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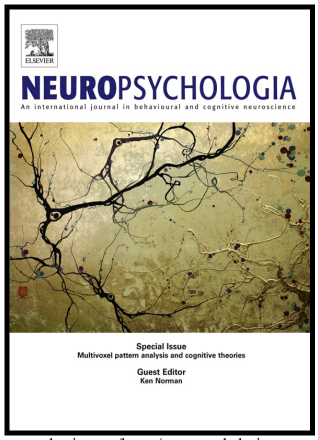

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Laugh or cringe? Common and distinct processes of reward-based schadenfreude and empathy-based fremdscham

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Abstract:

Witnessing others' plights can be funny for observers, but may also trigger one to empathically cringe with the victim of the predicament. In the present study, we examined the common and distinct neural networks involved in schadenfreude (i.e. pleasure derived from another's misfortune) and fremdscham (i.e. empathically sharing the embarrassment about another's misfortune). Using functional magnetic resonance imaging we examined a total of *N*=34 participants while they observed social integrity threats of a misfortunate other and either reported on their schadenfreude or fremdscham. In this between-subject design, we found that despite a broad overlap in brain regions involved in social cognition, the left anterior insula (AI) was activated less if observers were asked to focus on their schadenfreude. Further, the nucleus accumben's activity exclusively covaried with the intensity of the schadenfreude experience and had a higher functional connectivity with the left AI in the context of schadenfreude than during fremdscham. With the present findings, we demonstrate that the valence and intensity of interpersonal emotions strongly depend on the experimental context and that empathy and reward circuits are involved in shaping the subjective experience.

Introduction

The idea of exposing the failures of protagonists to a broader audience has been part of the history of theatre, movies, and television not only since Laurel and Hardy. Recently, talent and celebrity shows like "Britain's got talent" or "I'm a

Celebrity...Get Me Out of Here!", or the famous "Mortified!" have capitalized on this motive and allow interested observers to witness others' failures and how they are ridiculed live on television. The emotional reaction of observers to such public pratfalls and predicaments is rather complex and can comprise different valences. While previous studies have focused on the empathic sharing of others embarrassment (Krach et al., 2011; Müller-Pinzler et al., 2012; Melchers et al., 2015; Miller, 1979; Paulus et al., 2015a) it is quite common that observers also feel pleasure at the public misfortunes of others (Leach et al., 2003) and it seems not a very far-fetched thought that this pleasure also contributes to the financial success of these shows. In some languages, the German term 'schadenfreude' has been established as a label for such malicious joy, initially thought of as a "discordant" reaction because one's positive emotional experience arises from another's (social) suffering (Heider, 1958). With this study we aim to disentangle the neural processes that people engage while they report to experience schadenfreude in response to another's misfortune.

Schadenfreude

Social psychology research has recently characterized the concept of this social emotion more thoroughly and found several determinants and moderators of the schadenfreude experience. Thereby, the character and behaviour of the social target, personality characteristics of the observers, or the relationship between the social target and the observer have been in the focus of experimental studies. First, this prior research suggests that observers react with schadenfreude when they think that the other somehow deserved the misfortune (Feather and Nairn, 2005; Feather, 2006; Feather and Sherman, 2002; van Dijk et al., 2005). This form of justification occurs if observers disapprove of how another person has acted, attribute some sort of responsibility for the misfortune to the other (van Dijk et al., 2008), or may simply be inferred based on mental states i.e. when the social target had bad intentions in mind when the misfortune took place (Dasborough and Harvey, 2016). In this line, it might even be sufficient to consider the other as an arrogant or hypocrite person (Hareli et al., 2011; Powell and Smith, 2013) to trigger schadenfreude. Second, previous research also emphasized relational aspects. It was demonstrated that the experience of schadenfreude varies with the social dependencies between observer and target. For example, if observers receive a factual gain from the other's misfortune they also report greater schadenfreude (Dasborough and Harvey, 2016; Feather and Sherman, 2002; Smith et al., 1996; Takahashi et al., 2009; van Dijk et al., 2006). The experience of envy thereby has been specifically considered as a source of schadenfreude and some studies now indicate that envy - in its malign appearance - leads to schadenfreude during later social interaction. Third, studies that focus on the observer's characteristics suggest that schadenfreude also depends on the self-concept of the observers: if an observer holds a negative view on him- or herself (Leach et al., 2003; Leach and Spears, 2009; van Dijk et al., 2011) he or she also reacts with greater schadenfreude in response to another's misfortune. This association of the observer's self-esteem with schadenfreude has been explained by a beneficial downward comparison which helps to preserve and restore a positive attitude towards oneself (van Dijk et al., 2011). In this line, the domain of failure needs to be self-relevant for the observer (Heider, 1958) in order to make observers profit from the comparison with the social target.

While these studies emphasize different aspects of the dyad between observers and social target for the schadenfreude experience, it must be noted that the different viewpoints on the causes and moderators of schadenfreude are by no means independent and schadenfreude must be considered an inherently interpersonal emotion. It thus might have a functional role in the regulation of social hierarchy (Lange et al., in press), and may even be experienced in social groups (for more detailed analyses on group-based schadenfreude see e.g. Cikara & Fiske, 2012; Fiske, 2010; Smith, Powell, Combs, & Schurtz, 2009). Schadenfreude, however, does not occur if the observer is causally involved in the misfortune of the other in one or another way. In this regard schadenfreude can be differentiated from the social emotion of gloating which arises in social interaction and active defeat of another through direct competition. While one might gloat after one humiliates another in a competition, schadenfreude is experienced in response to accidental and rather uncontrollable circumstances that cause another's misfortune (for discussions, see Leach, Snider, & Iyer, 2002; Leach et al., 2003). This implies that while observers need to witness the other's predicament, they do not need to be able to directly interact with the social target to report genuine schadenfreude and gain from another's suffering.

