NeuroImage 109 (2015) 109–117

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

Reality TV and vicarious embarrassment: An fMRI study

Martin Melchers [a,*], Sebastian Markett [a,b], Christian Montag [c], Peter Trautner [b,d,e], Bernd Weber [b,d,e], Bernd Lachmann [c], Pauline Buss [a], Rebekka Heinen [a], Martin Reuter [a,b]

[a] Department of Psychology, University of Bonn, Kaiser-Karl-Ring 9, 53111 Bonn, Germany
[b] Center for Economics and Neuroscience (CENs), University of Bonn, Nachtigallenweg 86, 53127 Bonn, Germany
[c] Department of Psychology, University of Ulm, Helmholtzstr. 8/1, Ulm, Germany
[d] Department of Epileptology, University Hospital Bonn, Sigmund-Freud Str. 25, 53127 Bonn, Germany
[e] Life & Brain Center, University Hospital Bonn, Sigmund-Freud Str. 25, 53127 Bonn, Germany

ARTICLE INFO

Article history:
Accepted 6 January 2015
Available online 14 January 2015

Keywords:
Vicarious embarrassment
Perspective taking
Middle temporal gyrus
Supramarginal gyrus
Inferior frontal gyrus
Psychophysiological interaction

ABSTRACT

Background: Vicarious embarrassment (VE) is an emotion triggered by the observation of others' pratfalls or social norm violations. Several explanatory approaches have been suggested to explain the source of this phenomenon, including perspective taking abilities or ingroup identification. Knowledge about its biological bases, however, is scarce. To gain a better understanding, the present study investigated neural activation patterns in response to video clips from reality TV shows. Reality TV is well known for presenting social norm violations, flaws and pratfalls of its protagonists in real life situations thereby qualifying as an ecological valid trigger for VE.
Methods: N = 60 healthy participants viewed stand stills from previously watched video clips taken from German reality TV-shows while undergoing functional magnetic resonance imaging. The clips were preselected for high versus low VE content in a pilot study. Besides the investigation of differences in brain activation elicited by VE versus control stand stills (blocked design contrast), we performed additional exploratory functional connectivity analyses (psychophysiological interaction; PPI) to detect VE related brain networks.
Results: Compared to the low VE condition, participants in the high VE condition showed a higher activation in the middle temporal gyrus, the supramarginal gyrus, the right inferior frontal gyrus and the gyrus rectus. Functional connectivity analyses confirmed increased connectivity of these regions with the anterior cingulate in the VE condition. Moreover, self-ratings of VE and brain activity were correlated positively.
Conclusion: Reality TV formats with high VE content activate brain regions associated with Theory of Mind, but also with empathic concern and social identity. Therefore, our results support the idea that the ability to put oneself in other person's shoes is a major prerequisite for VE.

Introduction

Shame and embarrassment belong to a group of emotions that have been labeled as "self-conscious" and "moral" in the literature (e.g., Lewis et al., 2010). From an evolutionary perspective, these emotions fulfill an important task by helping to adapt human social behavior to universal or culture-specific norms by punishing failure to comply with these norms with negative emotional states like embarrassment or guilt (e.g., Tangney et al., 2007). Important mechanisms for this effect are self-reflection and self-evaluation of one's own behavior (e.g., Tracy & Robins, 2004).

Intriguingly, research shows that the experience of self-conscious feelings cannot only be elicited by one's own misconduct, but also by the evaluation of other people's behavior, a phenomenon that has been described as a *vicarious* or *empathic* feeling (e.g., Lickel et al., 2005; Miller, 1987; Welten et al., 2012). This process even can take place in cases where there is neither a relationship between observer and protagonist nor any responsibility of the observer for the protagonist's actions (Marcus, Wilson, & Miller, 1996; Shearn et al., 1999). By definition, feelings of *vicarious embarrassment (VE)*[1] can be triggered independently of the intentionality of the protagonist's action and independently of his or her awareness of the social norm violation (e.g., Hawk et al., 2011; Krach et al., 2011), which means that the protagonist does not have to feel the same as the observer. *Empathic embarrassment* on the other hand presupposes a match of the observer's feelings to the protagonist's internal state (Paulus et al., 2013), which in turn presupposes awareness and self-conscious feelings of the protagonist.

In the literature, two major ideas have been put forward to explain the transmission of an originally self-reflective feeling to another person (e.g., Welten et al., 2012). The first originates from self-identity theory

* Corresponding author at: University of Bonn, Department of Psychology, Kaiser-Karl-Ring 9, D-53111 Bonn, Germany. Fax: +49 228 73 62331.
E-mail address: martin.melchers@uni-bonn-diff.de (M. Melchers).

[1] VE = vicarious embarrassment; ToM = Theory of Mind; ALE = activation likelihood estimate; ACC = anterior cingulate cortex.

http://dx.doi.org/10.1016/j.neuroimage.2015.01.022
1053-8119/

and supposes that the norm violations of another person can affect the observer's self-concept by threatening his or her social identity. In such a case it is necessary that the observer and the protagonist both identify with the same social group (Tajfel & Turner, 1979). The second idea is based on the concept of Theory of Mind (ToM) also defined as mentalizing, which describes the ability to attribute mental states to oneself and others and to understand that others have beliefs, desires, and intentions that are different from one's own (Premack & Woodruff, 1978). This ability is of immense importance for VE. The better an observer is able to attribute mental states of another person, the more he or she is able to imagine cognitions and feelings she or he would experience if being in the same situation characterized by social norm violations (e.g., Stocks et al., 2011). Therefore, pronounced experiences of VE can be seen as the result of pronounced perspective taking abilities. Distinguishing between both explanatory approaches is difficult, because recent evidence indicates that ingroup identification activates the mentalizing/ToM network when participants judge and punish norm violating behavior of ingroup members, but not if they punish the same behavior in outgroup members (Baumgartner et al., 2012). This suggests that the observation of an ingroup member in contrast to an outgroup member might promote the attribution of mental states. Therefore, both approaches are not completely distinct from one another.

