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The structural neuroanatomy of self-disgust: A VBM analysis with a non-clinical sample

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ABSTRACT

The personality trait self-disgust describes the tendency of individuals to appraise themselves as repulsive. This may refer to their own body and personality ('personal self-disgust') and/or to their behaviors ('behavioral self-disgust'). The current voxel-based morphometry (VBM) study aimed at identifying associations between grey matter volume (GMV) in specific brain regions of the 'disgust network' (e.g., insula, prefrontal cortex) and reported self-disgust in a non-clinical sample. VBM data from 59 women (mean age = 24.8 years) with high vs. low scores on a self-disgust questionnaire were compared with each other. Relative to women with low personal self-disgust, women with a higher degree of this trait were characterized by less GMV in the bilateral insula. This difference was independent of depressed mood. The reduced insula volume may be one neural correlate of an undifferentiated, negatively valenced self-concept.

1. Introduction

According to evolutionary approaches, disgust evolved as a disease avoidance emotion (Davey, 2011). A variety of different stimuli and situations, such as spoiled food, body products, poor hygiene, and illness typically elicits disgust. The common characteristic of these disgust elicitors is that they can transmit pathogens, parasites and other infectious agents. Therefore, disgust motivates behaviors that reduce the risk of contamination, such as avoidance, rejection, grooming, and cleaning. However, disgust reactions are not limited to disease-relevant cues. Disgust can impact on many other areas of life. Disgust influences friend and mate choices, what social groups we reject (concepts of outgroups), political attitudes, moral decisions, as well as social learning (for a review see Kavaliers, Ossenkopp, & Choleris, 2019). Thus, disgust is a motivational system, which is involved in a broad spectrum of avoidance/rejection behaviors.

Disgust is typically directed toward stimuli in the external environment but sometimes people show self-directed disgust responses. Self-disgust is defined as the tendency to experience disgust when appraising one's own personal attributes and behaviors (Overton, Markland, Taggart, Bagshaw, & Simpson, 2008). Overton et al. (2008) were the first ones who developed a questionnaire for the assessment of the personality trait self-disgust. The self-disgust scale (SDS) has a two-factor structure: disgust as it relates to aspects of the self (disgusting self; e.g., "I find myself repulsive") and disgust as it relates to aspects of one's behavior (disgusting ways; e.g., 'The way I behave, makes me despise myself').

Elevated self-disgust is dysfunctional. It is associated with different mental disorders, such as depression, borderline personality disorder (BPD), skin-picking disorder (SPD) and eating disorders (Ille et al., 2014; Overton et al., 2008; Schienle, Ille, Sommer, & Arendasy, 2014; Schienle, Leutgeb, & Wabnegger, 2015; Schienle, Übel, & Wabnegger, 2018). Power and Dalgleish (2008) postulated that self-disgust and sadness may couple to produce the typical phenomenology of depression. In line with this conception, Overton et al. (2008) showed that self-disgust mediated the relationship between dysfunctional cognitions and depressive symptoms. Ille et al. (2014) conducted a questionnaire study with different clinical groups (BPD, bulimia nervosa, schizophrenia, specific phobia). Individuals with BPD and bulimia reported the most pronounced self-disgust. In a recent study by Schienle et al. (2018), patients with skin-picking disorder (SPD) were characterized by high levels of self-directed disgust. The main symptom of SPD is repetitive and excessive scratching of one's own skin to the extent that damage (wounds, scars) is caused.

In contrast to these clinical groups, the degree of self-disgust in mentally healthy individuals is typically very low (Ille et al., 2014; Overton et al., 2008; Schienle et al., 2014). Nevertheless, associations between this trait and other personal characteristics have been found. Von Spreckelsen, Glashouwer, Bennik, Wessel, and de Jong (2018) showed that self-disgust was related to a negative body image in

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healthy normal-weight students. An earlier study pointed to the association between body dissatisfaction and self-disgust (Griffiths & Page, 2008). Somewhat similar, features of the physical appearance of others that are perceived as unattractive or disease-relevant are able to elicit externally oriented disgust (Oaten, Stevenson, & Case, 2011; Park, van Leeuwen, & Stephen, 2012).

