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# Neurofunctional correlates of esthetic and moral judgments

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## HIGHLIGHTS

- ► Our study compares the neurofunctional correlates of esthetic and moral judgments.
- ► Our results suggest similar functionality in comparable neural networks (OMPFC).
- ► Unique activation was found in the moral judgment condition (PCC/Precuneus, TPJ).
- ► These regions have been related to self-processing and theory of mind.

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## ABSTRACT

Recent neuroimaging studies indicate that there may be common ground for esthetic and moral judgments. However, because previous studies focused on either esthetic or moral judgments and did not compare the two directly, the issue remains open whether a common ground actually exists. We employed functional magnetic resonance imaging in order to study, in a within-subjects design, the potential equivalence of esthetic and moral judgments. One-line verses from poems and short moral statements were used as stimuli. Our results suggest a common basis for the two judgment categories, revealing comparable neural networks mainly the orbitomedial prefrontal cortex. However, additional activations were found in the moral judgment condition, that is, in the posterior cingulate cortex, the precuneus, and the temporoparietal junction. These regions have been related to understanding the minds of others.



## 1. Introduction

There is an old debate on the possibility of a common ground for esthetic (EJ) and moral judgments (MJ). David Hume, a promoter of moral sense theory, defined EJ as subjective evaluations relying on feelings of pleasure or displeasure [42], further extending this to hold true for MJ [15]. Regarding EJ, Immanuel Kant accepted Hume's view, while promoting a pure rational notion of morality. This generated a debate on the nature of MJ: are they reason-based, or emotion-based [15,25]? In psychology, rationalists had dominated until the social intuitionist model (SIM) was developed. SIM, based on moral sense theory, defines MJ as intuitive evaluations of actions or character (good or bad) [15].

EJ and MJ similarities seem to depend upon the nature of these judgments. Both are considered value judgments [2], where each value can be either positive or negative: beauty and ugliness, and rightness and wrongness. Furthermore, several cognitive processes seem shared: cognitive control, reward-seeking behavior, representation of actions and sensory imagery [3,11]. The boundaries between EJ and MJ seem rather unclear, since certain subjects of esthetic assessment can be morally evaluated (moral assessment of works of art) and vice versa (esthetic judgments of moral conduct or character). Although several attributes distinguish the two: EJs are intrinsic, demand no consistency, but require a direct confrontation with the stimuli; MJs are more preferential, imply a ranking of alternatives, involve others and require action [2,7].

Although the neuroscientific literature has shown strong interest in EJ [19,20,22] and MJ [12,24], only few papers have connected the judgment modalities [40,41].

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We consider a psychological process supporting both evaluations of esthetic and moral stimuli [15] likely, yet unclear. Are EJ and MJ similar or the same, processed by equivalent brain structures? A number of regions involved in processing beauty and morality were identified [40,41]. The question arises whether a universal network for judgments is involved or whether – independent of such a network – EJ and MJ are processed in the same brain regions. The former appears unlikely, as research suggests that different judgments have different neural correlates [18]. Even when comparing akin judgments, that is, esthetic and symmetry judgments, different regions are activated [20].

Based on previous literature, we expect to find common activation in several areas: orbitofrontal cortex (OFC) and insula [40], medial prefrontal cortex (MPFC), precuneus, middle temporal gyrus (MTG), and temporal pole [13,19,41]. However, some areas may have an extra functional role for MJ: the default mode network (DMN) may be more active in MJ due to a convergence of its components and typical MJ structures [14,17]. It was speculated that this convergence results from introspection or inflated personal ruminations [12]. Parts of the DMN – temporoparietal junction (TPJ) and MPFC – were related to theory of mind (ToM), which has also been related to MJ [26]. We are unaware of any reported direct link between DMN, or ToM, and EJ. Thus, we expect a stronger engagement in MPFC, posterior cingulate cortex (PCC), precuneus and TPJ for the MJ. We do not include anterior cingulate cortex (ACC) since this structure has been shown to be active during cognitive conflict [16], which could be generated by both experimental conditions.

## 2. Method

### 2.1. Participants

Sixteen right-handed subjects (9 female; mean age 28.25) with normal or corrected to normal vision participated. The study was conducted in accordance with the Declaration of Helsinki and approved by the local ethics committee. All participants provided written informed consent prior to participation and received financial reward.