From a neuroimaging perspective, research up to date has majorly focused on first person experiences of self-conscious feelings, especially on the exploration of shame, embarrassment and guilt. These studies identified regions like the orbitofrontal cortex, the medial prefrontal cortex, the insula, the anterior cingulate cortex, the amygdala and the posterior superior temporal sulcus as neural correlates of self-conscious emotional activity (e.g., Berthoz et al., 2002, 2006; Finger et al., 2006; Morita et al., 2008; Wagner et al., 2011). Furthermore, efforts have been made to differentiate brain activity of different self-conscious emotions (e.g., Takahashi et al., 2004) and to cover the development of these emotions in children and adolescents (e.g., Burnett et al., 2009; Klapwijk et al., 2013; Somerville et al., 2013).

Imaging research on the basics of vicarious feelings is rather scarce. Articles in the field for example deal with vicarious feelings of other's pain (e.g., Vachon-Presseau et al., 2012) or with research on the emotional mirror system (e.g., Nummenmaa et al., 2008; Schaefer et al., 2012). To our knowledge, there are only two studies, one by Krach et al. (2011) and another by Paulus et al. (2014), explicitly investigating the neural bases of VE in healthy adults. In both studies, drawn comic vignettes depicting typical embarrassing situations are used as stimulus material. These situations differ concerning the protagonists' intentionality and awareness of the norm violation. Major results are that the anterior cingulate cortex and the left anterior insula are strongly implicated in the experience of other's norm violations, and that this activation is positively correlated with individual differences in trait empathy. In the second study, Paulus et al. furthermore elucidate differences between embarrassment *with* (i.e. the protagonist is embarrassed and the audience shares the embarrassment) and embarrassment *for* (i.e. the protagonist does not recognize the norm violation, while the audience feels embarrassment for her or him) another person's mishaps. Here, the authors show additional activation in the posterior superior temporal sulcus when participants share the embarrassment of others. Most interesting, many of the activated areas found in this study match results concerning the core network for empathy (Fan et al., 2011), which gives another hint for the relation between VE and empathy.

Based on this previous research, our present study aims to increase knowledge on the neural bases of VE by investigating the influence of reality TV formats. A feature of many formats in the area of reality TV is the presentation of flaws and embarrassing situations through depiction of sexual content, obesity, lack of hygiene, inability to sing or dance etc. (e.g., Harry, 2008). While this might be enjoyable or funny for many viewers, it is a source of VE in others, because of the portrayed norm violations and the unfavorable presentation of the protagonists in such shows. Since the original air date of Big Brother in the summer of 2000 in the USA (Andrejevic, 2004), the reality TV genre has initiated major changes to the television industry (e.g., Kjus, 2009). In the meantime, several subgenres have developed (e.g., Nabi et al., 2006; Ouelette & Murray, 2004) and the format opened up new business options for the television industry (Deery, 2004). Due to the fact that reality TV is very popular in western societies and well known for presenting social norm violations, flaws and pratfalls of its protagonists in real life situations, it qualifies as an ecological valid trigger for VE.

In the present study, we want to investigate whether watching reality TV formats that trigger VE activates specific neural networks in comparison to emotionally neutral video clips. Reality TV is an important factor in today's media landscape, which is why knowledge about brain activity that is triggered by consumption of reality TV can be very helpful to understand how media consumption affects our brain activity and perhaps even resulting behavior. Furthermore, we want to detect whether brain activity related to VE is identical to that reported for ToM processes or social identity. Even if a distinction purely at the level of brain activity might be difficult, our results might be helpful to develop a more accurate idea of what cognitive processes trigger VE. For ToM and social identity, associations have been reported, for example, with the right inferior frontal gyrus, the right inferior parietal lobule, the right superior parietal lobule, the left lingual gyrus, the anterior cingulate cortex, the precuneus (Scheepers et al., 2013), the dorsomedial prefrontal cortex, the superior temporal sulcus, the temporo-parietal junction, and the anterior temporal poles (Frith & Frith, 2006; Schnell et al., 2011). Besides, we expect findings in line with Krach et al. (2011), as our stimuli were selected to trigger the same feelings of VE that were investigated in Krach et al.'s study. However, the type of stimulus material we use is very different: the clear advantage of our stimuli is the higher ecological validity, because real acting humans instead of comic vignettes are shown, which should make it easier for our participants to imagine themselves in situations like the depicted. On the other hand it is not possible to categorize scenes from reality TV formats concerning intentionality and awareness (as Krach et al. did), because the viewer simply does not know whether the protagonists in the shows are aware that their actions are perceived as norm violations and if they intend to violate social norms.

Finally, if we find specific brain activations, we intend to take activated regions as seeds for whole brain functional connectivity analyses (by using psychophysiological interaction; PPI). Functional connectivity has been defined as the correlations between spatially remote neurophysiological events (Friston et al., 1997) and can be an important basis to understand the interaction of spatially remote brain regions in response to a specific task or a specific condition. The analysis can be a hint as to whether two (or more) activation contrasts (based on the experimental conditions) in different brain clusters represent a single neural process, or whether they represent parallel, independent neural processes. These analyses are of exploratory nature and may provide preliminary information about the neural relationship of structures involved in VE.

Materials and methods

Pilot study: selection of stimulus material

Before starting with the main experiment, we first conducted a pilot study to select appropriate video material. The major aim was to select a category of film clips that made observers feel VE and a second category that was experienced as an emotionally 'neutral' counterpart. Clips for both categories were matched for length, general format and setting and selected to include a diversity of topics. Overall, $N = 14$ participants rated 56 video sequences which were taken from German reality TV. Participants were asked to rate on a five point Likert scale whether the respective scene made them feel vicariously embarrassed, whether the scene was amusing and whether they felt compassionate for the protagonists. High scores indicate strong feelings of VE, amusement and compassion for the protagonists. Each video sequence was introduced by a short neutral comment providing information on the background of the depicted scene (e.g., "Thomas had an argument with his girlfriend. Now he is preparing a surprise …").