The neural basis of externally oriented disgust has been extensively studied. Functional as well as structural neuroimaging approaches point to a 'disgust network' that includes the insula, the amygdala, the prefrontal cortex, and basal ganglia structures (Schienle, Walter, & Vaitl, 2002; Wicker et al., 2003). Especially the insula has been identified as a central neural correlate of state disgust (Wicker et al., 2003) and trait disgust (Scharmüller & Schienle, 2012).

In contrast, self-disgust has not been studied with structural brain imaging. The current voxel-based morphometry (VBM) study aimed at identifying associations between grey matter volume (GMV) in specific brain regions of the 'disgust network' (e.g., insula, prefrontal cortex regions) and reported self-disgust in a non-clinical sample. We compared VBM data from 59 healthy women with high vs. low scores on a self-disgust questionnaire.

2. Methods

2.1. Participants

We analyzed brain-structural data from 59 healthy women with a mean age of 24.8 years (SD = 6.55). The majority of women were University students (85%); the remaining participants were white-collar workers (years of education were on average 12.5, SD = 2.13). The participants were recruited via advertisements at the University campus and in social media. The analysis was restricted to women because of sex-related differences in reported self-disgust and brain morphometry (Cahill, 2006; Lazuras, Ypsilanti, Powell, & Overton, 2019; Schienle et al., 2014). Written informed consent was obtained from each participant prior to entry. The study was approved by the ethics committee of the University and was conducted in accordance with the Declaration of Helsinki.

2.2. Questionnaires

In the present investigation, all participants completed the Questionnaire for the Assessment of Self-Disgust (QASD; German version; Schienle et al., 2014). The QASD has two subscales: 'personal self-disgust' (9 items; disgust elicited by one's own physical appearance and personality; e.g., 'I find myself repulsive'; I hate some of my personality traits'), and 'behavioral self-disgust' (5 items; disgust elicited by one's own behavior; e.g., 'Some of my behaviors are repulsive to others'; 'I feel humiliated'). The items are rated on 5-point scales (0 = never; 4 = always). Possible mean scores for each subscale range between 0 and 4.

All participants additionally answered the depression subscale of the Brief Symptom Inventory (BSI-18; Spitzer et al., 2011) with 6 items. The presence of depressive symptoms (e.g.,'Feeling hopeless', 'Feeling worthless') are rated on 5-point scales (0 ='not at all' to 4 = 'extremely').

2.3. Determination of cut-off scores for personal and behavioral self-disgust

In order to be able to compare participants with higher and lower self-disgust scores in their brain morphometry, we first created a Receiver Operating Characteristic (ROC) curve to complete a sensitivity/specificity report (IBM SPSS statistics 25). In a ROC curve, the true positive rate (sensitivity) is plotted as a function of the false positive rate for different cut-off points of a parameter. Each point on the ROC curve represents a sensitivity/specificity pair corresponding to a particular decision threshold. The area under the ROC curve (AUC) indicates how well a parameter can distinguish between two diagnostic groups.

We attempted to differentiate between participants with 'functional' and 'dysfunctional' self-disgust (high vs. low self-disgust). For the analysis, we used a sample that included mentally healthy women (n = 125) as well as female patients (n = 105) with different diagnoses of mental disorders such as skin-picking disorder, borderline personality disorder, and depression. These clinical groups are known to report elevated self-disgust (Ille et al., 2014; Overton et al., 2008; Schienle et al., 2014, 2018). For 'personal self-disgust', we chose a cut-off score of 0.39, which was associated with a sensitivity of 83% (correct identification of the patients) and 75% specificity (correct identification of healthy participants). The AUC was 0.89 for personal self-disgust (excellent classifying accuracy). For 'behavioral self-disgust', a cut-off of 0.50 was selected (87% sensitivity; 72% specificity). The AUC for this subscale was 0.87.