### 2.2. Stimulus material

Forty-five subjects evaluated 42 one-line verses from German poems (i.e. “Wer reitet so spät durch Nacht und Wind” from Goethe’s Erlkönig/“Who’s riding so late through th’ endless wild”) and moral statements (i.e. “It is false to wage war”) for valence and arousal in a pre-study. A five-point Likert scale was used, with scores ranging between -2 (unpleasant/agitating) and 2 (pleasant/calming), to ensure a comparison on a similar level. Extreme values were excluded on an [−1,1] interval; only 24 stimuli remained in each category similar in valence (−0.37 esthetic, and 0.38 moral) and arousal (−0.12 esthetics, and −0.12 moral). A paired *t*-test was used in order to control for stimuli sentence length. There was no statistically significant difference between esthetic ($M$ = 7.00, SD = 1.25) and moral stimuli ($M$ = 6.96, SD = 2.76), $t(23)$ = 0.0641, $p$ = 0.94. A control condition was also used in the fMRI study. Participants were asked judge if sentences comprised of randomized letters make up real words. This particular control condition was used in order to insure unbiased semantic and syntactic processing of esthetic and moral stimuli, thus preventing linguistic representation, and to control for optical input.

### 2.3. Procedure

Functional magnetic resonance imaging was used to examine the two judgments. A block design was used with 8 blocks per condition, each block comprising 3 stimuli on a black background. The order of stimuli and blocks was pseudo-randomized (Presentation, Neurobehavioral Systems, USA). Subjects viewed the stimuli via a mirror attached to the head-coil on a LCD screen behind the scanner. Stimuli were presented for 3500 ms, followed by 1000 ms displaying a black screen with a white question mark while subjects decided whether the stimuli could be considered either beautiful (poems), or right (moral statements) by pressing a button (Cedrus Lumina response box, Cambridge Research Systems Ltd.). After each block, a fixation asterisk appeared on screen for 6000 ms.

The study was conducted with a 3 T system (Philips ACHIEVA, Germany) at the University Hospital LMU Munich. For anatomical reference T1-weighted MPRAGE sequence was performed (TR = 7.4 ms, TE = 3.4 ms, FA = 8°, 301 saggital slices, FOV = 240 × 256 mm, matrix = 227 × 227, inter-slice gap = 0.6 mm). For BOLD imaging T2*-weighted EPI sequence was used (TR = 3000 ms, TE = 35 ms, FA = 90°, 36 axial slices, slice thickness = 3.5 mm, inter-slice gap = 0 mm, ascending acquisition, FOV = 230 × 230 mm, matrix = 76 × 77, in-plane resolution = 3 × 3 mm). In total 177 functional volumes were acquired.

### 2.4. Data processing and analysis

Preprocessing and statistical analyses for all data were performed using SPM8 (Wellcome Department of Cognitive Neurology, London, UK). Motion correction, realignment and spatial normalization were performed in the preprocessing analysis.

Smoothing was executed using a Gaussian kernel of 8 mm FWHM. The experimental conditions (Esthetic – EJ, Moral – MJ, and Control – C) were modeled by a boxcar function convolved with a hemodynamic response function. Several single-tailed t-contrasts were calculated for each subject (EJ > C, C > EJ, MJ < C, C > MJ, EJ > MJ, MJ > EJ) in the first level. The individual contrast images were used for a random effect analysis in SPM second level. A conjunction analysis [9] was performed to identify positive changes in BOLD signal intensity commonly seen in EJ and MJ by using contrast images of each condition compared with the control condition. Group activation contrasts ($p$ < 0.0001) were cluster-level corrected by family wise error (FWE) < 0.05.

## 3. Results

### 3.1. Behavioral data

The subjects rated 48% of the esthetic stimuli as beautiful, and 43% of the moral stimuli as right. A *t*-test revealed no differences between esthetic ($M$ = 0.48, SD = 0.13) and moral stimuli ($M$ = 0.43, SD = 0.1); $t(15)$ = 0.892, $p$ = 0.38. Thus a similar number of positive and negative evaluations of EJ and MJ were used. There was no significant difference in reaction time ($F(2, 42)$ = 2.98; $p$ = 0.06) in EJ ($M$ = 481, SD = 57 ms) compared to MJ ($M$ = 523, SD = 65 ms) and control ($M$ = 477, SD = 48 ms).

### 3.2. fMRI data

A conjunction analysis was used in order to find common activations between EJ and MJ. Common activation for the judgment modalities (compared to control) was found in: OFC (Brodmann Area, BA - 47), inferior frontal gyrus (BA 45), MPFC (BA 32), ACC (BA 32), premotor area (BA 6), supplementary motor area (SMA/BA 6), MTG (BA 22), insula (BA 13), substantia nigra, and visual cortex (BA 18) (Table 1, Fig. 1).

In order to find the unique brain activations for the two judgment modalities a direct comparison was done. No regions were found activated for EJ in the EJ > MJ comparison. However, MJ seem to elicit more activation in the middle frontal gyrus (MFG/BA 8),