Fremdscham

However, as outlined above, one might not only feel pleasure at the public misfortunes of others, but could also share the protagonist's unfortunate moment in an empathic manner (Miller, 1987). In this case the resulting empathic embarrassment (the German noun 'fremdscham' currently best fits this concept) would be "concordant" with the protagonist's reaction and his or her emotional experience is shared in an isomorphic fashion. More recently, we could show that fremdscham is experienced even if the observed protagonist is not embarrassed him- or herself, for example in "spinach-in-the-teeth" kind of situations (Krach et al., 2011; Müller-Pinzler et al., 2012; Paulus et al., 2015a, 2013). While the social target might not be aware of the ongoing mishap, observers indeed are, creating a somewhat different kind of vicarious reaction. We have therefore differentiated proper empathic embarrassment from its vicarious form, which similarly to schadenfreude classifies as a “discordant” reaction in the sense that the emotional state of the observer and social target do not match (Paulus et al., 2014b). Here, however, the “discordance” between the social target and the observer emerge because the threat to the social integrity of the exposed target is only correctly assessed from the observer’s perspective. This concept of “discordance” is thus not related to an egocentric motivation to obtain a gain out of another’s misery but related to the different access of information about the present integrity threat (see Paulus et al., 2013 for a more detailed discussion).

Neural bases of Schadenfreude and Fremdscham

Both the experience of schadenfreude and fremdscham are contingent upon another’s misfortunes and thus require perceiving a threat to the protagonist’s integrity. Understanding these identity threats to another - specifically if they represent socially instead of bodily harmful situations - and representing the emotional consequences of these events, however, is a complex process. Two distinct but interacting routes have been characterized that enable humans to understand another’s condition (Keysers and Gazzola, 2007; Paulus et al., 2013; Waytz and Mitchell, 2011). First, “mirroring” or “sharing” is assumed to be a direct mapping of others’ sensory or affective states and actions on one’s own neural system. This rather reflexive route thus results in the representation of another’s emotional state in neural systems that represent similar own affective experiences. Recent neuroscience studies revealed that a network usually comprising the anterior cingulate cortex (ACC) and the anterior insula (AI) responds to the observation of threats to another person's physical and social integrity (Beeney et al., 2011; Krach et al., 2011). This activation was positively associated with the intensity of the emotional experience which is why they are considered to be part of the shared circuits for representing negative affect, being it for oneself or another (see however

Zaki et al., 2016 for a critical discussion of that matter). The activity of the ACC and AI network is not only upregulated with increasing intensity of the self-reported affective experience (Paulus et al., 2015; Saarela et al., 2007), but also when participants envisioned close others in social predicaments as compared to strangers (Müller-Pinzler et al., 2016). Likewise, other research could show that shared circuit activity in the AI and ACC, e.g. during empathizing with another's bodily pain, can even be modulated by only manipulating contextual cues such as social closeness (Cheng et al., 2010; Meyer et al., 2012) or perceived fairness (Singer et al., 2006).

By figuratively putting oneself into another person's shoes, "mentalizing" processes are considered to be the second route to infer another person's condition. Among regions in the temporal lobe and temporo-parietal junction, the medial prefrontal cortex (mPFC) and the precuneus (Frith and Frith, 2003) show increased activations when participants consciously reflect about their behavior and more importantly, the evaluation of one's own behavior in-the-eyes-of-others (Müller-Pinzler et al., 2015; Takahashi et al., 2008; Zahn et al., 2009). It is thus not surprising that mentalizing activity is also implicated during social comparisons, when people reflect about their own social status in relation to others (Dvash et al., 2010; Shamay-Tsoory et al., 2007). Both processes, mirroring and mentalizing, can therefore be understood as ongoing simulation processes that enable observers to consciously experience another person's state (Paulus et al., 2013; Waytz and Mitchell, 2011) and are essentially engaged in all kinds of interpersonal emotions that occur in socially interactive settings and require the presence of other social beings (Müller-Pinzler et al., 2016).

In addition to the processes that help getting access to the other's condition, the experience of schadenfreude also involves the rewarding and malicious side of seeing the other person fail. In fact, in one or another way, the experience of schadenfreude implies a gain for the observer, being either related to finding justice, one's own benefit or preserving self-worth. Takahashi and colleagues (2009) could show that if an envied person failed or underwent a public mishap, study participants not only reported schadenfreude, but also that this experience was associated with greater neural activation in the ventral striatum – a central hub in the brain's dopaminergic reward system (see e.g. Haber and Knutson, 2009; McClure et al., 2004 for reviews). Other studies, mostly in the domain of neuroeconomics, revealed that observing failures and sufferings of antisocial individuals led to greater schadenfreude related ventral striatal activity in opponents than failure of prosocial contenders (Singer et al., 2006). In a study on real-world rivalry between fans of opposing baseball teams, Cikara and coworkers could show that the ventral striatal activity was increased not only at own team wins but also at other team losses and that the degree of striatal activity during these losses was correlated with self-reported pleasure (Cikara et al., 2011). Adding to this evidence, Shamay-Tsoory and coworkers revealed that intranasal oxytocin, a neuropeptide that predominantly binds on receptors in the ventral striatum, increased ratings of schadenfreude at relative gains as compared to an opponent (Shamay-Tsoory et al., 2009). Furthermore, in a similar study, Dvash and colleagues could show that the response in the ventral striatum increased after both an absolute gain of money and the relative gain as compared to the payoffs of a putative opponent (Dvash et al., 2010). Overall, these findings suggest a significant role of the ventral striatum not only in the processing of rewards per se, but also in the emotion of schadenfreude arising from social comparison and the resulting relative gains.