14 films with the highest VE ratings ($M_{(exp)} = 4.38$; $SD = 0.506$) and 14 films with the lowest ratings ($M_{(cont.)} = 1.57$; $SD = 0.472$) were selected for the main study. Both experimental conditions (exp/cont) were compared by means of repeated measures ANOVA. Analysis of the main effect of film category revealed a huge effect on VE ($F_{(1, 13)} = 550.075$, $p < 0.001$, $\eta^2 = 0.977$). The films of both categories also differed with respect to perceived amusement ($M_{(exp)} = 2.22$; $SD = 0.877$; $M_{(cont)} = 1.29$; $SD = 0.242$; $F_{(1, 13)} = 15.155$, $p = 0.002$, $\eta^2 = 0.538$) and compassion ($M_{(exp)} = 2.95$; $SD = 1.082$; $M_{(cont)} = 1.35$; $SD = 0.322$; $F_{(1, 13)} = 31.980$, $p < 0.001$, $\eta^2 = 0.711$). Even after correcting for the effects of amusement and compassion on VE in a repeated measures ANCOVA model, the effect of condition was statistically significant indicating that the stimulus material is suitable for the analysis of VE ($F_{(1, 11)} = 18.974$, $p < 0.001$, $\eta^2 = 0.633$). Because the clips contain footage from popular German TV broadcasts, we also asked participants if they knew the presented material and if they had seen it before on TV or social media. The overall familiarity was low (4% for the VE films and 0% for the control films) and most crucially did not differ between both categories ($F_{(1, 13)} = 3.692$, $p = 0.103$).

For presentation in the fMRI scanner, we opted for stills from the videos instead of the original material. This decision represents a compromise between better controllability of stimuli and higher ecological validity: While videos as such offer the highest ecological validity, because information can be retrieved from various sources (like facial expression, movement etc.), they can cause additional (irrelevant) brain activity based on the dynamic nature of the stimulus material, which might overshadow the effect under investigation (for example, due to movements or differences in brightness throughout the video). Pictures in general are much easier to control for in aspects like context, color, hue, saturation etc. So far, there is very little research dealing with the influence of stimulus properties on neural processing. One of the few available studies in the field (dealing with emotion perception) suggests that videos trigger a stronger neural signal than pictures (Fine et al., 2009). Furthermore, in their review Risko et al. (2012) provide a number of studies with differences in results depending on the utilized stimuli material. Here, the authors conclude (for the field of social attention) that the best way to understand social processing is using stimuli ranging in their approximation to a real social interaction. Thereby, more ecologically valid approaches can be compared with more precise controlled approaches. The sequences from reality TV shows are not well suited for an fMRI design, as it is very difficult to time lock the hemodynamic response to the precise moment when a video elicits feelings of VE because some of the videos trigger VE throughout the whole scene while others include one or two highlights. For this reason, the use of this sort of stimulus material would be problematic for an event related design. Therefore, five standstills from each video were prepared for presentation in the scanner in the main study. Major criterion for selecting the stills was to choose pictures that are suitable to cover the topic, the plot, and the main point of the respective video scene which triggers VE. Because an fMRI blocked design allows testing with higher power as compared to an event related design, and as the stand stills reconstruct the plot sequence of the video scenes participants watched before the scanner session, we decided to use a blocked design for stimulus presentation in the scanner.

Main study: reality TV and vicarious embarrassment

Participants

We investigated a sample of $N = 60$ healthy participants ($n = 39$ women, $n = 21$ men). The majority of participants (age $M = 22.95$, $SD = 5.38$) were psychology students at the University of Bonn, Germany. All participants gave informed written consent to participate in the study. Furthermore, the study was approved by the local ethics committee at the University Clinics of Bonn, Germany.

Experimental design

Participants were invited to the fMRI facility at the Life & Brain Center in Bonn. The experiment started with a questionnaire package including information on the study procedure, the informed consent sheet, briefing on fMRI safety procedures and some other questionnaires, which were not part of this study. Before entering the scanner, the video material including the VE content and its neutral counterpart was shown to the participants in a silent room. The order of videos was randomized. Once again, each video sequence was introduced with a short comment providing information on the background of the depicted scene and participants rated their feelings of VE, amusement, and compassion after each sequence. Besides, participants were asked for the familiarity of the depicted scenes (compare Pilot study: selection of stimulus material section).

After the video presentation, participants went into the scanner. Here, the five stand stills from each video were shown in a blocked design. Each sequence of still shots was presented twice, resulting in an overall presentation of 56 blocks (14 films × 2 categories × 2 presentations). The order of blocks was randomized. The pictures of each block were sorted according to the plot of the video sequence and each picture was presented for 4 s resulting in 20 s for each block of pictures. In order to assure that participants looked at the pictures and did not close their eyes, a single control picture followed each block, and the participants had to push a button to decide if the present control picture had been shown in the preceding picture block. Out of 56 possible responses (one control picture for each block), participants answered on average 52.58 ($SD = 1.92$) times correctly. The mean number of button presses (regardless of the correctness) was 54.16 ($SD = 2.01$).

Statistical methods

We performed ANOVA and ANCOVA to check the validity of our manipulation according to the procedure which had already been used in the pilot study (see Pilot study: selection of stimulus material section). Furthermore, additional correlations were calculated to depict the relationship between the three rating scales for the VE as well as for the control condition.

For image acquisition, an echoplanar imaging (EPI) sequence with the following properties was used: number of slices = 31, TR = 2.5 s, TE = 45 ms, slice thickness = 3 mm and a 90° flip angle. The slices were acquired in an AC–PC orientation, with a FOV of 192 mm in an interleaved manner with a standard 8 channel head coil on a Siemens (Erlangen, Germany) Avanto scanner with 1.5 T field strength.

