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fMRI responses to pictures of mutilation and contamination

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Abstract

Findings from several functional magnetic resonance imaging (fMRI) studies implicate the existence of a distinct neural disgust substrate, whereas others support the idea of distributed and integrative brain systems involved in emotional processing. In the present fMRI experiment 12 healthy females viewed pictures from four emotion categories. Two categories were disgust-relevant and depicted contamination or mutilation. The other scenes showed attacks (fear) or were affectively neutral.

The two types of disgust elicitors received comparable ratings for disgust, fear and arousal. Both were associated with activation of the occipitotemporal cortex, the amygdala, and the orbitofrontal cortex; insula activity was nonsignificant in the two disgust conditions. Mutilation scenes induced greater inferior parietal activity than contamination scenes, which might mirror their greater capacity to capture attention.

Our results are in disagreement with the idea of selective disgust processing at the insula. They point to a network of brain regions involved in the decoding of stimulus salience and the regulation of attention.

Keywords: Disgust; Contamination; Mutilation; fMRI

The application of functional neuroimaging to the study of disgust has yielded conflicting data. On the one hand, there are findings suggesting that the insula selectively processes disgust cues [7,8,16,18]. This was first indicated by functional magnetic resonance imaging (fMRI) studies where the subjects viewed pictures of facial disgust expressions [7,8,16,18]. Later the data on disgust recognition were complemented by demonstrating that the production of disgust states by olfactory stimuli [21] and by pictures depicting repulsive scenes [6] were also able to specifically activate the insular cortex. On the other hand, there are fMRI investigations on the processing of disgust-eliciting scenes [12,15] and facial expressions of disgust [22] where no disgust-specific insula activation was observed. Further, in these experiments amygdala activity was present during the disgust condition [12,15,22]. These findings tend to disconfirm the hypothesis that there are distinct neural circuitries subserving individual emotions where the amygdala is considered the fear processor.

The discrepancies between the studies, especially between those using non-facial stimuli, may be partly due to the type of selected disgust pictures. Although disgust is considered to be a single basic emotion, there are several separate disgust domains (e.g. body products, spoiled food, death/mutilation). Wright et al. [23] were the first ones to compare neural responses to pictures of two different types of disgust elicitors with fear-relevant and neutral scenes. The subjects viewed scenes from the categories of contamination (e.g. spoiled food) and mutilation (e.g. murder victims). Both picture types involved the anterior insula, whereas mutilation uniquely activated the superior parietal cortex. The data seem to support the view that disgust is specific to the insular cortex. However, the authors were unable to image the amygdala with their 3T scanner, and thus it remains open if the amygdala would have shown differential responses to the three aversive picture conditions.

The current study attempted to replicate the data of this previous investigation [23] with a 1.5 T scanner. We compared the neural responses to pictures from four categories: contamination, mutilation, threat and neutral. Also, we performed correlation analyses, where we related state/trait disgust measures [14] to the brain activation.

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Twelve healthy right-handed females aged 19–41 years gave written informed consent for the study. The volunteers denied taking any medication at the time of the scan and indicated no history of psychiatric or neurological disorders. The ethics committee of the German Society for Psychology approved this study.

The stimulus material consisted of 160 pictures in total. They were chosen from the IAPS [3] and a further picture set [12] to represent four emotional categories: contamination, mutilation, fear and neutral. The 40 contamination scenes depicted stimuli associated with poor hygiene and contaminants (e.g. maggots, garbage piles, excrements, a man eating spoiled food). Mutilation pictures showed human injuries or disease (e.g. murder victims, wounds, blood draws). The 40 generally fear-inducing scenes depicted threatening situations either through attacks by animals or by humans. The 40 affectively neutral scenes consisted of e.g., household articles, geometric figures or nature scenes. Each picture was shown for 1.5 s within a block consisting of 40 pictures of the same category. Within a block the pictures were shown in a random sequence. Each category block was repeated six times during the course of the experiment in a pseudo-randomized sequence with the restriction that no more than two categories of the same type could follow each other. The duration of the experiment was 24 min. The pictures were viewed with a mirror attached to the head coil (visual field = 18°). After scanning, the subjects were provided with four sheets of paper. Each sheet depicted the 40 pictures from one specific category. The subjects were asked to give disgust-, fear- and arousal-ratings for each of the categories on 9-point scales ('9' indicates that the subject felt aroused, disgusted and anxious). They also gave self-reports for their disgust sensitivity (QADS, [14]), trait anxiety (STAI, [4]) and blood/injury fear (MQ, [2]).