Aim of present study

Previous neuroscience studies have either examined the determinants of schadenfreude in the context of an interaction history of the observer with the social target, or the emergence of schadenfreude in a comparative or competitive setting involving an unknown counterpart (Dvash et al., 2010). It is yet unknown if and how schadenfreude is experienced while witnessing strangers who are ridiculed in public when there is no context of direct social comparison. This is surprising considering the many incidents in which observers see someone they have never met before and report to feel schadenfreude. While some prior evidence exists about potential mechanisms that trigger schadenfreude, such as low self-esteem and beneficial downward comparisons, as well as attributed bad intentions or flawed character of the social target, the involvement of specific reward related signals has yet to be shown. With the present study, we aim to bridge this gap and investigate the common and distinct networks of the genuinely interpersonal emotions fremdscham and schadenfreude when observing others' pratfalls without having access to additional information about this person or a history of prior social interactions. We postulate that sharing the threats to another's social integrity would trigger fremdscham and related shared circuit activity in the ACC and AI while focusing on the funniness of another's flaws would drive the reward related experience of schadenfreude which more strongly depends on a striatal reward signal.

Methods

Ethics Statement

We confirm that the research has been conducted in compliance with the ethical guidelines of the American Psychological Association (APA). The study protocol was approved by the local ethics committee at the local faculty of medicine and all subjects gave written informed consent.

Participants

All participants (N = 34) were male and fluent in German and had normal or corrected to normal vision. Participants were assigned either to a schadenfreude or a fremdscham condition. The N = 17 participants in the fremdscham condition (aged 19-31 years, M = 24.12, SD = 2.96; IQ 95-132, M = 113.41, SD = 10.48) were age and IQ-matched with the N = 17 participants who received the schadenfreude instruction (aged 22-29 years, M = 24.59, SD = 1.80; IQ 87-132, M = 109.00, SD = 10.31; $ps \geq .225$). Besides the matching between the two conditions, it should be noted that the homogeneity of the sample might limit the generalizability of the findings. Since participants in the fremdscham condition were also part of a control group for people with autism spectrum disorders (Krach et al., 2015) this study design was however preferred for economic reasons besides the potential limitations with regards to the generalizability of the results due to including only male subjects.

Stimuli, Experimental Design, and Procedure

In a between-subjects design one group was assigned to the schadenfreude and the other one to the fremdscham condition. Both groups viewed a set of 50 previously validated hand-drawn sketches, consisting of 40 situations showing a person being exposed in an embarrassing situation and ten neutral sketches serving as control situations. The situations that displayed a target person whose social integrity was threatened were supposed to elicit fremdscham (FS) or schadenfreude (SF), depending on the instruction participants received. Neutral control stimuli displayed the social target in a public context without an apparent threat to the social integrity of the protagonist. For clarification, each sketch was accompanied by a two-sentence description of the current situation (e.g. "You are at the grocery store: You observe a woman at the cashier realizing that she cannot pay her purchase…", see Fig. 1). In the FS condition, the participants were asked to rate their experience of vicarious embarrassment for the social target after viewing the situations ("How intense was your vicarious embarrassment?"). In the FS condition subjects read in the instructions that bystanders might feel vicariously embarrassed while observing the social integrity threat of another person. In the SF condition, they were asked to rate the intensity of schadenfreude ("How amusing was the situation for you?") and read in the instructions that people sometimes make fun of another's mishap and feel malicious joy.

To cover a broad variety of potential social integrity threats that might elicit embarrassment on behalf of others and schadenfreude in everyday life, situations modelled four different types of scenarios, varying the degree of intentionality and awareness of the social target's behaviour (see Krach, et al., 2011 for a detailed description). For the means of the present study, however, the four types of situations were assembled into one and compared to the neutral control situations.

After providing written informed consent, participants were carefully instructed about the experimental procedure. Therefore, participants received two exemplary situations that were not displayed during the fMRI session and were asked to visualize the displayed situations as vividly as possible, while observing the presented social target. Afterwards they were asked to rate their affective experience of either fremdscham or schadenfreude. In the MRI, all sketches were presented for 12 s together with the description of the situation. The text was presented in a black 24-point non- serif font (Arial) on a white background in two to three rows below the sketches. The stimulus presentation was followed by a blank screen for 1 s and the subsequent rating period of 3 s manipulating the primary emotion experienced. During the rating period, participants were asked to evaluate the intensity of their preceding affective experiences on a scale ranging from 1 ('not at all') to 5 ('very strong') using a button press of the right hand.

A jittered low-level baseline showing a fixation cross for an average of 8 s was interleaved between the rating period and the following trial. Stimuli were presented in a pseudo-randomized order, ensuring that no class of situation was immediately repeated and different situations had equal frequency throughout the entire fMRI time-series. The total duration of the experiment was 20.28 min.

Data Acquisition

Participants were scanned at 3T (Siemens Trio, Erlangen) with 36 near-axial slices and a distance factor of 10% providing whole brain coverage. An echo planar imaging (EPI) sequence was used for acquisition of functional volumes during the experiment (TR= 2.2 s, TE = 30 ms, flip angle= 90°, slice thickness = 3 mm, FoV= 192). Stimuli were presented on an LCD screen with Presentation 11.0 software package (Neurobehavioral Systems, Albany, CA, USA).

Data Analysis

Behavioral Data

Data were analyzed with PASW Statistics 18 (SPSS, 2009, Chicago, IL). Each participant's self-reports of fremdscham or schadenfreude were averaged within the conditions of norm violating and neutral situations. Averaged self-reports of emotions were then analyzed using analyses of variance (ANOVAs) for each group with Category as a within-subject factor (four conditions depicting a social identity threat (SIT) and a neutral condition (NEUT)). A priori contrasts comparing the SIT with NEUT situations were implemented to test the effects of emotion induction.