Based on the ROC analysis, the sample was divided into two groups for QASD personal self-disgust (low: n = 38; high: n = 21) and behavioral self-disgust (low: n = 33; high: n = 26). Participants high vs. low in personal self-disgust did not differ from each other with respect to mean age and years of education (ps > 0.098).The two groups high vs. low in behavioral self-disgust did also not differ in mean age and duration of education (ps > 0.082). Details can be found in Table 1.

2.4. Voxel-based morphometry (VBM)

This investigation used voxel-based morphometry (VBM). VBM is a computational approach to neuroanatomy that measures differences in local concentrations of brain tissue through voxel-wise comparisons of multiple brain images (Mechelli, Price, Friston, & Ashborner, 2005). A voxel represents one volume element of the brain. A standard VBM analysis consists of three steps of preprocessing: normalization, segmentation, and smoothing (Kurth, Gaser, & Luders, 2015). In the central segmentation step, normalized brain images are classified as grey matter (cell bodies and dendrites of nerve cells), white matter (nerve fibers, myelinated axons) and cerebrospinal fluid. After the data have been preprocessed, it is possible to carry out statistical analyses on the basis of the general linear model. Grey or white matter volumes can be compared between groups. A VBM analysis can cover the whole brain or can be restricted to specified brain regions of interest (ROIs).

2.4.1. Recording and analysis of grey matter volume

T1-weighted scans were acquired using a 3-T Siemens Skyra with a 32-channel head coil (Siemens, Erlangen, Germany). The scanning parameters were as follows: voxel size: 0.88 × 0.88 × 0.88 mm; 192 transverse slices, FoV = 224 mm, slice thickness: 0.88 mm, TE = 1.89 ms, TR = 1680 ms; TI = 1000 ms, flip angle = 8°. The structural scans were analyzed with the Computational Anatomy Toolbox (CAT12; v1059) implemented in SPM12 (v6906; Wellcome Trust Centre for Neuroimaging; http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) in order to gain voxel-wise comparisons of GMV.

Prior to normalization, each individual image was repositioned by setting the origin manually to the AC/PC line. Structural data were segmented into grey matter, white matter and cerebrospinal fluid. Mainly default settings of the CAT12 toolbox were applied. To compensate for the effect of spatial normalization, images were modulated, as spatial normalization could lead to volume changes. This approach preserves the total amount of grey matter. The final resulting voxel size was 1.5 × 1.5 × 1.5 mm. For quality assurance, we checked resulting images for homogeneity. As all images had high correlation values (> 0.87), none of the images were discarded. Finally, grey matter images were smoothed with a Gaussian kernel with a full width at half maximum (FWHM) of 8 mm.

Table 1
Comparison of women scoring high vs. low on personal/behavioral self-disgust.

Personal self-disgust	High (n = 21)	Low (n = 38)	T-values	p	Cohen's d
	M (SD)	M (SD)			
Mean age (years)	23.7 (3.88)	25.4 (7.62)	t(57) = 0.97	0.336	0.26
Mean years of education	13.1 (1.49)	12.2 (2.37)	t(57) = −1.68	0.099	−0.46
Total intracranial volume	1455.2 (105.47)	1520.6 (163.86)	t(57) = 1.65	0.105	0.45
Personal self-disgust	0.64 (0.17)	0.15 (0.12)	t(57) = −13.06	< 0.001	−3.55
Depression	2.14 (1.71)	1.32 (1.45)	t(57) = −1.96	0.054	−0.53

Behavioral self-disgust	High (n = 26)	Low (n = 33)	T-values	p	Cohen's d
	M (SD)	M (SD)			
Mean age (years)	23.23 (3.70)	26.00 (7.97)	t(47.37) = 1.77	0.083	0.43
mean years of education	12.9 (1.41)	12.2 (2.55)	t(57) = −1.28	0.207	−0.36
Total intracranial volume	1468.81 (104.40)	1519.80 (173.51)	t(57) = 1.32	0.192	0.35
Behavioral self-disgust	0.992 (0.36)	0.224 (0.16)	t(33.16) = −10.09	< 0.001	−2.86
Depression	2.08 (1.67)	1.24 (1.44)	t(57) = −2.06	0.044	−0.54