A 1.5 Tesla whole-body tomograph (Siemens Symphony, Erlangen, Germany) with a standard head coil was used to acquire a total of 492 volumes (T2*-weighted gradient echo-planar imaging sequence with 30 slices covering the whole brain, slice thickness = 5 mm, no gap, interleaved, TA = 100 ms, TE = 60 ms, flip angle = 30°, field of view = 192 mm × 192 mm, matrix size = 64 × 64). The orientation of the axial slices was parallel to the AC–PC line. The first six volumes were discarded to control for saturation effects.

For the preprocessing and statistical analyses the statistical parametric mapping software package (SPM2, Wellcome Department of Cognitive Neurology, London) implemented in Matlab (Mathworks, Inc., Natick, MA, USA, release 12) was used, which is based on the general linear model (GLM) approach. Slice time correction, realignment and normalization to the standard space of the Montreal Neurological Institute brain were performed. Smoothing was executed with an isotropic three-dimensional Gaussian filter with a full width at half maximum (FWHM) of 9 mm. Each of the experimental conditions contamination (C), mutilation (M), fear (F) and neutral (N) was modeled by a boxcar function convolved with a hemodynamic response function in the GLM. The six movement parameters of the rigid body transformation were introduced as covariates in the model. Serial correlations were controlled by an AR(1) process; the high pass filter was set at 512 s. Several *t*-contrasts (first level) were calculated for each subject: C > N, M > N, F > N, C > M, C > F, M > C, M > F, F > M, F > C. These contrasts were then used in second level random effects analyses. The statistical maps were thresholded with an uncorrected $p = .01$; the minimum cluster size was five voxels. We computed exploratory voxel intensity tests for the whole brain volume and voxel intensity tests for regions of interest (ROI). The ROIs had been chosen based on the results reported by [23] and previous disgust-relevant findings by our own group (amygdala, insula, orbitofrontal cortex, superior/inferior parietal cortex, occipitotemporal cortex). The ROIs had been defined by the anatomical parcellation of the normalized brain (single-subject high-resolution T1 volume of the Montreal Neurological Institute, [19]). Based on this assignment between anatomical structures and voxel coordinates we created masks [20]. Error probabilities (p) were corrected for multiple comparisons (familywise error correction). When exploratory analyses were conducted, p was corrected for the whole brain volume, when a ROI-test was used p was corrected for the specific volume of interest according to the tested hypothesis. The significance level was always set to alpha = .05.

The subjects obtained the following mean questionnaire scores ± S.D.: overall disgust sensitivity (QADS): 1.7 ± 0.5, QADS subscales death/mutilation: 0.9 ± 0.7, poor hygiene/contamination: 1.8 ± 0.4, trait anxiety (STAI): 35.1 ± 6.2, blood/injury fear (MQ): 7.2 ± 3.5. Accordingly, the participants were characterized by a low to moderate degree of disgust sensitivity, trait anxiety and blood/injury fear (QADS scores range from 0 to 4, STAI scores from 20 to 80 and MQ scores from 0 to 30).

The affective ratings for the four picture categories are displayed in Table 1. The disgust and fear categories elicited the target emotions to a moderate degree. The aversive picture categories received comparable arousal ratings ($F(2, 22) = .34$, $p = .71$) and were rated as more arousing than the neutral scenes. The contamination and mutilation pictures obtained similar fear- and disgust-ratings. Both categories induced more disgust than the fear pictures. The fear scenes were more fear inducing than the contamination pictures, but comparably fear-eliciting as the mutilation pictures (all pairwise comparisons: $p < .01$). The neutral pictures neither induced fear nor disgust.

The mutilation pictures (contrast: mutilation > neutral) induced significant activation in the right inferior occipital gyrus. This activation peak was surrounded by an extended bihemispheric cluster (7066 voxels), which also contained superior and medial occipital regions, superior parietal regions, as well as parts of the cerebellum. ROI activation occurred in the left amygdala, the left orbitofrontal cortex, the left inferior parietal cortex

Table 1
Mean affective ratings and standard deviations

Rating	Category			
	Contamination	Mutilation	Fear	Neutral
Arousal	3.8 ± 1.8	4.2 ± 2.4	3.8 ± 2.0	1.6 ± 1.2
Fear	1.4 ± 0.7	2.0 ± 1.8	3.0 ± 2.1	1.0 ± 0.0
Disgust	5.1 ± 1.8	5.4 ± 2.5	1.7 ± 1.2	1.0 ± 0.0