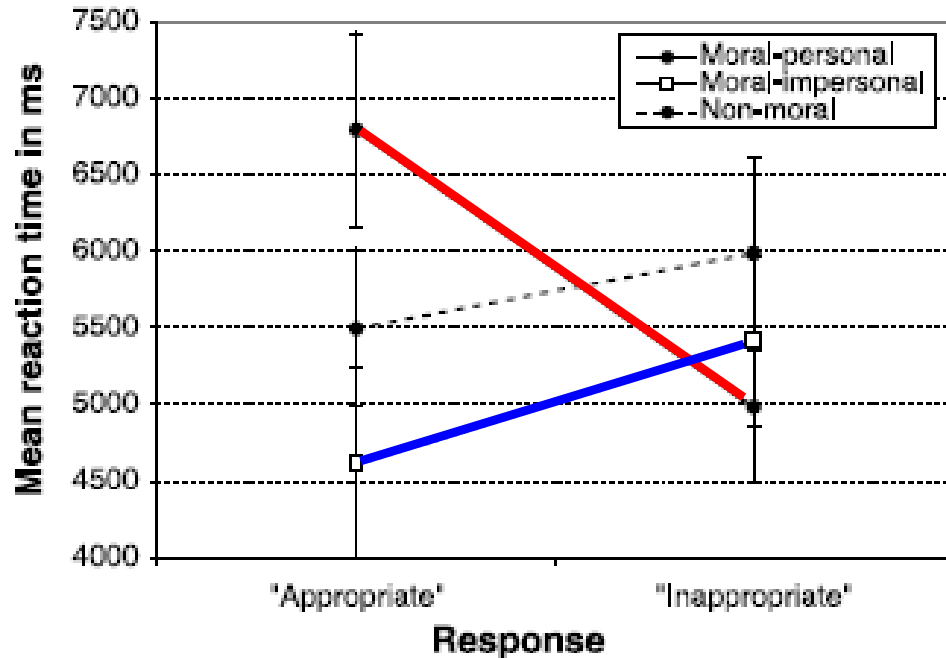
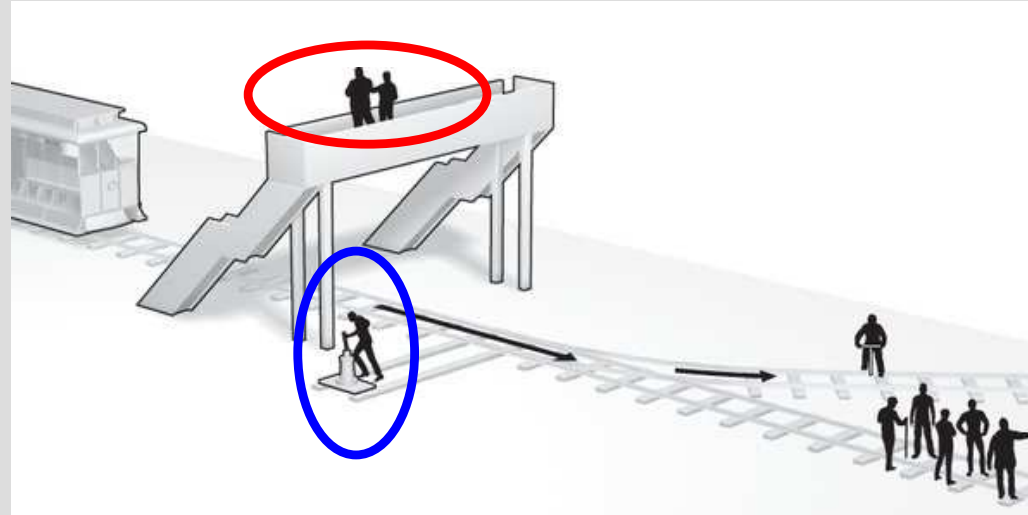


# 3. Neural correlates of morality

## Competing emotional and cognitive subsystems

Greene et al., 2001:

*Comparison*



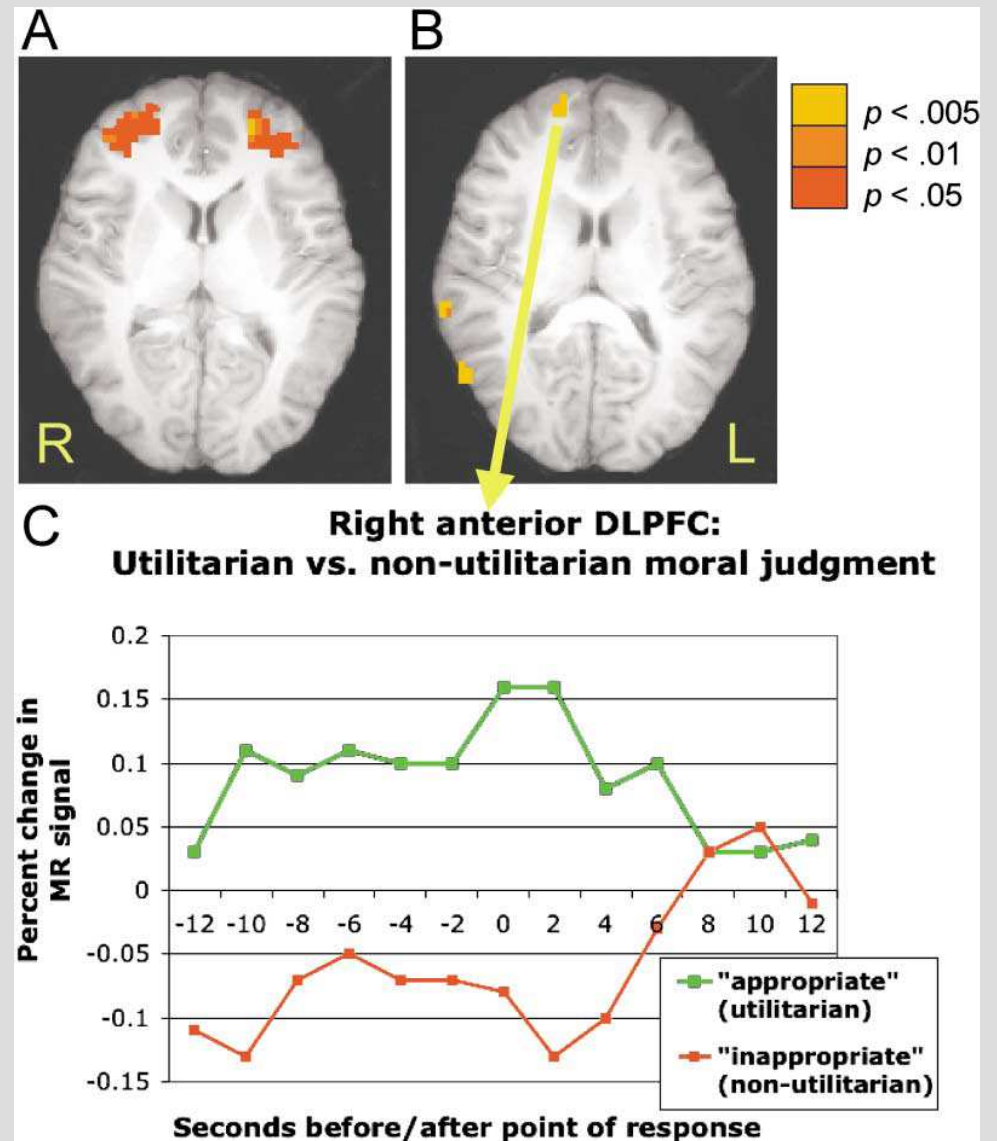
Greene et al., 2001

# 3. Neural correlates of morality

## Competing emotional and cognitive subsystems

### Greene et al., 2004:

- Comparison of neural activity between utilitarian vs. non-utilitarian solutions
- Increased activity in right DLPFC and anterior cingulate cortex
- The conflict in the moral dilemma is detected by the ACC which recruits control mechanisms and rational reasoning processes associated with neural activity in the DLPFC



Greene et al., 2004

# 3. Neural correlates of morality

## Social cognitive processes and mental state reasoning

- **Mental state reasoning (ability to take other people's intentions, beliefs and desires into account) is important for the making of moral judgments**
- **Young et al., 2007: Hypothetical scenarios**

*“Grace and her friend are taking a tour of a chemical plant. When Grace goes over to the coffee machine to pour some coffee, Grace’ friend asks for some sugar in hers. The white powder by the coffee is not sugar but a toxic substance left behind by a scientist. Because the substance is in a container marked ‘sugar’, Grace thinks that it is sugar. Grace puts the substance in her friend’s coffee. Her friend drinks the coffee and dies.”*  
(from Young, Cushman, Hauser, & Saxe, 2007)