2.5. Statistical analyses

The statistical analyses for the self-report data were conducted with Jamovi (version: 0.9.2.3; jamovi project 2018) and included *t*-tests and Pearson correlations. A reliability analysis for the questionnaires was carried out with the Lambda4 package (v3.0; Hunt, 2013) in R (R Development Core Team, 2008).

For the GMV data, two separate analyses of covariance (ANCOVAs) were computed in order to compare the groups (high vs. low personal self-disgust; high vs. low behavioral self-disgust). To correct for differences in brain size, the total intracranial volume (TIV) was implemented as a covariate. Moreover, age and BSI depression scores were used as additional covariates. To restrict the analysis to grey matter, images were thresholded for all analyses with an absolute threshold of 0.1.

Based on previous neuroimaging studies on disgust (Scharmüller & Schienle, 2012; Schienle et al., 2002; Wicker et al., 2003; Woolley et al., 2015) we selected the following ROIs: insula, amygdala, medial prefrontal cortex (MPFC), orbitofrontal cortex (OFC) and basal ganglia. The volumes for the used ROIs were as follows: insula (L: 9153 mm^3, R: 9564 mm^3); amygdala (L: 2761 mm^3, R: 2872 mm^3); OFC (L: 13551 mm^3, R: 11117 mm^3); MPFC (L: 36585 mm^3; R: 48303 mm^3); basal ganglia (L: 14310 mm^3, R: 12771 mm^3).

We used masks with a 25% threshold derived from the Harvard–Oxford cortical structural atlas Center for Morphometric Analysis, MGH-East, Boston/MA, USA). The masks were resliced to a voxel size of 1.5 × 1.5 × 1.5 mm with nearest neighbor interpolation. Only results with a *p*-value corrected for family-wise-error (FWE) below 0.05 (peak level; small volume correction) as well as Bonferroni correction (cutoff: 0.05/10 = 0.005) are reported because of the exploratory approach of this study.

3. Results

3.1. Questionnaires

The mean questionnaire scores (standard deviations) were as follows: QASD personal: M = 0.32 (SD = 0.27; range: 0–1.11), QASD behavioral: M = 0.56 (SD = 0.47; range: 0–2), BSI depression: M = 1.61 (SD = 1.59; range: 0–5). The reliability (Guttman's Lambda 4) of the scales in the present sample were 0.71 (personal), 0.67 (behavioral), and 0.69 (depression). Means (SD) for the sub groups can be found in Table 1.

Trait depression was positively correlated with both QASD subscales (behavioral self-disgust: r = 0.28, p = .033; personal self-disgust: r = 0.30, p = .021). The correlation of the two self-disgust subscales was r = 0.54, p < .001.

3.2. VBM

Relative to women with low scores on the 'personal self-disgust' scale, women with high scores showed reduced GMV in the left and right insula (Fig. 1). This group difference was not only statistically significant in the ROI analysis but also in the whole brain analysis (Table 2). The group difference (high vs. low personal self-disgust) in insula volume was still present when depression (BSI score) was introduced as a covariate (Table 2).

Groups with high vs. low behavioral self-disgust did not differ in GMV.

4. Discussion

The present VBM study examined the personality trait self-disgust in a nonclinical sample. Women with high personal self-disgust (according to a ROC curve analysis) displayed reduced bilateral insula volume relative to women with low personal self-disgust. This difference was independent of depressed mood.

Numerous functional neuroimaging experiments have revealed that the insula is active when experiencing states of disgust in response to stimuli in the external environment (Schienle et al., 2002; Wicker et al., 2003). Moreover, the personality trait 'disgust proneness', the temporally stable tendency of a person to experience disgust in response to stimuli in the external environment, showed a positive association with grey matter volume in the insula (Scharmüller & Schienle, 2012).