Functional MRI Data

FMRI data were analyzed using SPM8 (www.fil.ion.ucl.ac.uk/spm). The first four images were dummy scans and were discarded from further analyses. The remaining 549 EPI volumes were corrected for timing differences of the slice acquisitions, motion-corrected and spatially normalized to the standard template of the Montreal Neurological Institute (MNI) using the EPI template. The normalized volumes were resliced with a voxel size of 2x2x2 mm, smoothed with an 8 mm full-width half-maximum isotropic Gaussian kernel and high-pass filtered at 1/256 Hz to remove low frequency drifts.

Fremdscham and Schadenfreude related Activations

Statistical analysis was performed in a two-level, mixed-effects procedure. The fixed-effects generalized linear model (GLM) on the first level included six epoch regressors modeling hemodynamic responses to the SIT situations (4), NEUT situations (1), and rating phase (1) with the abovementioned stimulus durations. The fremdscham or schadenfreude ratings after each SIT stimulus were entered as parametric modulators to explain additional variance in neural activation due to differences in emotional responses on the within-subject level. Six additional regressors modeling head movement parameters were introduced to account for noise.

Contrast images of activation differences between the SIT and the NEUT situations were analyzed on the second level. The second-level analysis of activation differences was conducted with a random-effects GLM. The GLM contained one factor for the fremdscham vs schadenfreude condition (FS vs SF) and a second factor for the four dependent levels of differences between SIT and NEUT situations. To identify brain regions that are involved in fremdscham and schadenfreude we averaged the four levels of activation differences of SIT vs NEUT for each of the groups. The results of these analyses were thresholded at $p < .05$ applying family-wise error (FWE) correction for a whole brain analysis on the voxel level. To find brain regions that show stronger activations during fremdscham than schadenfreude and vice versa the above contrasts for both groups were contrasted against each other (FS-SF and SF-FS). The results of this analysis were corrected within a bilateral NAcc region-of-interest (ROI) derived from an automated meta-analysis of 143 studies with the term “nucleus accumbens” (http://www.neurosynth.org, Yarkoni et al., 2011 and see Paulus et al., 2015 for details) due to the expected involvement of reward circuits during schadenfreude. Due to the previously described role in the processing of fremdscham we defined the anterior aspects of the left insula based on a similar procedure and ran an automated meta-analysis of 502 studies with the term “anterior insula”. We restricted the resulting image to $Z > 6.5$ for the cluster of the left insula lobe to achieve a sufficiently smooth and specific ROI for the left AI. The ROI for the ACC was computed accordingly, however this automated meta-analysis included 1677 studies. All results are reported in MNI space.

The association of emotion self-reports and neural activation was analyzed by implementing an additional random-effects GLM on the second-level. The GLM again contained one factor for the two separate groups (FS vs SF) and a second factor for the four dependent levels of the parametric weights contrasts of either fremdscham or schadenfreude self-reports. The second-level analysis was controlled for individual differences in the variation of emotion self-reports within each category and across both group by introducing subjects’ standard deviations of emotion ratings within each category as four separate covariates in the GLM. To find brain regions that show increased activations associated with self-reports of fremdscham and schadenfreude respectively we averaged the contrasts across the four levels of SIT situations. Specific associations for fremdscham and schadenfreude self-reports were analyzed by contrasting both groups against each other (FS-SF and SF-FS). The results were family wise error corrected on the voxel level within the ROIs of the bilateral NAcc, the left anterior insula (AI) and the anterior cingulate cortex (ACC).

Functional Connectivity Analysis of the NAcc

To examine group-specific connectivity patterns in the context of experiencing fremdscham or schadenfreude for others mishaps we conducted a functional connectivity analysis. We selected the NAcc that showed a stronger association with schadenfreude than fremdscham self-reports as seed region (sphere of 6mm around the peak voxel -6, 16, -6mm, see Results section). NAcc timeseries were mean centered and task-related variance was removed by applying an effects-of-interest correction with an *F*-contrast set to the six movement parameters (Paulus et al., 2014a). To account for noise, two additional timeseries were extracted for each subject from the first eigenvariates of all voxels within masks covering medial cerebrospinalfluid regions (CSF) or white matter (WM) (Bedenbender et al., 2011). The fixed-effects GLM for the connectivity analysis on the first-level thus included the timeseries of the NAcc, the WM and CSF noise regressors, and the above described regressors of the original design matrix including the regressors modeling head movement parameters. Beta-maps of the NAcc timeseries effect were analyzed on the group-level with a random-effects GLM. Differences in functional connectivity profiles of the NAcc between the FS and SF group were investigated and FWE corrected within the left AI and ACC ROI as described above.

Results

Behavioral Data

Emotion ratings showed significant main effects of stimulus Category (SIT and NEUT) for both groups (FS: $F_{(4, 16)} = 59.93$, $p < .001$; SF: $F_{(4, 16)} = 49.32$, $p < .001$). As expected and previously found, an a priori contrast showed that participants in the fremdscham group reported stronger fremdscham for all SIT situations (M=2.91, s.d.=0.64) compared to the NEUT condition (M=1.04, s.d.=0.07), $F_{(1, 16)}$ =151.06, $p <$ .001. In the schadenfreude group self-reports of schadenfreude were also increased for the SIT situations (M=2.47, s.d.=0.48) compared the NEUT situations (M=1.06, s.d.=0.11), $F_{(1, 16)} = 135.49$, $p < .001$. While situations with social identity threat induced stronger affective experience in both conditions we also found the schadenfreude that subjects reported in the SF group was significantly lower than the fremdscham in the FS group ($t(32) = 2.27$, $p = .030$).