Preprocessing of the functional images was implemented using the Matlab based (The MathWorks, Inc.) software SPM8 (http://www.fil.ion.ucl.ac.uk/spm) and included slice timing correction, realignment, coregistration, normalization on MNI standard using the unified segmentations of the high resolution structural image, and smoothing with a Gaussian filter with a full width of 8 mm at half maximum (Evans et al., 1993, http://www.bic.mni.mcgill.ca). General linear models (GLMs) were estimated with a high pass filter of 128 Hz. For the analyses, we defined three regressors (embarrassing stimuli, control stimuli and control query) and six additional movement regressors which were convolved with the canonical hemodynamic response function (HRF). Resulting linear contrasts were entered into a 2nd level random effects analysis with age and gender as covariates. All results presented were thresholded at $p < 0.05$ FWE-corrected with an extent-threshold of 20 voxels. Next to this analysis investigating the main effects of VE, we also analyzed whether there were main effects for gender in VE. Here, we used a two sample *t*-test with age as a covariate. To check whether participants' brain activation was associated with self-report data on VE, we extracted individual mean beta coefficients from each cluster observed in the analyses. These coefficients were then correlated with participants' self-report data on VE. Furthermore, we performed the same analysis for participants' ratings of compassion to rule out the possibility that differences in compassion between VE and control films could explain the results.

To investigate functional connectivity, we performed PPI analyses (Friston et al., 1997) to estimate changes in connectivity between brain regions through experimental manipulation. Seed regions for the PPI analysis were centered around each individual's maximum within a six millimeter sphere around peak activation at group level. Neural time courses in terms of the first eigenvariate were extracted from these seed regions. Separate interaction terms between the deconvolved time course from the seed region and the task regressor were calculated for both conditions of interest (VE vs. control). The interaction terms were reconvolved with the HRF and then added to the GLM as further regressors of interest. All PPI results presented were thresholded at $p < 0.001$ uncorrected, because of the exploratory nature of these analyses and because of the large main effect in the data.

Results

Video ratings

As in the pilot study, participants' ratings of the stimulus material suggest that the material is suitable to trigger VE. On average, participants rated the films in the experimental condition significantly higher on VE than in the control condition ($M_{(exp.)} = 3.85$; $SD = 0.867$; $M_{(cont.)} = 1.48$; $SD = 0.452$; $F_{(1,\ 59)} = 694.488$, $p < 0.001$, $\eta^2 = 0.922$). In congruence with the pilot study, there were also significant effects of condition on ratings of amusement ($M_{(exp.)} = 2.42$; $SD = 0.867$; $M_{(cont.)} = 1.26$; $SD = 0.283$; $F_{(1,\ 59)} = 110.092$, $p < 0.001$, $\eta^2 = 0.651$) and compassion ($M_{(exp.)} = 2.81$; $SD = 0.989$; $M_{(cont.)} = 1.51$; $SD = 0.428$; $F_{(1,\ 59)} = 143.013$, $p < 0.001$, $\eta^2 = 0.708$). Controlling for these additional ratings in an ANCOVA model reduced the difference in VE ratings but the effect was still strong ($F_{(1,\ 57)} = 36.516$, $p < 0.001$, $\eta^2 = 0.386$). Overall, the difference between both film categories was smaller than in the pilot study, which can be explained by a few non-responders in our main study, who did report very few feelings of VE irrespective of the video material (on a 5-point Likert-scale 2 participants responded with a mean rating < 2 for the VE condition; 3 additional participants responded with a mean rating < 2.5).

For none of the three dependent variables (VE, amusement and compassion) there were effects of gender observable. With respect to age, we found negative correlations with amusement in the control condition ($r = -0.340$, $p = 0.008$) and with feelings of VE in the experimental condition ($r = -0.412$, $p < 0.001$). Table 1 shows the correlations between the three rating categories for both conditions (corrected for age if necessary; see above). For the VE condition, we found that the more VE our participants experienced, the more compassion they felt for the protagonists of the observed scenes. Amusement was not related to either VE or compassion. Although mean ratings in the control condition were very low, there were still some very sensitive participants who experienced VE, amusement or compassion. Therefore, we also checked for correlations of the three subscales in the control condition. Here, the association between VE and compassion was even stronger.

Table 1
Correlation coefficients between the rating scales for VE, amusement and feelings of compassion for the VE and control condition.

	VE/amusement	VE/compassion	Compassion/ amusement
VE condition	n.s.	$r = 0.342$; $p = 0.008$	n.s.
Control condition[a]	n.s.	$r = 0.453$; $p < 0.001$	n.s.

[a] Results have been corrected for age.

Functional magnetic resonance imaging analyses

Fig. 1 presents the results of the VE > control contrast. We found six activated clusters (FWE-corrected on the whole brain level with an minimum extent-threshold of 20 voxels): bilateral activation of the middle temporal gyrus, bilateral activation of the supramarginal gyrus, and two smaller clusters in the right inferior frontal gyrus, and the left gyrus rectus (compare Table 2). Analyses of gender effects delivered no significant results.

Correlation of participants' mean beta coefficients for each cluster with self-report data on VE revealed positive significant associations (compare Table 3). For ratings of compassion, there were no significant results.

Results concerning the reverse contrast control > VE are presented in Table 4. Here, the bilateral medial occipitotemporal gyrus and the bilateral middle occipital gyrus were significantly more active when participants looked at the control pictures than when they saw the VE pictures.

Functional connectivity analyses

Results of the PPI analyses with a statistical threshold of $p < 0.001$ (uncorrected) are presented in Table 5. We chose a more liberal threshold level for the analysis because of the strong main effects in our data which, according to Friston et al. (1997), can make it difficult to detect PPIs as strong main effects may overshadow interactions. We found significant interactions between the clusters presented in Table 2 for the contrast VE > controls with the right caudate nucleus, the left anterior cingulum, the left calcarine, the left superior temporal gyrus, the left putamen, the left superior occipital gyrus, and the left lateral fronto-orbital gyrus. FWE-correction on cluster level revealed only the peak voxel of the anterior cingulate cortex (−35/35/−5) as significant.

Discussion

The major aim of the present study was to investigate whether reality TV formats which trigger VE in contrast to more neutral formats generate specific brain activity. Besides, we wanted to explore whether this activity was in accordance with prior work on ToM, social identity and other studies on VE with different stimulus material. Finally, we wanted to search for functional connectivity between VE specific brain activation and the activation of other brain areas. We were able to show differences in the processing of pictures between VE and control condition. In detail, we found higher brain activation for the VE condition in the middle temporal gyrus (bilateral), the supramarginal gyrus (bilateral) and the right inferior frontal gyrus as well as in the left gyrus rectus.

