

Brain correlates of aesthetic judgments of beauty

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Introduction

Aim

Functional Magnetic Resonance Imaging (fMRI) was used to investigate the neural correlates of aesthetic judgments of beauty of geometrical shapes.

Background

What are the brain correlates of aesthetic judgment? Previous studies have investigated effects of attractiveness and preference, but none of these studies aimed at identifying the network of aesthetic judgment per se. Aesthetic judgments can be considered a subset of evaluative judgments such as those made on social, religious, or moral cues. These were reported to engage frontomedian areas around Brodmann Areas (BA) 9/10, posterior cingulate cortex or precuneus, and ventral prefrontal BA 45/47[4,7,10,12,14]. Do aesthetic judgments engage a similar cerebral network?

Methods

Participants

15 right-handed, healthy young volunteers (6 male; 21–33 years; mean age 25.4 years)

Stimulus Material (see Figure 1)

220 novel, abstract graphic patterns were presented [9] to minimize influences of attitudes or memory-related processes and to test effects of stimulus symmetry and complexity. Stimulus complexity - which has a significant influence on aesthetic judgment of beauty[5,1,9] - varied as a scalar property in order to allow to additionally analyze its parametric influence.

Task (see Figure 2)

Participants performed evaluative aesthetic judgments (beautiful or not?) and descriptive symmetry judgments (symmetric or not?) on the same stimulus material. Symmetry was employed because aesthetic judgments are known to be often guided by criteria of symmetry.

Data acquisition

- 3T Bruker Medspec 30/100
- 22 axial slices (FOV 192 mm; 64 x 64 pixel; thickness 4 mm; spacing 1 mm), single-shot gradient echo-planar imaging (EPI) sequence (echo time, 30 msec; flip angle, 90°; repetition time, 2 s)
- 2D anatomical images, MDEFT sequence (256 x 256 pixel) and high-resolution whole-brain images (160 slices, 1 mm thickness), T1-weighted 3D segmented MDEFT sequence

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Stimulus Material

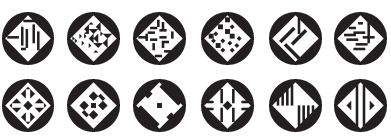
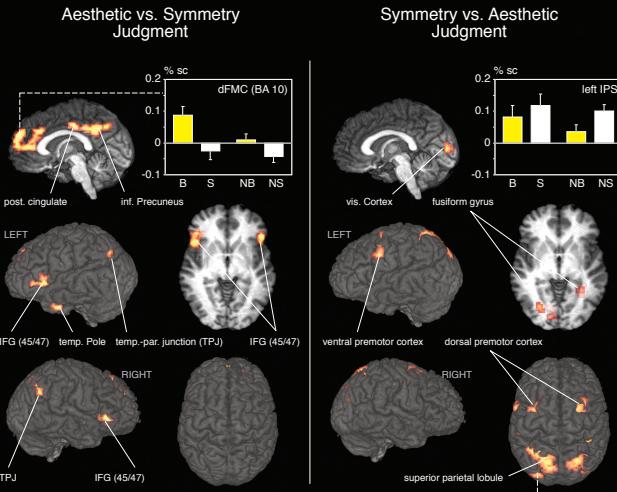


Figure 1. Simple and complex stimuli which are either symmetric or not were used in both the aesthetic judgment task and the symmetry judgment task. Each stimulus consisted of a solid black circle (8.8 cm in diameter) showing a centered, quadratic, rhombic cutout and 86 to 88 basic graphic elements (small black triangles) arranged within the rhomb according to a grid and resulting in a graphic pattern. The basic elements were arranged such that geometric figures like triangles, squares, rhombuses, horizontal, vertical or oblique bars were created. Using this approach of basic elements, the overall luminance was identical for all stimuli. Half (110) were symmetrical, i.e. one mirroring operation given four possible symmetry axes was sufficient to detect symmetry. The other half of the stimuli was clearly not symmetric.

Figure 2. Exemplary trials for both judgment tasks (middle) and for the control condition (top right). A variable jitter time of 2.5 to 4 s was followed by a task cue (1 s) and a picture presented at screen center for 2.5 s. Participants were asked to press the selected response button while the picture was presented. They were asked to decide whether or not the presented stimulus was beautiful (aesthetic judgment) or symmetric (symmetry judgment); in the control condition, they were asked to press the left button for arrow pointing left and the right button for arrow pointing right. Stimulus examples (bottom left) depict simple (upper row) and complex (lower row) stimuli which are either symmetric (right column) or not (left column).