FMRI Data

In line with prior studies on that induced vicarious embarrassment (Krach et al., 2011; Müller-Pinzler et al., 2016b; Paulus et al., 2015a), participants in the fremdscham group showed increased activity extending to the ACC ROI and also left AI while observing SIT situations vs NEUT situations. Additionally, we found indications for an involvement of the mentalizing network with significantly increased mPFC activation (see Paulus et al., 2015a). But also the thalamus and the NAcc, regions which have been implicated in reward processing (Knutson et al., 2000), showed increased activation in the fremdscham condition ($p < .05$, FWE-corrected for whole brain analyses. In the schadenfreude group a relatively similar pattern of activation emerged. Together with the ACC, the mPFC also showed increased activity specifically while participants observed SIT situations ($p < .05$, FWE-corrected for whole brain analyses), however, we did not find a significant AI activation on average. Additionally, the left and right NAcc showed increased activation (see Figure 2 and Table 1 for the main effects and illustration of the overlap of the FS and SF condition).

The direct comparison of the SIT specific activation between the FS and SF group (FS[SIT-NEUT]-SF[SIT-NEUT]) showed a significantly higher activation of the left AI in the FS group compared to the SF group (x=-26, y=26, z=8; $t(128)=3.32$, $p=.041$; FWE-corrected within left AI ROI) but no higher activations for the SF group or differential effects within the NAcc ROIs. No effects were found for the ACC. Including inter-individual differences in intensity of the affective experience during the scanning in the model could only partially explain this effect. On the one hand, we found a significant positive association of the self-reported strength in the affective experience with AI activation (x=-36, y=10, z=-10; $t(127)= 3.25$, $p = .048$, FWE-corrected within left AI ROI). On the other hand, controlling for the intensity of self-reported SF and FS ratings, however, also reduced the interaction effect to a trend-level ($t(127)=2.95$, $p=.101$, corrected within left AI ROI)

Regarding the intra-individual association of the self-reported intensity in the affective experience with neural activation, we could also replicate previous findings. Within the FS group we found a significant association between the intensity of the fremdscham self-report and neural activation in the left AI (x=-36, y=8, z=-6; $t(124)=3.40$, $p=.032$; corrected within left AI ROI). In the SF group self-reports of schadenfreude were also positively associated with activity of the left AI (x=-34, y=26, z=-4; $t(124)=4.02$, $p=.005$; corrected within left AI ROI and see Figure 3 for the results of a conjunction analysis) the ACC (x=10, y=14, z=38; $t(124)=4.73$, $p=.002$; corrected within ACC ROI) but also variability of activity in the bilateral NAcc (left NAcc: x=-12, y=16, z=-2; $t(124)=3.44$, $p=.015$; right NAcc: x=16, y=16, z=-4; $t(124)=3.03$, $p=.035$; corrected within ROIs). When contrasting the effects of the parametric weights between SF and FS within these ROIs we found a stronger association of schadenfreude ratings with left NAcc activity (x=-6, y=16, z=-6; $t(124)=3.14$, $p=.033$; corrected within left NAcc ROI).

To explore task-dependent differences in the association of empathy circuits with reward structures a functional connectivity analysis of the NAcc region was conducted. Independent of task variance there was a trend for a significantly stronger signal correlation between the NAcc and the left AI (x=-34, y=18, z=12; $t(32)=3.35$, $p=.072$, corrected within left AI ROI) as well as the ACC (x=10, y=40, z=26; $t(32)=3.84$, $p=.087$, corrected within ACC ROI) in the schadenfreude group compared to the FS group. Parameter estimates indicate a positive signal correlation between the NAcc and the AI during schadenfreude and a negative correlation during fremdscham (see Figure 4).

Discussion

The emotions people experience while witnessing anothers' misfortunes significantly vary with regards to their quality and valence. While some people share the discomfort in response to the perceived social integrity threat, others might have a good laugh in response to the very same incident. With the present study, we aimed to delineate the common and distinct neural networks underlying such reward based schadenfreude and empathy based fremdscham. We applied an explicit experimental manipulation and asked participants in a between-group design to either concentrate on their fremdscham experience or to report on their pleasure during the observation of anothers' awkward moments. Thereby, prior interaction history with the exposed protagonist or personality characteristics of the other were not explicitly considered to explain common and distinct processes in the affective experience. The results clearly indicate that the fundamental brain networks helping to understand another person's condition are involved in these interpersonal emotions. Regardless if people focus on the embarrassing or amusing quality of the situations we find the mPFC, as part of the mentalizing network, to be engaged while observing another's public predicaments. This is not surprising, since modeling another person's thoughts and intentions as well as representing other bystanders' negative evaluations is fundamentally required to grasp the threat to the protagonist's social integrity (Müller-Pinzler et al., 2015a; Paulus et al., 2015a). This is also in line with prior studies, implying the mPFC to be engaged in reflecting about oneself in the context of others (Finger et al., 2006) and representing social event knowledge (Krueger et al., 2009), two fundamental processes when assessing another's social integrity threat. Further, the ACC as part of the shared circuits, which enables humans to represent one's own and another's bodily affect, was commonly involved in both the fremdscham and the schadenfreude experience.