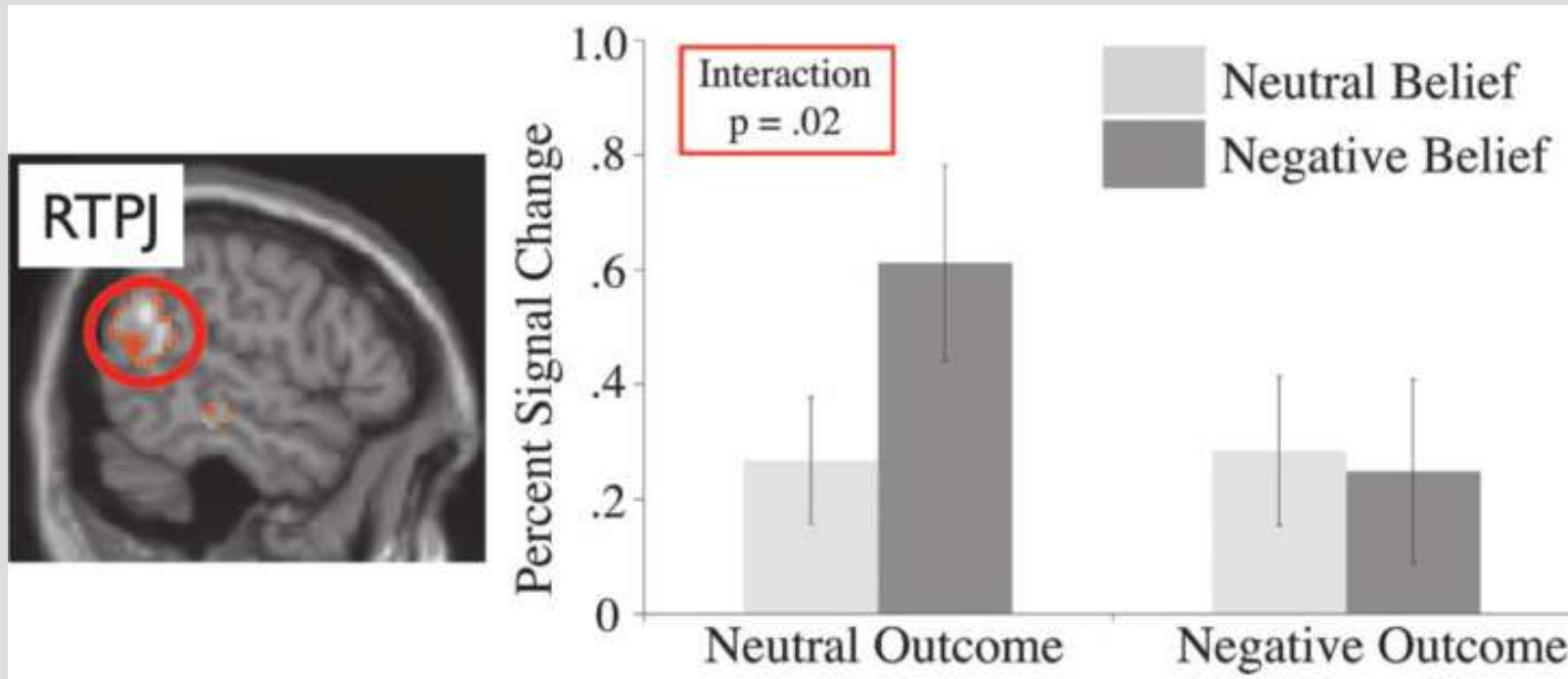
### **Systematic variation**

**of outcomes (dying or not) and beliefs (she thinks it is sugar or toxic)**

### 3. Neural correlates of morality

#### Social cognitive processes and mental state reasoning

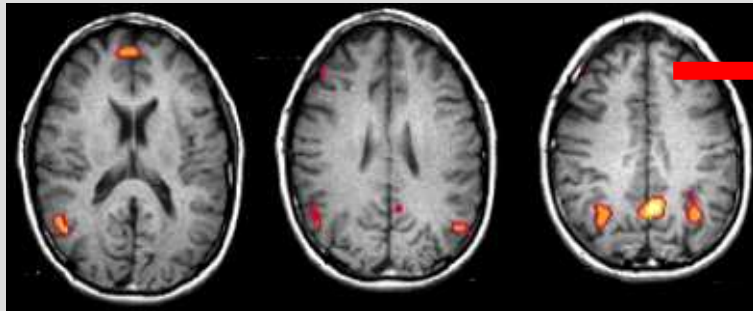
Young et al., 2007:



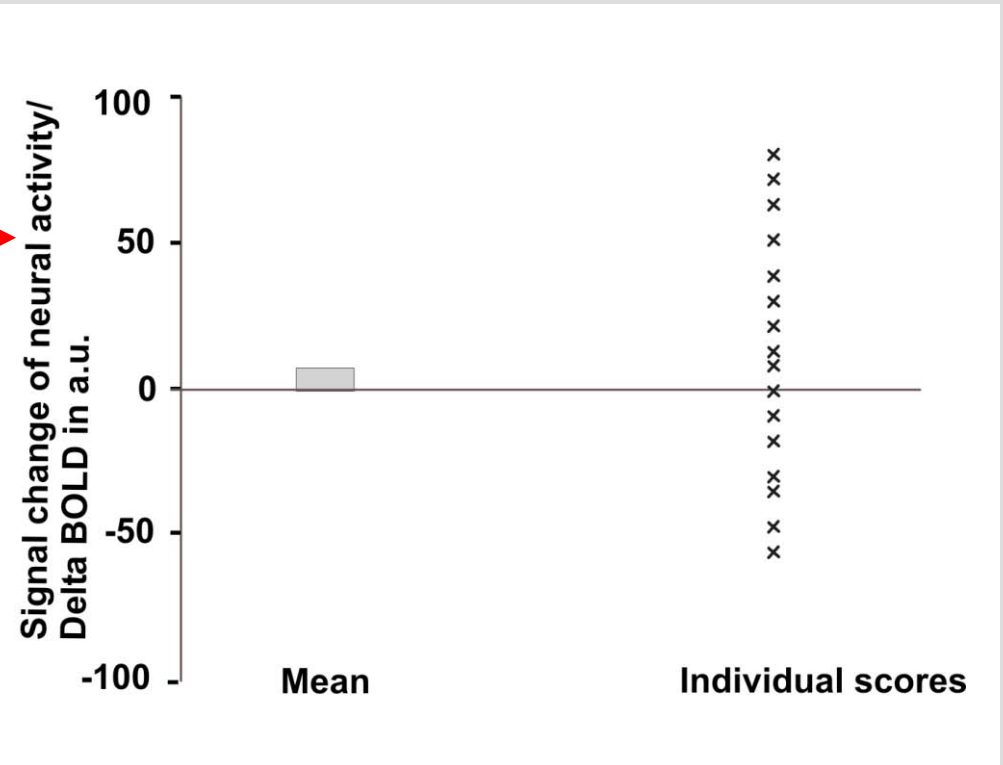
- **Young et al., 2010:** Disruption of right TPJ reduces the role of mental state information and increases the role of outcomes