The activated brain regions for the VE > control contrast are located in areas that have been associated with ToM and related constructs in the literature. The middle temporal gyrus, for example, has been identified as a part of the mentalizing network in an activation likelihood estimate (ALE) meta-analysis with more than 200 studies and is activated in ToM tasks (Bzdok et al., 2012). Furthermore, this region has been associated with the processing of false belief stories (which presuppose ToM abilities) in a meta-analysis (Schurz et al., 2013), the need to take the perspective of another person in a communicative task (Dumontheil et al., 2010), trait perspective taking abilities (Falk et al., 2012) and the processing of social rejection (Premkumar et al., 2012). These results fit well to our own results: To be able to exhibit a vicarious reaction, our participants needed to put themselves into the shoes of the protagonists. When they did so, they most probably felt VE because they judged action and appearance of the protagonists to be a norm violation which in turn can lead to social rejection. Therefore, this activation might not only represent a process of mental attribution and perspective taking, but also the associated assessment of the protagonists'

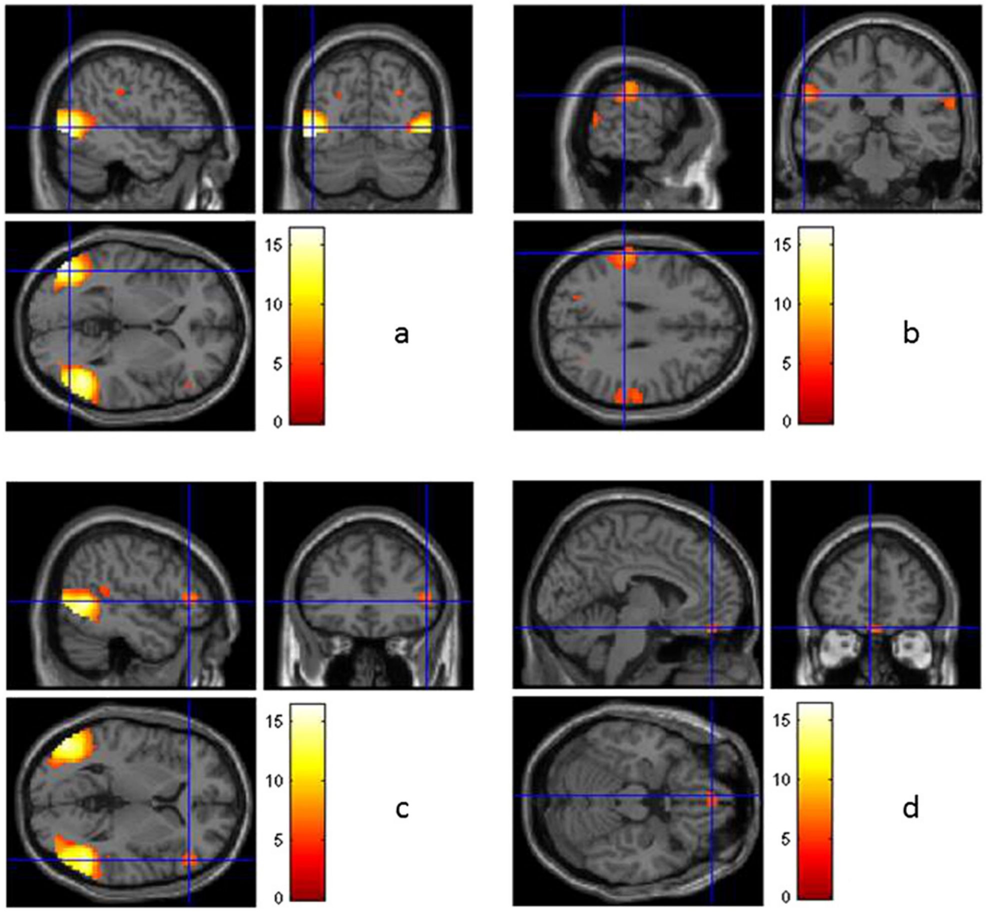

Fig. 1. Significantly higher brain activation in vicarious embarrassment compared to control pictures ($p < 0.05$, FWE-corrected, $k > 20$) in the bilateral middle temporal gyrus (a), bilateral supramarginal gyrus (b), the right inferior frontal gyrus (c), and the left gyrus rectus (d).

behavior and its possible consequences. Furthermore, the activation of the middle temporal gyrus could represent memory activity related to judging an action as a norm violation: Social norms are shaped by the cultural environment of a person (e.g., Heinrichs et al., 2006). Therefore, culture specific information on normative behavior must be stored to allow retrieval in a (potentially) norm-violating situation. The middle temporal cortex has been identified as an important part of the semantic memory network (Martin & Chao, 2001). Besides, this brain structure has been repeatedly related to moral and socio-normative judgments in the literature (Avram et al., 2013; Borg et al., 2006, 2008; Prehn et al., 2008). Therefore, the encountered activation may represent the retrieval of information on learned norms to allow the comparison of such norms with the observed behavior.

For the right supramarginal gyrus, Silani et al. (2013) found an association with reduced emotional egocentric biases in social judgments of others indicating that a higher activity is related to overcoming emotional egocentricity and to enhanced perspective taking. van der Heiden et al. (2013) showed that the supramarginal gyrus is of high relevance for explaining differences in perceiving oneself versus another person in pain, indicating once again its involvement in processes of perspective taking. Further evidence comes from Lawrence et al. (2006), who found activation in the supramarginal gyrus playing a role for the representation of another's emotional state.

Activity in the right inferior frontal cortex has been associated with the ability to attribute beliefs to others (Vogeley et al., 2001). The authors showed that the region is activated by the interference of the self in a fictional story (the participants were included as characters in the story) when attributing a mental state to another character. Apparently, this region is involved in the inhibition of the self-perspective. This finding has been validated in a clinical study (Samson et al., 2005). In addition, studies on false-belief tasks showed a bilateral activation of the inferior frontal gyrus in tasks with high demand on the inhibition of the observer's own perspective (Hartwright et al., 2012; van der Meer et al., 2011). Finally, the inferior frontal gyrus has been involved in emotional empathy (Banissy et al., 2012; Schulte-Rüther et al., 2007; Shamay-Tsoory et al., 2009), cognitive empathy (Hooker et al., 2010) and self-reported feelings of compassion (Simon-Thomas et al., 2012).