Despite these quite broad commonalities in the underlying processes of fremdscham and schadenfreude our results also show a distinct regulation of brain activation and connectivity when people deliberately concentrate on either one of the two. If subjects were instructed to evaluate their fremdscham experience, which is thought to be a rather empathy based representation of the negative affect in response to the perceived social integrity threat, we observed a significantly greater left AI activation. This is in line with the notion of the AI activity to represent an embodied and consciously accessible maker of affective arousal (Craig, 2009, 2003) which is also supported by a covariation of the AI activity with the intensity of the self-reported fremdscham experience, also replicating previous findings (Paulus et al., 2015). Notably, the potential down-regulation of the AI when observers report on their schadenfreude suggests that this shared arousal in response to the evident integrity threat is less pronounced. This finding is supported by previous studies, that examined the AI response during empathy for physical pain and its modulation by perceived fairness of the other (Singer et al., 2006) or membership of the suffering social target in rivaled outgroup (Hein et al., 2010). As observed here, when people focused on their pleasure during another’s misfortune, these studies show the AI response to be significantly less pronounced if observers have a history of unfair interactions with the other or ascribe undesirable attitudes to the social target, resulting in a lower motivation to empathically share the other’s suffering and also engage into helping behavior (Hein et al., 2010). With the present data, we broaden this perspective and show that it is possible to deliberately put people into a motivational state that reduces the AI activation in response to another’s suffering. Thus, adding on earlier findings on the significance of real or constructed interaction history (e.g. in football rivalry) or the assumption of a universal mechanism of out-group demarcation we provide first evidence that by simply changing the instruction, people do up- or down-regulate their empathic modes. Following up on this idea, future studies might investigate the behavioral consequences of such deliberate choices on e.g. subsequent helping behavior.

Further, the intensity of schadenfreude that observers experienced in the presence of another's misfortune more strongly depended on activation of the NAcc in the ventral striatum. As part of brains reward circuitries, the NAcc is engaged in processing all kind of incentives being it monetary (Knutson et al., 2000) or social stimuli (Rademacher et al., 2010; Spreckelmeyer et al., 2009). The link of NAcc activity to the rewarding aspect of schadenfreude has been previously established (Takahashi et al., 2009) and prior studies could already show that in a competitive environment the NAcc activity signifies for a subjective gain in response to another's misfortune (Cikara et al., 2011). In this line, we can now demonstrate that the intensity of the subjectively experienced schadenfreude more strongly covaries with trial-by-trial NAcc activity compared to the experience of fremdscham. This finding is novel in so far, that the social context of the present study does not offer any gain to the observers, except their own pleasure they have while witnessing the social integrity threat of another. While we cannot rule out that people automatically attribute personality characteristics to the social target that help to justify the misfortune or gain self-worth from assumed downward comparisons during the schadenfreude instruction, this study again shows, that the involvement of neural reward circuits in interpersonal emotions might heavily dependent on subtle contextual and motivational factors that further shape the quality and valence of interpersonal emotions.

The increased functional connectivity of the NAcc with the left AI might already indicate a potential mechanism of how information might be differentially processed in similar brain regions depending on the experimental and social context resulting in differently valenced affect. Despite the diminished involvement of the AI during schadenfreude, we observed that the variability in the intensity of the schadenfreude experience was positively correlated not only with the NAcc but also the AI activation. Further, the functional coupling of the NAcc also depends on the context of the experiment: if subjects are asked to focus on the pleasure they experience in the face of another's misfortune, the connectivity with the left AI is significantly stronger compared to a context when subjects are asked to report on their fremdscham. This suggests that a common signal of the NAcc and the AI to contribute to schadenfreude experience and fremdscham to be more strongly dependent on AI activation and a decoupling with the NAcc. While we cannot assess the exact mechanism of the underlying dynamics in the functional coupling in this study, it might be reasonable to assume that the coupling and common covariation are related to contextual dependent appraisals of the subjects.

Notably, the AI has been found to be involved in many different and also positively empathic emotions with positive valence (Jabbi and Keysers, 2008; Mobbs et al., 2009) but also reward processing per se (Knutson and Greer, 2008). In this line, it is also not surprising to find the AI to be activated - while being less engaged on average - when participants report on their schadenfreude. The interoceptive signal of the AI (Craig, 2003) as measured with the fMRI BOLD signal thus obviously represents activation related to arousal of very different valences. In correspondence with the concept of emotional constructivism (see Lindquist et al., 2012 for a review), the definite emotional experience is then only shaped by the interaction of AI signaling and activation in other brain networks, such as the dopaminergic reward circuits, and others involved in ongoing appraisal processes. Even within the present study it cannot be verified that the affective quality induced while observing another's social integrity threat in fact differs between groups. It might be the case that some subjects in the SF condition experienced FS or vice versa or that subjects represent all kind of different appraisals relevant for the two affective qualities so they can generate a concurrent representation of SF and FS even if instructed otherwise. Some aspects of the results support this notion as we observe great congruence of brain activation for both conditions and after controlling for the intensity of self-reported affect even the AI response for the interaction is only significant at trend level. At the same time, when generating the self-report of their experienced affect subjects report stronger vicarious embarrassment in case their NAcc was responding less and greater schadenfreude, when it was more active while observing another's social integrity threat. It seems that subjects rely on activity in different neural systems when communicating their schadenfreude or fremdscham and it is an interesting notion that humans dynamically adjust how they use the variety of available appraisals for generating an affective representation they can communicate (Barrett et al., 2015). The context dependent regulation of the AIs functional coupling might thereby help to understand the diversity of affective experiences people report in such complex social scenarios creating a shared understanding of affect.

Conclusion

The neural mechanisms underlying the process of empathizing with another's social suffering, e.g. tripping on stage or losing one's lines during a speech, can be explicitly modulated by varying the instruction and thereby the motivational stance of the observer. If instructed to emotionally resonate with another person's predicament neural activations in empathy-related networks are upregulated. In contrast, when asked to focus on the funniness at witnessing another's chagrin, neural activation in empathy networks was diminished while the dependency on reward-related activation was intensified. Here, we can show this effect under explicit experimental manipulation in a context with no interaction history with the unlucky protagonist and no functional gain for the observer suggesting implications for the active control of social emotions during social interactions as well training interventions.