### 3. Neural correlates of morality

#### *The influence of individual differences in moral judgment competence*



from Greene et al., 2001

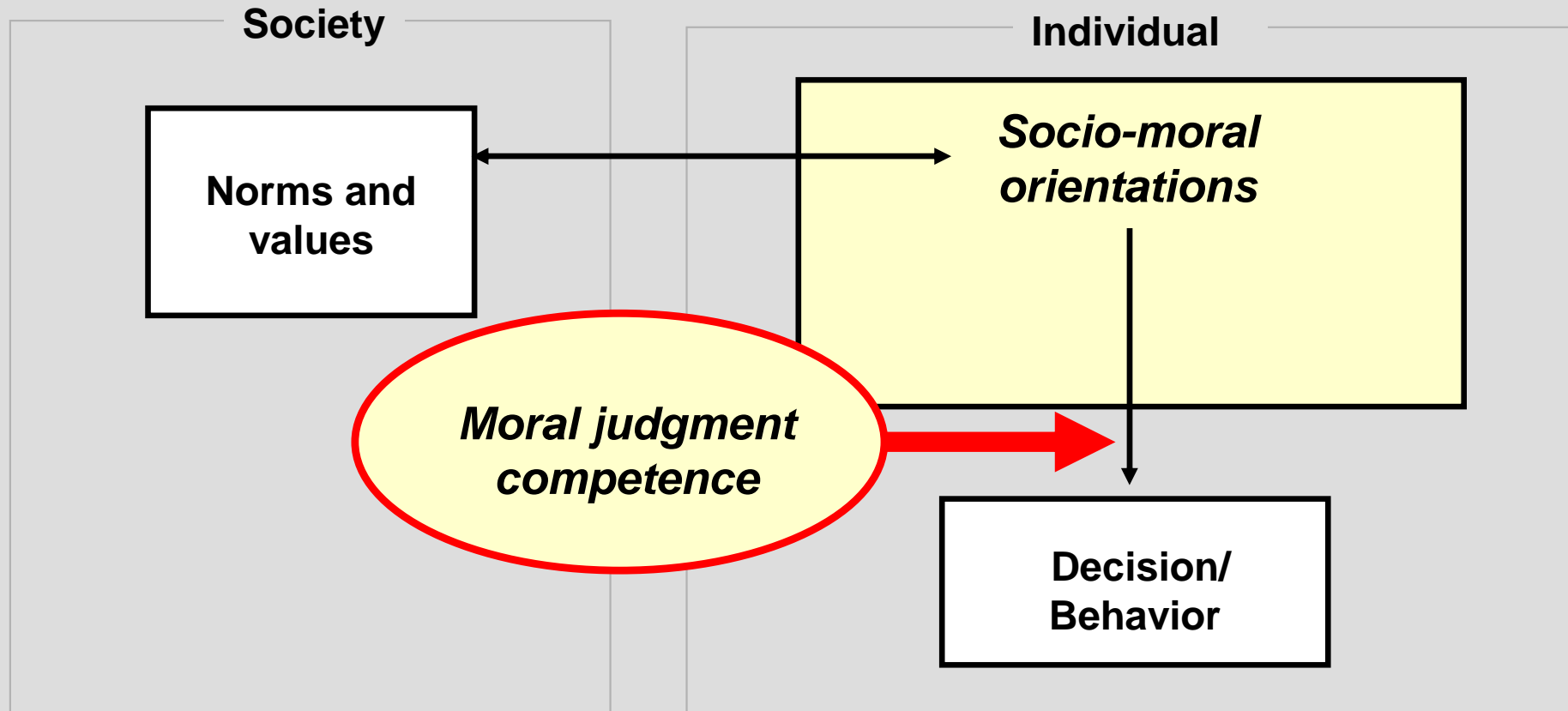


*One man's noise is  
another man's data...*

### 3. Neural correlates of morality

#### *The influence of individual differences in moral judgment competence*

#### Georg Lind's Dual Aspect Theory



# 3. Neural correlates of morality

## *The influence of individual differences in moral judgment competence*

### **Aim to investigate:**

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



### **Hypothesis:**

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

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

### 3. Neural correlates of morality

#### *The influence of individual differences in moral judgment competence*

	Moral decision making	Grammatical decision making
Violation	X uses public transportation. <b>He smashes the window.</b>	X uses public transportation. <b>He look* out of the window.</b>
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