Table 2
Activated brain areas in the contrast vicarious embarrassment films > control films ($p < 0.05$, FWE-corrected, $k > 20$).

Cluster no.	Region	Coordinate of peak (MNI)	Cluster size	*t*-Score of peak
1	Middle temporal gyrus left	−51/−73/−2	546	16.34
2	Middle temporal gyrus right	48/−58/1	576	15.01
3	Supramarginal gyrus left	−60/−28/31	144	8.33
4	Supramarginal gyrus right	63/−21/37	105	7.30
5	Inferior frontal gyrus right	48/35/7	44	7.09
6	Gyrus rectus	−3/47/−23	24	6.79

Table 3
Correlations between participants mean beta coefficient and self-reported vicarious embarrassment and compassion ratings. Results are based on the 6 activation clusters from the main fMRI analysis.

	Vicarious embarrassment ratings	Compassion ratings
Cluster 1	$r = 0.492$; $p < 0.001$	$r = 0.196$; n. s.
Cluster 2	$r = 0.429$; $p < 0.001$	$r = 0.185$; n.s
Cluster 3	$r = 0.300$; $p = 0.020$	$r = 0.163$; n. s.
Cluster 4	$r = 0.272$; $p = 0.035$	$r = 0.183$; n. s.
Cluster 5	$r = 0.334$; $p = 0.009$	$r = -0.075$; n. s.
Cluster 6	$r = 0.255$; $p = 0.049$	$r = 0.046$; n. s.

The results for the supramarginal gyrus and the right inferior frontal cortex once again fit well to ToM findings in the literature. Reality TV as stimulus material differs from comic vignettes in such a way that the behavior depicted in the scenes can appear scripted or far(er) away from everyday experiences of the observers. Therefore, mental attribution can require greater efforts, because the distance between own and the protagonists' perspective is simply bigger. If the supramarginal gyrus and the inferior frontal cortex are important structures to suppress the egocentric perspective and to represent others' emotional states, it makes sense that we find a rather strong activation in the contrast VE > control films when using reality TV as stimulus material. On the other hand, the use of comic vignettes as stimulus material requires transferring the plot from a cartoon to the real world, which should lead to comparable high (while qualitatively different) requirements for perspective taking. The activation of the inferior frontal gyrus also accords to findings concerning the neural bases of social identification: Scheepers et al. (2013) found that participants with high trait identification exhibited stronger activation of this area when presented with faces of ingroup-members compared to outgroup-members. This means that for those who see the group as an important part of their self-concept, recognition of the ingroup correlates with activation of the inferior frontal gyrus. Recent research shows that ingroup identification activates the mentalizing network (Baumgartner et al., 2012). Therefore, findings concerning social identification might rely on the same basic mechanisms as ToM/mentalizing.

For the gyrus rectus, Hynes et al. (2006) found an association between the activity of the left gyrus rectus and participants' ability for emotional perspective taking (attributing emotions to others) when asked for their feelings in written scenarios. Goodkind et al. (2012) demonstrated a relationship between atrophy in gray matter of the gyrus rectus and reduced performance in a dynamical emotion tracking task in a sample of participants with diverse neurodegenerative diseases. In our study, ratings for compassion with the protagonists of the videos were overall rather low. Nevertheless, the encountered activity may represent participants' (cognitive) attempt to generate the feelings which they would feel if being in the protagonists' situation, even without sympathizing with them. This fits nicely to the results of Hynes et al., because in their paradigm participants attributed emotions, without having to sympathize or feel the same way as the protagonists. Furthermore, analyses concerning the correlation between brain activity in the gyrus rectus and ratings for compassion revealed no significant results. This supports the idea that activation of the gyrus rectus is not driven by feelings of compassion.

Interestingly, the areas that were activated in our study design show very few overlap with the results of Krach et al. (2011), who found major activations in the anterior cingulate cortex and the insula. Most likely, this variation represents differences in the processing of the stimulus material, as the presentation of comic vignettes with typical pratfalls may elicit other reactions than the observation of a person in a reality TV format. The regions reported by Krach et al. are mainly associated with the affective empathy/compassion system (compare Li et al., 2014) and it should be rather easy for the participants to feel with the depicted persons in the vignettes as the portrayed pratfalls could happen to everyone. However, the stimuli in our study present protagonists who are with high probability dissimilar (concerning their behavior, appearance etc.) from the observers. Therefore, it might be more difficult for our participants to feel compassion for these protagonists. Support for this assumption comes from the compassion ratings: participants had average compassion ratings of 2.77 for the VE condition on a five point Likert scale, which is about half of the compassion they could have reported at maximum. Furthermore, correlations between amusement and VE pictures showed only 22% of shared variance. Therefore, we assume that our participants took a more cognitive road which explains the activation in regions closer related to ToM than to affective empathy/compassion.

The correlations of neural activity during processing of VE stimuli with the VE ratings support our study design: the higher participants rated the video material as vicariously embarrassing, the higher was the observed difference in neural activation between the two experimental conditions. Therefore, we can be confident that the observed activation patterns represent feelings of VE, which is a very important validation. In this context, results concerning the correlation of neural activity with ratings for compassion show that the encountered neural activation is specific to VE and cannot be explained by the overlap between ratings of compassion with those of VE.

The control > VE contrast revealed activity in areas that primarily deal with visual processing (e.g., Beauchamp et al., 1999; Fortin et al., 2002, Larsson et al., 2006; Tyler et al., 2013). Bottom-up visual

Table 5
Brain regions with psycho-physiological interactions with the activation clusters of the main contrast ($p < 0.001$, uncorrected, $k > 20$).