These findings have been interpreted based on the specific functions of the insula. The insular cortex is involved in the conscious experience of somatic sensations and becomes activated by perturbations in the organism's physiologic milieu (Feldman Barret, 2017; Uddin, 2015). Such perturbations can be elicited by an aversive taste or smell, the sight of an ill organism or an immoral action. These are all typical disgust elicitors (Rozin, Haidt, & Fincher, 2009). More generally spoken, the insula is involved in interoceptive awareness, connecting homeostatic information from the body with higher-level cognitive processes. Such integration also involves emotional functions (Paulus &

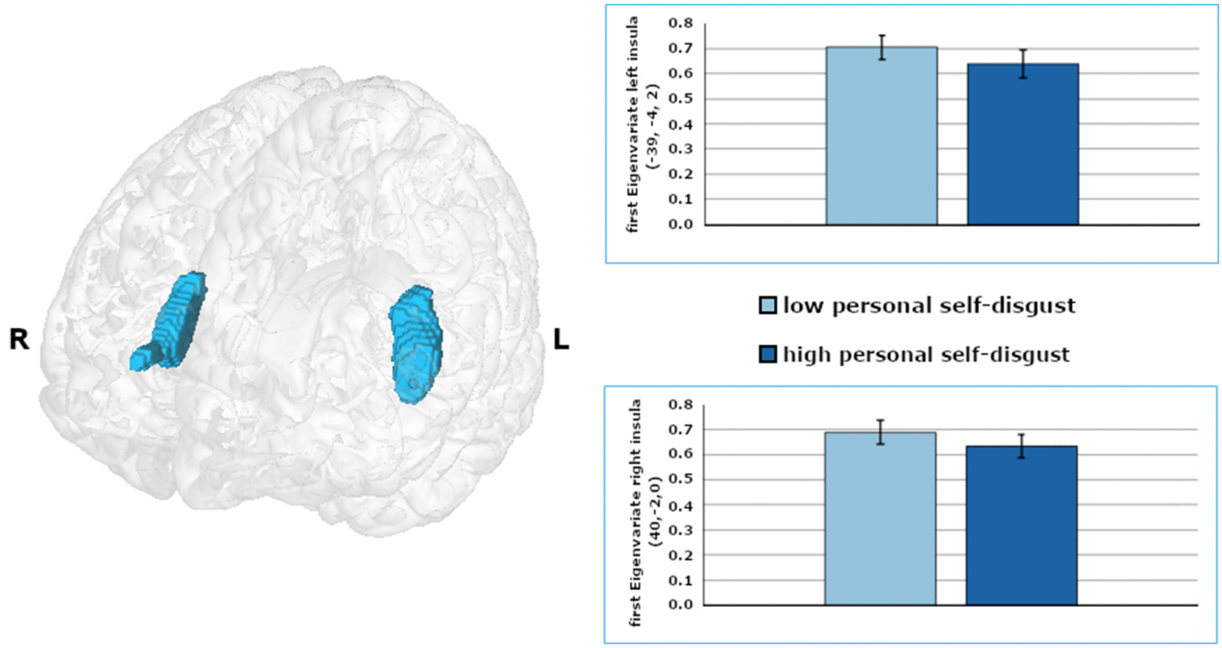

Fig. 1. Reduced insula volume in women with low vs. high personal self-disgust.

Table 2
Comparison of grey matter volume in the insula between women with low and high personal self-disgust (with and without depression as covariate).

H	x	y	z	t-value	z-value	p(FWE) ROI/WB	Cohen's d
Personal self-disgust							
L	−39	−4	2	5.82	5.12	< .001/.006	1.57
R	40	−2	0	5.35	4.78	< .001/.026	1.44
Personal self-disgust: covariate depression							
L	−38	−6	3	6.46	5.54	< .001/ < .001	1.76
R	40	−3	0	5.83	5.11	< .001/.006	1.59

Footnote: H: hemisphere; MNI coordinates (x,y,z); p(FWE): p-value corrected for family-wise error; ROI: region of interest; WB: whole brain.