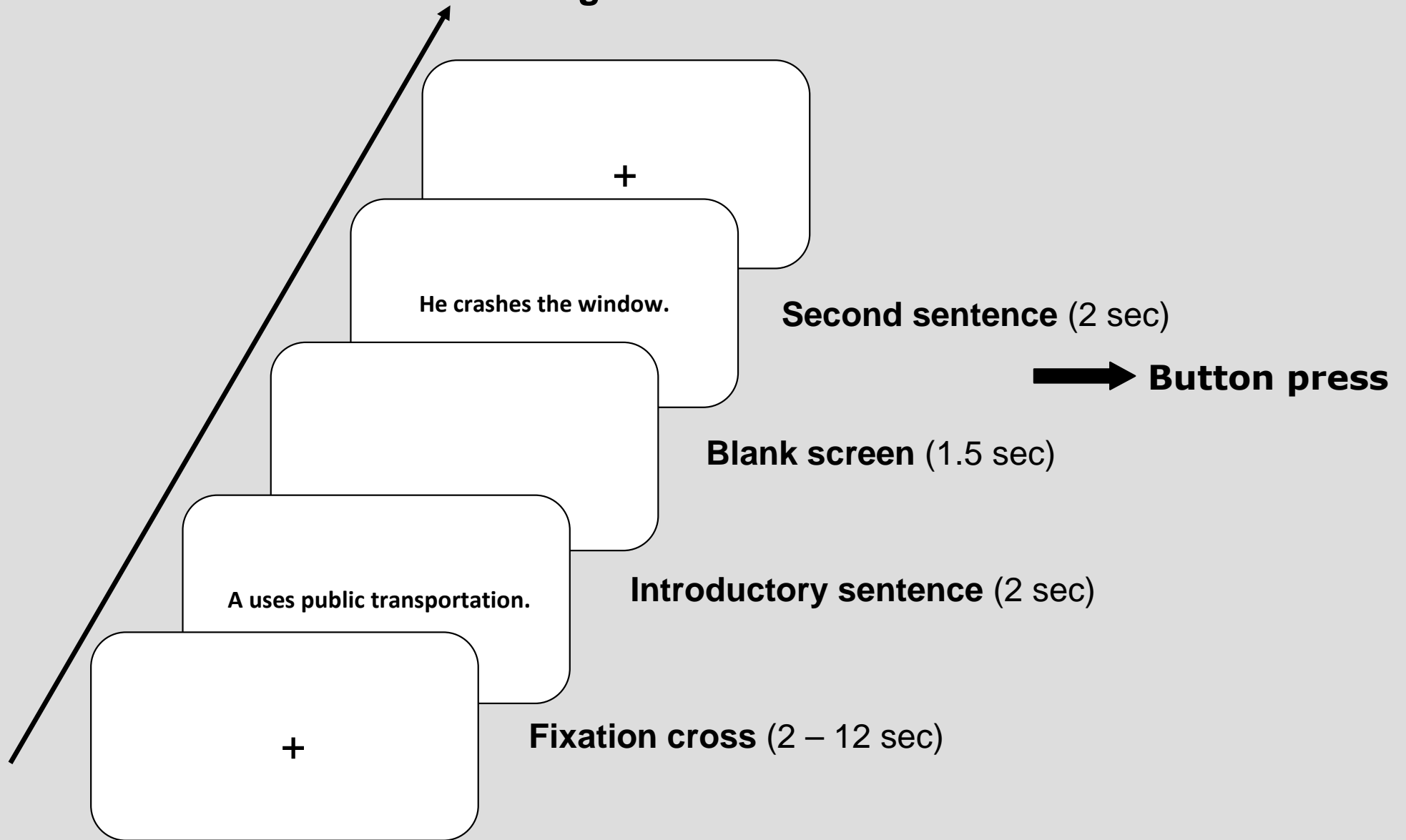
- **Matched for number of syllables and word frequencies**
- **Validated in a questionnaire-based investigation (n = 80)**
- **Presented in a mixed blocked/ event-related design**



### 3. Neural correlates of morality

#### *The influence of individual differences in moral judgment competence*

Mixed blocked event-related design



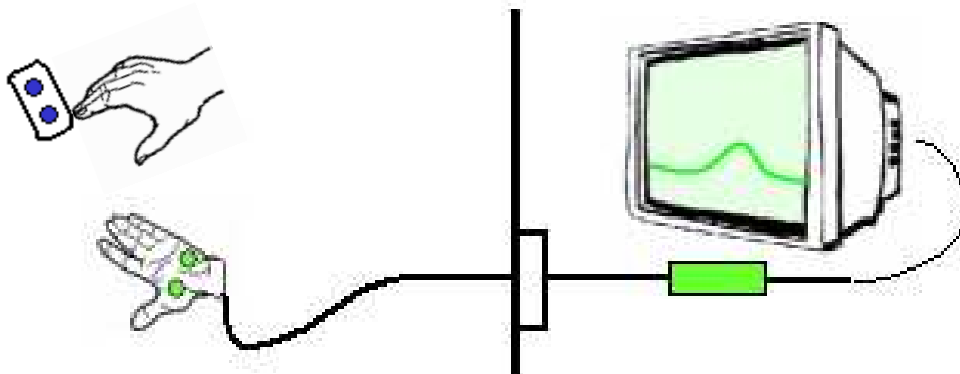
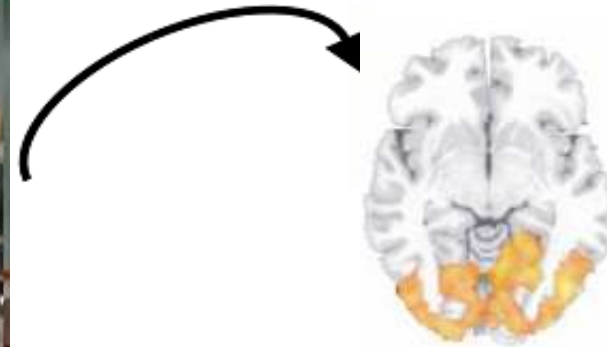
### 3. Neural correlates of morality