	Interacting with	Coordinate of peak (MNI)	Cluster size	*t*-Score of peak
Caudate nucleus right	Cluster 1	6/11/−5	69	6.01
Anterior cingulum left	Cluster 1	−3/38/−5	72	4.90
	Cluster 2	−3/35/−5	26	5.23
	Cluster 3	−3/35/−5	20	5.40
	Cluster 4	−3/35/−5	11	4.88
	Cluster 5	−3/35/−5	35	5.19
	Cluster 6	−3/35/−5	19	4.59
Calcarine left	Cluster 1	−12/−64/13	74	4.59
	Cluster 2	−12/−64/13	154	4.93
	Cluster 3	−15/−70/7	122	4.63
	Cluster 5	−15/−73/7	35	4.22
	Cluster 6	−12/−64/13	69	4.19
Superior temporal gyrus left	Cluster 1	−45/17/−14	13	4.20
Putamen left	Cluster 1	−24/11/−5	14	3.99
Superior occipital gyrus left	Cluster 2	−36/−88/25	53	4.63
	Cluster 5	−27/−82/19	15	3.86
Lateral fronto-orbital gyrus left	Cluster 5	−3/8/−17	12	4.23
	Cluster 6	0/11/−20	31	4.60

Clusters 1 & 2: middle temporal gyrus left/right; Clusters 3 & 4: supramarginal gyrus left/right; Cluster 5: inferior frontal gyrus right; Cluster 6: gyrus rectus.

Table 4
Activated brain areas in the contrast vicarious embarrassment films < control films ($p < 0.05$, FWE-corrected, $k > 20$).

Cluster no.	Region	Coordinate of peak (MNI)	Cluster size	*t*-Score of peak
1	Medial occipitotemporal gyrus left	−27/−49/−8	322	12.26
2	Medial occipitotemporal gyrus right	27/−46/−8	307	11.75
3	Middle occipital gyrus left	−36/82/37	70	8.10
4	Middle occipital gyrus right	42/−76/34	67	7.54

processing seems an unlikely explanation for the differences in cortical activation because visual stimuli in the two categories were carefully matched. Striate and extrastriate areas, however, are subject to top-down attentional modulation, which is our primary explanation for the effect observed. Research on the relationship between emotion and attention has revealed that emotions are able to redirect/influence attention (Hajcak et al., 2013; Taylor & Fragopanagos, 2005). Furthermore, attention to a certain region in space has been shown to enhance activity in visual areas retinotopically mapped to this region (zoom lens model of visual attention; Müller et al., 2003). If the VE pictures in the scanner reactivated the VE participants felt when viewing the video clips, the pictures might have modulated participants' attention by focusing on the embarrassing aspects of the respective pictures. In contrast, the control pictures do not trigger such strong and specific emotions in the observer and should therefore not trigger such attentional biasing towards specific aspects but leave room for a more widespread analysis of the whole picture. In conjunction with the block design, this should lead to more focused activation on the representation of VE relevant content in the visual cortical areas in the VE condition. But as the spatial position of VE relevant content varies across task blocks, activation foci between blocks in the VE condition will vary on the retinotopic map, neutralizing any supra-threshold activation cluster in contrast to the neutral condition. Future studies should investigate this hypothesis and explore, if differences in spatial attention between VE content and neutral contend can be validated.

Results concerning the PPI analyses particularly demonstrate connectivity between the abovementioned regions and the left anterior cingulate cortex (ACC). The interaction could be found for five of the six analyzed seed regions, and the peak cluster remained significant after FWE-correction. Interestingly, the ACC is also one of the major areas which Krach et al. identified in their study on VE. The authors argued that the ACC is a core element of the pain matrix, and that its activation represents social pain under vicarious embarrassing circumstances. Besides the results of Krach et al., the ACC has been shown to be relevant for empathy and perspective taking. For example, the meta-analysis of Lamm et al. (2011) detected the ACC to be associated with empathy for pain. Besides, Klimecki et al. (2013) were able to demonstrate that the empathic responses of healthy participants to the distress of others are associated with activation in the medial ACC. The absence of a main effect of the ACC in our study indicates that emotional processes are not sufficient to elicit VE. However, the interaction effects of the ACC with our seed regions in the PPI analyses demonstrate that emotional processes moderate cognitive TOM activities. Possibly, the interactions of the mainly ToM related areas in our study with the ACC represent the onset or the evaluation of an emotional/compassionate reaction, which is not visible in the main effect due to the peculiarities of the protagonists which make it more difficult for our participants to feel with the protagonists. Although the other results of the PPI analyses need to be handled with care because they did not stand FWE-correction, there are still some clues that link them to ToM. For example, the caudate nucleus and the superior temporal gyrus have both been associated with ToM activity (e.g., Hervé et al., 2013; Völm et al., 2006). Most interestingly, we did not find interactions between the brain regions that were identified in the main analyses. This finding suggests that in our study several neural processes have contributed to the experience of VE. In general, results of the PPI analyses should be replicated, because we used a very liberal threshold due to the exploratory nature of this approach.

We have to consider that the way we presented our stimuli in the scanner might be a limitation to our study. We chose to show the embarrassment and control films outside the scanner and to use stand stills for presentation in the MRI-scanner. This was done because the peculiarities of our stimulus material would have made it very difficult to time lock the VE responses (see Materials and methods section). Hence, our design includes a "memory factor", because our participants had to remember the scenes they saw outside the scanner. This may be relevant, as one of the major activations we found was located in a region that has also been associated with memory functions (middle temporal gyrus). However, the activation appeared in the contrast comparing both experimental conditions, which means memory functions could only explain our results if there had been specific memory activation in interaction with the experimental factor (i.e. if participants remembered the VE video clips better than the control video clips). This is rather unlikely, as the timeframe between watching the films and scanning was very small (about 5–10 min), and as films from both categories were shown in a randomized order, which means we don't have to expect condition specific memory effects due to different retention times. A second argument against an interpretation of our results as "memory only" concerns the choice of the stand stills: We made a very careful selection to assure that the stand stills represent the plot and the maximum VE points of the respective video scene. Therefore, the pictures alone "tell the story" and are able to elicit VE, although activation should be significantly lower if one only presents the pictures in comparison to a picture presentation with a preceding video presentation. Besides, the correlations between the beta coefficients for each cluster and the self-report data on VE provide a manipulation check, because the encountered brain activations are related to participants' ratings of VE. Finally, we must consider that feelings of VE also require memory processes: VE is most often elicited by norm violations, and norms are learned rules about which behaviors are acceptable or inacceptable. Therefore, a VE response presupposes a check whether the observed situation includes norm-violating elements or not. Such a check is only possible through activation of knowledge about norms, which is a memory function.