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Figure Legends

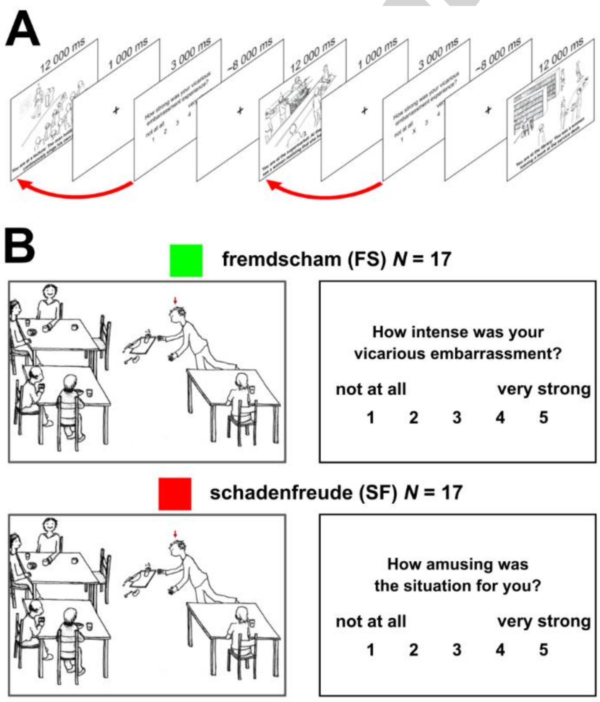

Figure 1. Overview about the experimental paradigm. **A** Sequence and timing of the experimental paradigm. Red arrows indicate how subjective ratings were used to inform the neural activation measure of the preceding situation in the fremdscham (FS) and schadenfreude (SF) condition. **B** Experimental manipulation. In a between subject design, participants were either instructed to concentrate on the vicarious embarrassment they feel while observing the protagonist or explained that threats to another's social integrity might be perceived as funny and instructed to concentrate on the amusement and rate the joy after each situation. This way both groups were presented similar sketches together with a vignette of two sentences describing the situation (e.g. "You are at a restaurant: the waiter is tripping so that the dinner spills all over…") depicting either social integrity threats (SIT) or neural situations (NEUT). In the fremdscham condition, the participants were asked to rate their experience of vicarious embarrassment for the social target while viewing the situations ("How intense was your vicarious embarrassment [fremdscham]?") while in the schadenfreude condition they were asked to rate the intensity of joy at the other's plight ("How amusing was the situation for you?").

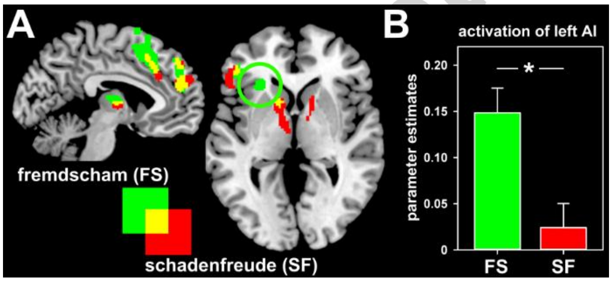

Figure 2. Neural activation while observing threats to another's social integrity. **A** Neural activation while observing another's social integrity threat (SIT) compared to neutral situations (NEUT). Activation associated with fremdscham (FS) in the FS group is indicated in green, activation during schadenfreude (SF) in the SF group is indicated in red and overlap is depicted in yellow. Results of the contrast [SIT-NEUT]

are family-wise-error corrected for whole brain analyses with *p* < .05 within each group. **B** Parameter estimates within the left anterior insula (AI) for the contrast of SIT vs NEUT situations for both the FS and the SF group. The AI activation in response to another's social integrity threat is significantly modulated by the group as indicated by the significant interaction FS[SIT-NEUT]-SF[SIT-NEUT] within the AI region of interest (ROI) at x=-26, y=26, z=8; $t(128)=3.32$, $p=.041$; corrected. * $p<.05$, corrected within AI ROI.

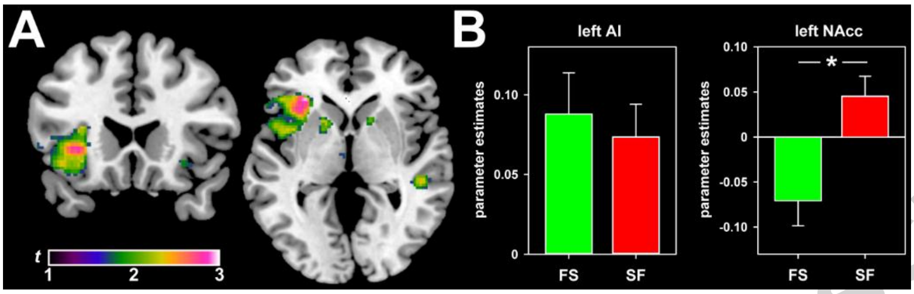

Figure 3. Association of the intensity of the self-reported affect with neural activation. **A** Positive association of intra-individual differences in affective experiences with anterior insula (AI) activation. Slices show the effect of the conjunction of the effect of the parametric weights in the fremdscham (FS, green) and schadenfreude (SF, red) condition thresholded at $p <.05$ uncorrected in the whole brain for displaying purposes. The conjunction of FS ∩ SF is significant within the left AI at x=-36, y=8, z=-6; $t(124)=3.40$, $p=.032$; corrected within region of interest (ROI). **B** Parameter estimates for the association of FS and SF self-reports with neural activation. While the left AI showed a consistently stronger activation when participants reported stronger SF or FS the association of the schadenfreude intensity was significantly stronger compared to the fremdscham ratings within the left Nucleus Accumbens (NAcc, x=-6, y=16, z=-6; $t(124)=3.14$, $p=.033$; corrected within left NAcc ROI). While stronger SF experiences were associated with greater NAcc activation, stronger FS ratings were associated with lower NAcc activity while observing the situation. * $p<.05$, corrected within NAcc ROI.