#### *The influence of individual differences in moral judgment competence*

**N = 23** ⇒ 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

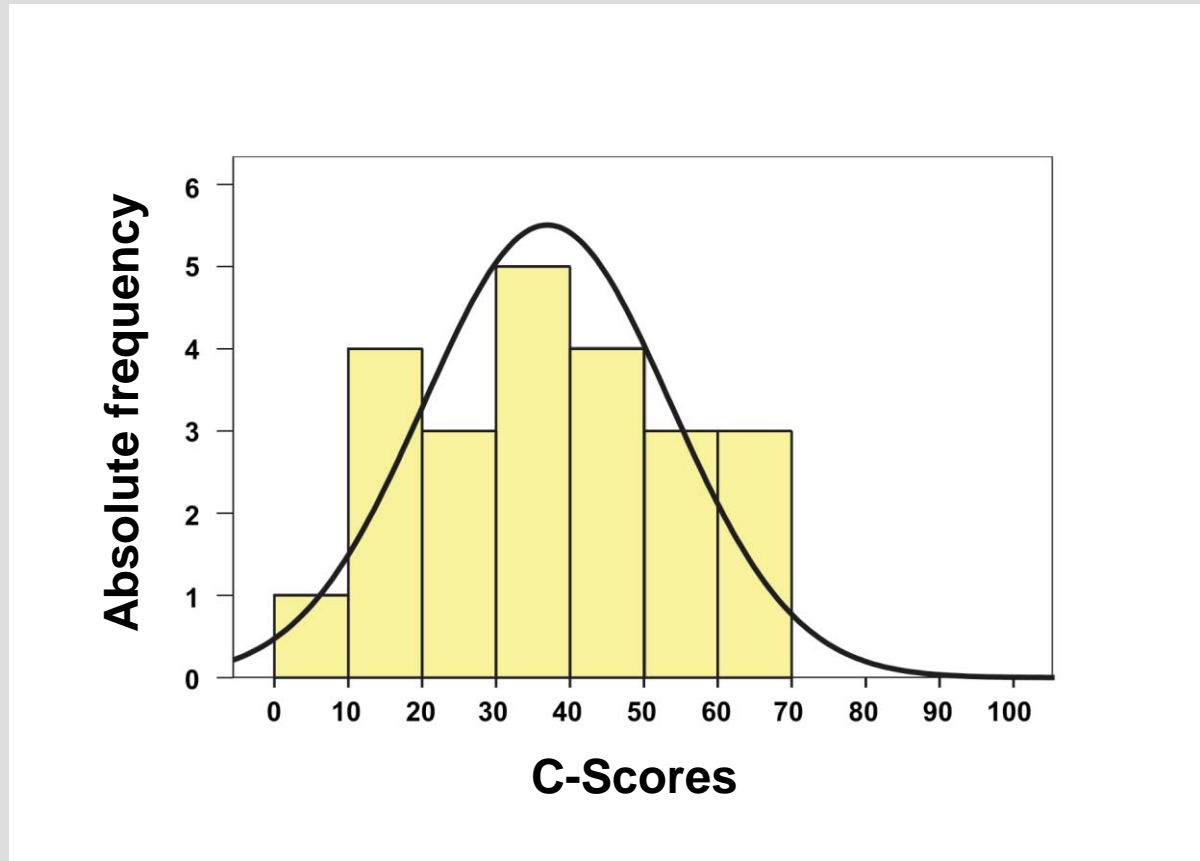


- **Behavioral data:**  
Response times, error rates
- **Skin conductance level**