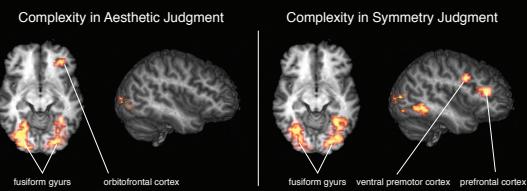
Results

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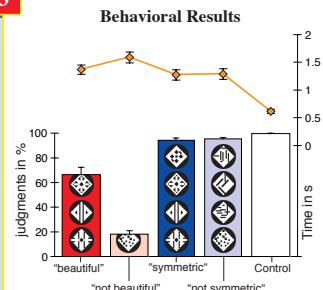
Brain correlates of experimental tasks. Group-averaged ($n=15$) statistical maps of significantly activated areas for aesthetic judgments as opposed to symmetry judgments (left panel) and for symmetry as opposed to aesthetic judgments (right panel). Z-maps were thresholded at $z=3.09$ ($p<0.05$ corrected). Bar charts depict maximal signal changes (% sc) for the two areas in which beautiful judgments (B) caused a higher BOLD signal than not-beautiful (NB) judgments (dFMC = frontomedian cortex at BA 10, and left IPS = intraparietal sulcus). In contrast, no significant differences were found between symmetric (S) and not-symmetric (NS) judgments. Further abbreviations: IFG (45/47) inferior frontal gyrus at BA 45/47.

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Brain correlates of parametric effects of stimulus complexity in aesthetic judgments (left panel) and symmetry judgments (right panel). For both conditions, activation was enhanced by high complexity in fusiform gyri. Differential effects were observed in the right orbitofrontal cortex for aesthetic judgments, and in the right prefrontal and premotor area for symmetry judgments.

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Discussion

1. Findings indicate aesthetic judgments of beauty to rely on a network partially overlapping with that underlying evaluative judgments on social and moral cues and substantiate the significance of symmetry and complexity for our judgment of beauty.
2. Mesial BA 9/10 in {Aesthetic Judgment > Symmetry Judgment} reflects the evaluation of internally generated information (as in contrast to externally available information)[3,8,6]. Memory-related areas (posterior cingulate cortex, precuneus[2]) could signify a strong behavioral bias to use episodic or semantic memories to guide aesthetic judgment.
3. Left intraparietal sulcus in {Beautiful Judgment > Not-beautiful} & {Symmetry Judgment > Aesthetic Judgment} reflects in our view that the analysis of stimulus symmetry[13] was boosted whenever participants found a stimulus beautiful. Metabolic findings hence nicely parallel the behavioral finding that in many participants, symmetry guides aesthetic judgments of beauty. Note that it can *not* be due to a higher ratio of symmetric patterns among those judged as beautiful because symmetric judgments did not cause higher signals than non-symmetric ones in this area.

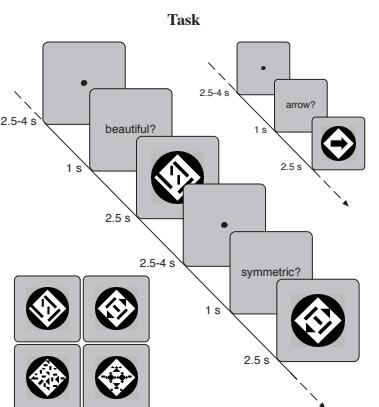
fMRI data analysis

Software package LIPSIS [11]

Preprocessing: motion correction; matching metric based on linear correlation; temporal offset correction: sinc-interpolation, Nyquist Shannon theorem; temporal high-pass filter 1/72 Hz; spatial gaussian filter 5.652 mm FWHM; rigid linear registration, volume standardized to Talairach stereotactic space, linear scaling; slice gaps interpolation, output data 3 x 3 x 3 mm

Statistics: GLM random effects; design matrix with synthetic hemodynamic response function and its 1st and 2nd derivative, event-related time-locked to stimulus (picture) onset. Individual estimates of the raw-score differences between specified conditions; second-level random effects analysis. To protect against false positive activations, only regions with z score > 3.09 ($p<0.01$; uncorrected) and with a volume > 405 mm³ (15 contiguous voxels) were considered. All reported activations survived a threshold corresponding to $p<.05$ (corrected for multiple comparisons) at the cluster level.

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