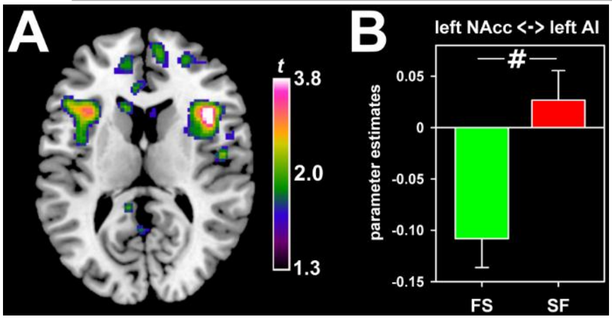

Figure 4. Differences in functional connectivity with the NAcc. **A** Greater functional connectivity of the left NAcc in the schadenfreude (SF) compared to the fremdscham (FS) condition. The axial slice depicts the effect for contrast of the group comparison [SF-FS] of the NAcc functional connectivity analyses (p < .05, uncorrected for displaying purposes) indicating a relatively specific pattern of greater coupling during SF with the bilateral anterior insula (AI). **B** Parameter estimates for the functional connectivity between left AI and left NAcc. The parameter estimates were extracted at the peak of the contrast [SF-FS] at x=-34, y=18, z=12 which was significant at trend-level within the left AI ROI $t(32)=3.35$, p=.072, corrected. # p=.072, corrected within left AI ROI.

Graphical abstract

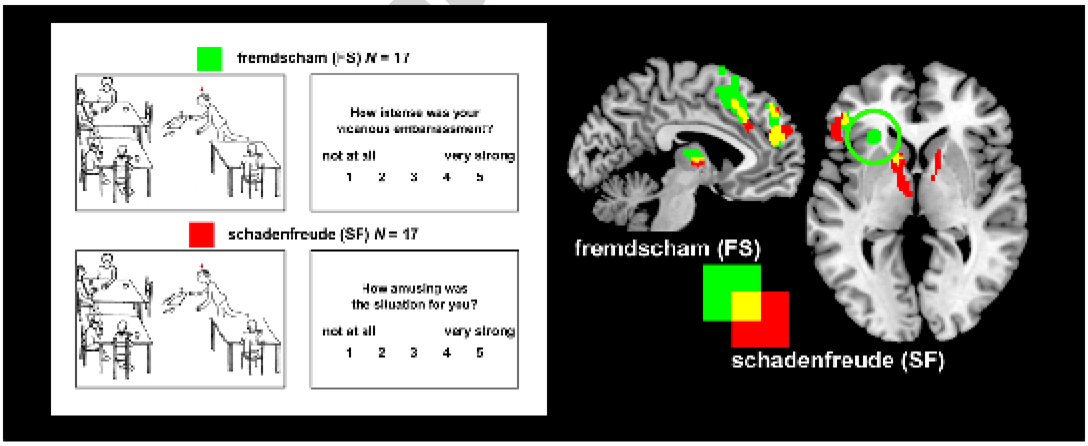

Table 1. Neural Activations during Fremdscham and Schadenfreude

Brain Region	Cyto Area	Side	Cluster Size	MNI Coordinates	*T*	*p*

Condition				x	y	z		
Fremdscham								
SMA		L	833	-4	22	48	8.57	<.001
		L		-2	16	66	5.41	.005
		L		-10	10	74	5.15	.015
Inferior Frontal Gyrus		L	1015	-46	36	8	6.91	<.001
Precentral Gyrus	Area 44	L		-50	12	34	6.65	<.001
		L		-42	28	20	6.08	<.001
Thalamus	Th-Temporal	L	349	-4	-10	8	6.72	<.001
Caudate Nucleus		L		-12	6	10	6.34	<.001
Caudate Nucleus		L		-12	12	2	5.62	.002
Insula Lobe		L	85	-26	26	2	6.53	<.001
Superior Medial Gyrus		L	262	-8	50	22	6.16	<.001
		L		-6	48	38	5.71	.002
		L		-10	48	30	5.62	.002
ACC ROI		L	51	-4	20	42	6.72	<.001
		R		8	22	42	6.72	<.001
Schadenfreude								
Caudate Nucleus		L	347	-12	8	10	6.50	<.001
Thalamus	Th-Prefrontal	L		-10	-4	4	5.87	.001
Superior Medial Gyrus		L	330	-6	56	26	5.99	<.001
		L		-2	50	38	5.91	.001
SMA		L	142	-4	22	44	5.87	.001
Anterior Cingulate Cortex		L		-6	30	30	5.45	.004
Inferior Frontal Gyrus	Area 45	L	113	-54	32	0	5.84	.001
Caudate Nucleus		R	109	12	10	8	5.79	.001
		R		12	0	6	5.09	.018
Fremdscham>Schadenfreude								
Anterior Insula ROI		L		-26	26	8	3.32	.041

Note. The contrast of fremdscham (Social Identity Threat(SIT)>Neutral(NEUT)) and Schadenfreude (SIT>NEUT) were FWE-corrected at p <.05 for whole brain analyses and FWE-corrected within the ACC region of interest (ROI); The interaction Fremdscham > Schadenfreude (FS[SIT-NEUT]-SF[SIT-NEUT]) were FWE-corrected within left anterior insula ROI p <.05.

Highlights

- Observing others' predicaments can trigger emotions of schadenfreude and fremdscham
- Common and distinct neural networks underlie schadenfreude and fremdscham
- Schadenfreude rather linked to reward, fremdscham rather linked to empathy
- Attenuated insula activity if observers focus on schadenfreude vs. fremdscham
- Valence and intensity of interpersonal emotions depend on motivational stance