### 3. Neural correlates of morality

#### *The influence of individual differences in moral judgment competence*

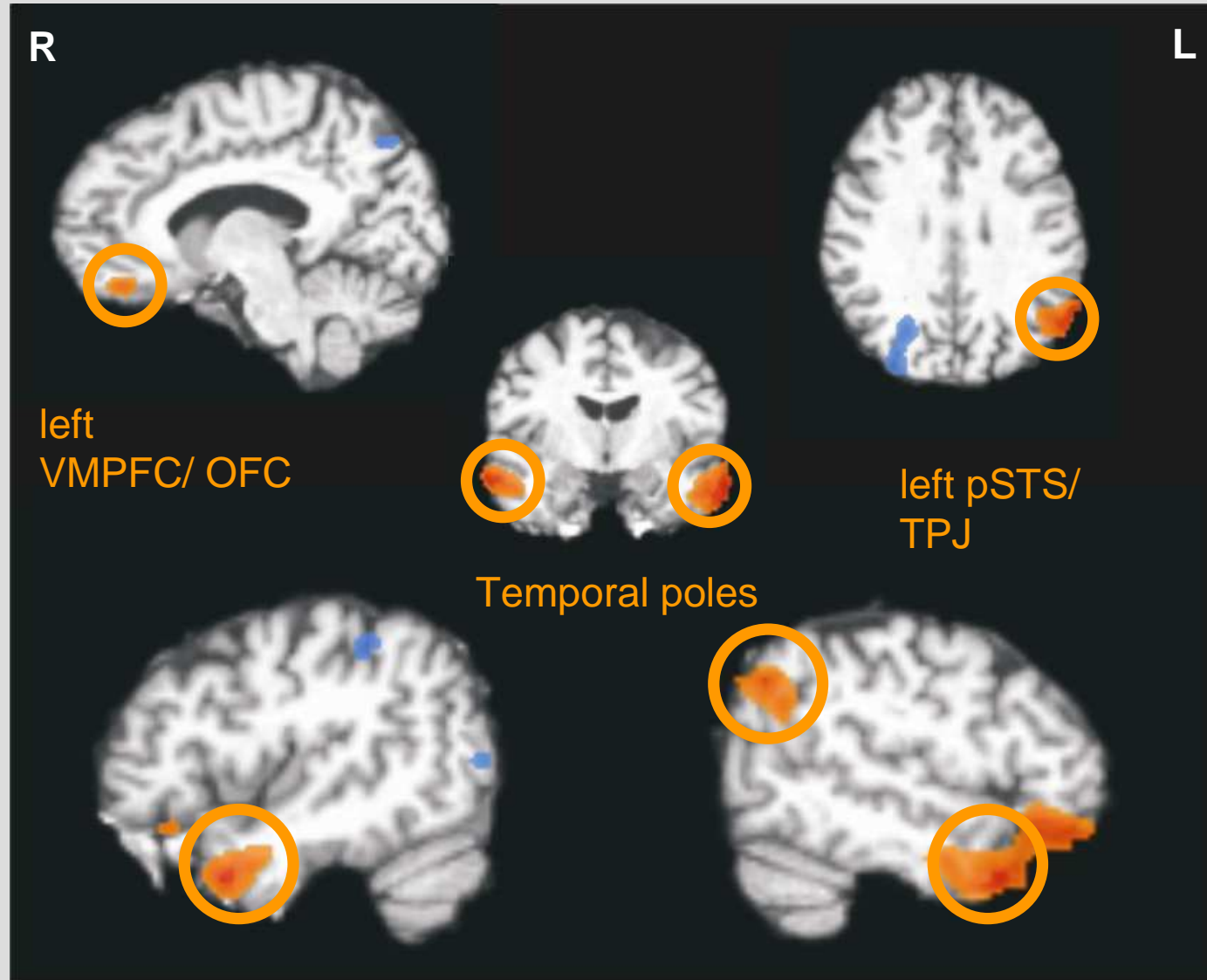
#### Moral judgment competence



36.93 [mean] ± 16.67 [SD] => Normally distributed

### 3. Neural correlates of morality

*The influence of individual differences in moral judgment competence*



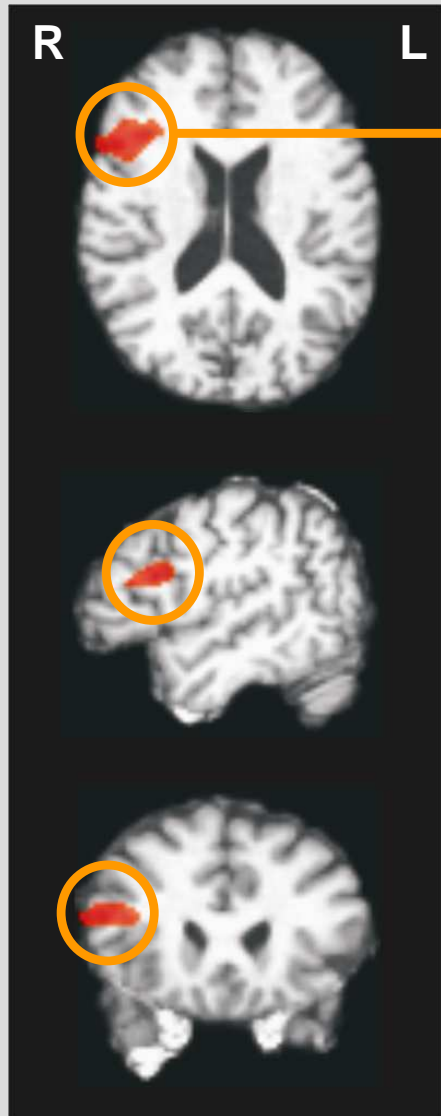
Moral  
decision making  
>  
Grammatical  
decision making

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

# 3. Neural correlates of morality

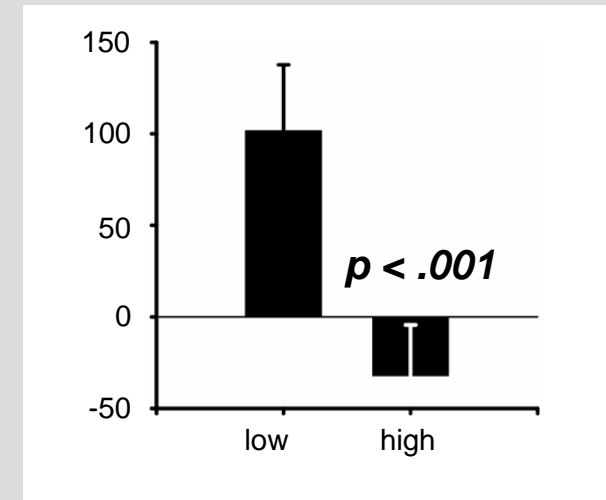
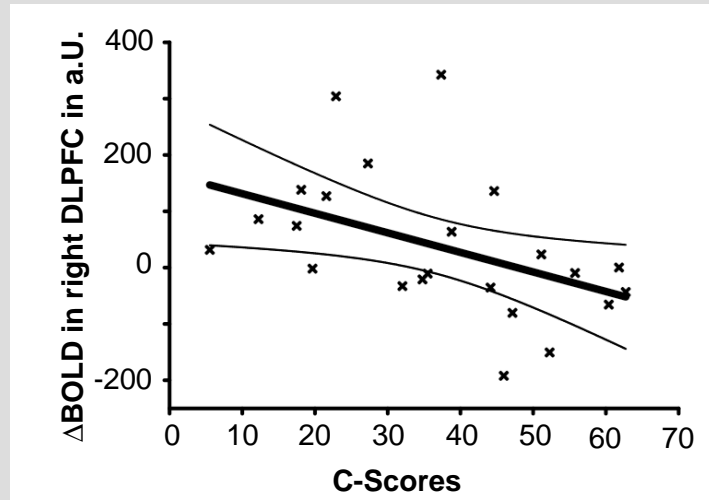
## The influence of individual differences in moral judgment competence

Right DLPFC  
(BA 45/46)