Stein, 2006; Schienle et al., 2002).

The insula is well suited for representing emotional experience in general because it receives interoceptive inputs from the whole body and is connected with prefrontal regions that can provide contextual information. Thus, the insula is one hub of a neural network that integrates information across the brain to create large-scale information patterns (Feldman Barret, 2017). These embodied brain representations are the basis on which upcoming sensory events, inside and outside the body, are anticipated and adaptive actions toward these events can be selected. The insula is one part of a system that filters incoming sensory input, constructs perception and other psychological phenomena, including self-referential emotions (Feldman Barret, 2017).

Another network model of the insula has been proposed by Uddin (2015). According to this model, the insula is central for mediating dynamic interactions between large-scale brain networks involved in externally oriented attention and internally oriented cognition/emotion. If this insular mechanism is compromised due to altered neural structure and function particular dysfunctions and pathology may develop. Reduced but also increased grey matter volume in the insula can negatively influence the functionality of this region as well as the information exchange with other brain regions leading to specific neuropsychiatric disorders (Uddin, 2015).

In line with this conception, increased grey matter volume in the insular cortex has been implicated in mental disorders with symptoms of excessive anxiety and disgust to external stimuli (see meta-analysis by Carlisi et al., 2016). In contrast, decreased insula volume has been found in patients with mental disorders that are characterized by difficulties in social and self-referential affective processing (for a summary see Uddin, 2015).

In the present study, a negative association was found between grey matter volume in the bilateral insula and a specific facet of self-disgust: the proneness to appraise one's own body and personality features as repulsive. Powell, Simpson, and Overton (2015a) defined the trait self-disgust as an undifferentiated disgust-based cognitive-affective orientation to the self. The reduced volume of the insula might be one neural correlate of such a limited and negatively valenced representation of the own person.

We did not find group differences in GMV for behavioral self-disgust, which was only moderately correlated with personal self-disgust. The administered questionnaire assesses behavioral self-disgust with items such as 'some of my behaviors are repulsive to others' or 'I feel humiliated'. These statements refer to how one is perceived by others. On the contrary, typical items of the subscale 'personal self-disgust' refer to one's own view of the self ('I find myself disgusting'). It has been argued that we use two different main sources of information to construct our self-concept. 'Reflected appraisal' results from our beliefs about how we are seen by others, whereas 'direct appraisal' is our own view of 'what we are like' (Leary & Tangney, 2012). The two different types of disgust-related self-concepts (direct vs. reflected) may rely on different neurocognitive strategies when making self-referential judgments and consequently on different neural substrates.

A number of limitations of the present investigation and recommendations for future work need to be mentioned. First, we only recruited women. This limits the generalizability of our results to men.

Second, although the present findings provide insight into the neural basis of self-disgust, the data cannot speak to causal directions; that is, the present data are unable to establish whether reduced insular volume facilitates the development of self-disgust, or if self-disgust causes volume reductions in the insula. Longitudinal studies addressing changes in cortical structure will be necessary to answer this question.

Third, based on the present findings, we cannot conclude that the insula is a specific neural correlate of self-disgust. This view is in line with network models of the insula that describe a broad spectrum of functions of this brain region all underlying allostasis (Feldman Barret, 2017). A disgust-related self-concept is only one facet of the multidimensional self-concept of a person. However, psychotherapeutic intervention studies might be especially helpful in order to reveal whether this facet is directly associated with insula volume. Powell, Simpson, and Overton (2015b) have described a modification training that specifically aims at attenuating self-disgust by encouraging self-affirming kindness. This type of training may be able to normalize insular function and structure.

Author contribution

Both authors were involved in the data analysis and writing of the manuscript.

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Declaration of Competing Interest

The authors declare no conflict of interest. Elements in the manuscript have not been published before and are not under consideration for publication elsewhere.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2019.06.003.

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