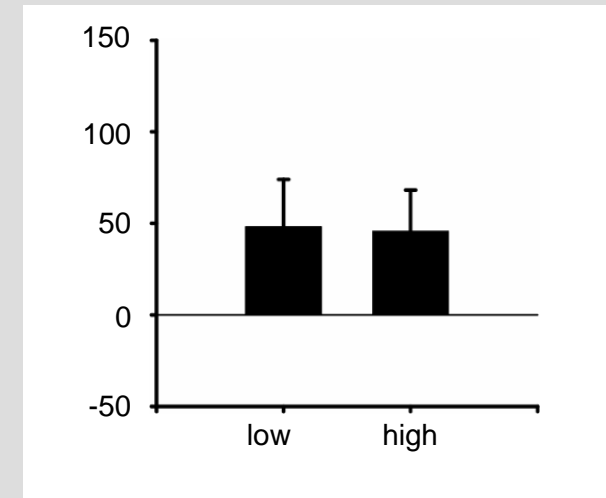
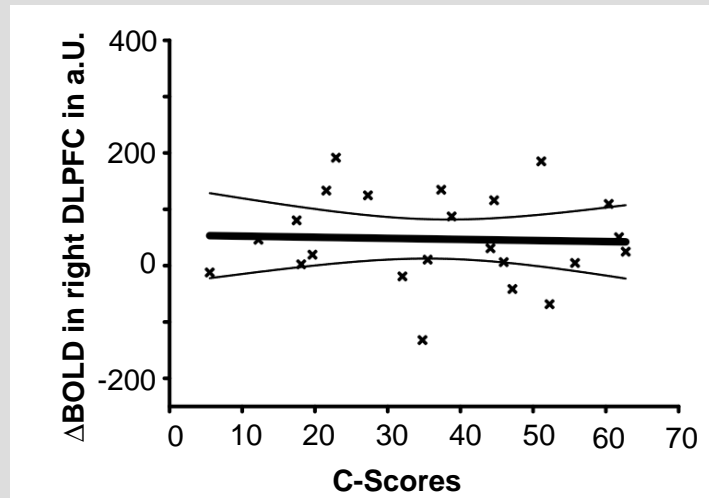


$p < 0,05$ , corrected

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



Grammatical decision making:  $r = - .05$



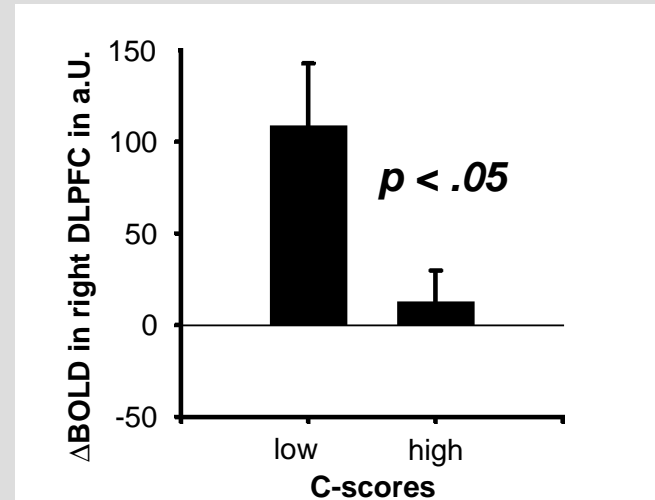
Prehn et al., 2008

# 3. Neural correlates of morality

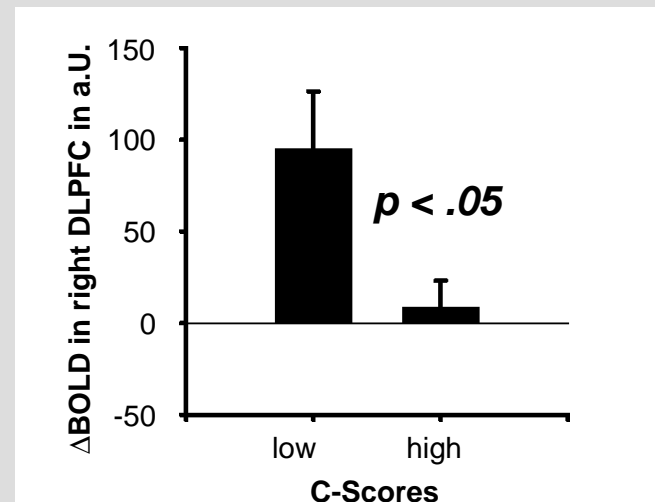
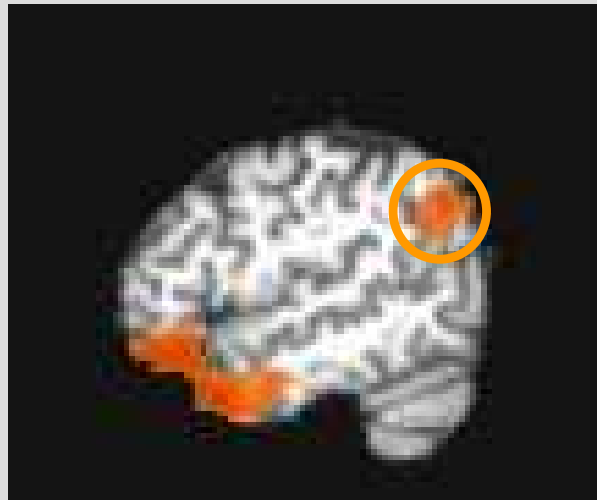
## *The influence of individual differences in moral judgment competence*

Specifically during identification of social norm violations:

Left VMPFC



Left PSTS/ TPJ



# 3. Neural correlates of morality

## *The influence of individual differences in moral judgment competence*

### Discussion:

- **Replication of a functional network contributing to moral decision making**
- **Neuronal correlate of individual differences in moral judgment 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 and PSTS/ TPJ: Increased involvement of emotional and socio-cognitive processes**  
(see Amodio & Frith, 2006; Young et al., 2007)

## 4. Outlook and next steps

***Neuroscientific support for the view that morality can be considered as a competence***

### **ToDo:**

- Investigating neural correlates of moral judgment competence during other (more complex) moral tasks
- Investigating effects of training and expertise
- Providing tools for clinical application (diagnosis and therapy of patients with antisocial personality disorder, psychopathy) □ Neuro-morality tests/ Neuro-psychotherapy



# Thanks!



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