Our study warrants further research. First of all it would be interesting to see, whether results can be replicated in other, for example older, samples or other cultures. Furthermore, a closer look on specific TV formats or specific topics presented could elucidate, which aspects of a TV-show trigger VE and whether these aspects interact with individual characteristics of the respective observer. Besides, the relation of VE to other possible reactions to reality TV like Schadenfreude etc. should be investigated in more detail.

Acknowledgments

Christian Montag was supported by a Heisenberg Grant of the German Research Council (DFG; MO-2363/3-1). Bernd Weber was supported by a Heisenberg Grant of the German Research Council (DFG; WE 4427/3-1).

References

Andrejevic, M., 2004. Reality TV: The Work of Being Watched. Rowman & Littlefield Publishers.

Avram, M., Gutyrchik, E., Bao, Y., Pöppel, E., Reiser, M., Blautzik, J., 2013. Neurofunctional correlates of esthetic and moral judgments. Neurosci. Lett. 534, 128–132.

Banissy, M.J., Kanai, R., Walsh, V., Rees, G., 2012. Inter-individual differences in empathy are reflected in human brain structure. Neuroimage 62 (3), 2034–2039.

Baumgartner, T., Götte, L., Gügler, R., Fehr, E., 2012. The mentalizing network orchestrates the impact of parochial altruism on social norm enforcement. Hum. Brain Mapp. 33 (6), 1452–1469.

Beauchamp, M.S., Haxby, J.V., Jennings, J.E., DeYoe, E.A., 1999. An fMRI version of the Farnsworth–Munsell 100-Hue test reveals multiple color-selective areas in human ventral occipitotemporal cortex. Cereb. Cortex 9 (3), 257–263.

Berthoz, S., Armony, J.L., Blair, R.J.R., Dolan, R.J., 2002. An fMRI study of intentional and unintentional (embarrassing) violations of social norms. Brain 125 (8), 1696–1708.

Berthoz, S., Grezes, J., Armony, J.L., Passingham, R.E., Dolan, R.J., 2006. Affective response to one's own moral violations. Neuroimage 31 (2), 945–950.

Borg, J.S., Hynes, C., Van Horn, J., Grafton, S., Sinnott-Armstrong, W., 2006. Consequences, action, and intention as factors in moral judgments: an fMRI investigation. J. Cogn. Neurosci. 18 (5), 803–817.

Borg, J.S., Lieberman, D., Kiehl, K.A., 2008. Infection, incest, and iniquity: investigating the neural correlates of disgust and morality. J. Cogn. Neurosci. 20 (9), 1529–1546.

Burnett, S., Bird, G., Moll, J., Frith, C., Blakemore, S.J., 2009. Development during adolescence of the neural processing of social emotion. J. Cogn. Neurosci. 21 (9), 1736–1750.

Bzdok, D., Schilbach, L., Vogeley, K., Schneider, K., Laird, A.R., Langner, R., Eickhoff, S.B., 2012. Parsing the neural correlates of moral cognition: ALE meta-analysis on morality, theory of mind, and empathy. Brain Struct. Funct. 217 (4), 783–796.

Deery, J., 2004. Reality TV as advertainment. Pop. Commun. 2 (1), 1–20.

Dumontheil, I., Küster, O., Apperly, I.A., Blakemore, S.J., 2010. Taking perspective into account in a communicative task. Neuroimage 52 (4), 1574–1583.

Evans, A.C., Collins, D.L., Mills, S.R., Brown, E.D., Kelly, R.L., Peters, T.M., 1993. 3D statistical neuroanatomical models from 305 MRI volumes. Proceedings of IEEE-Nuclear Science Symposium and Medical Imaging Conference, pp. 1813–1817.

Falk, E.B., Spunt, R.P., Lieberman, M.D., 2012. Ascribing beliefs to ingroup and outgroup political candidates: neural correlates of perspective-taking, issue importance and days until the election. Philos. Trans. R. Soc. B 367 (1589), 731–743.

Fan, Y., Duncan, N.W., de Greck, M., Northoff, G., 2011. Is there a core neural network in empathy? An fMRI based quantitative meta-analysis. Neurosci. Biobehav. Rev. 35 (3), 903–911.

Fine, J.G., Semrud-Clikeman, M., Zhu, D.C., 2009. Gender differences in BOLD activation to face photographs and video vignettes. Behav. Brain Res. 201 (1), 137–146.

Finger, E.C., Marsh, A.A., Kamel, N., Mitchell, D.G., Blair, J.R., 2006. Caught in the act: the impact of audience on the neural response to morally and socially inappropriate behavior. Neuroimage 33 (1), 414–421.

Fortin, A., Ptito, A., Faubert, J., Ptito, M., 2002. Cortical areas mediating stereopsis in the human brain: a PET study. Neuroreport 13 (6), 895–898.

Friston, K.J., Buechel, C., Fink, G.R., Morris, J., Rolls, E., Dolan, R.J., 1997. Psychophysiological and modulatory interactions in neuroimaging. Neuroimage 6, 218–229.

Frith, C.D., Frith, U., 2006. The neural basis of mentalizing. Neuron 50 (4), 531–534.

Goodkind, M.S., Sollberger, M., Gyurak, A., Rosen, H.J., Rankin, K.P., Miller, B., Levenson, R., 2012. Tracking emotional valence: the role of the orbitofrontal cortex. Hum. Brain Mapp. 33 (4), 753–762.

Hajcak, G., MacNamara, A., Foti, D., Ferri, J., Keil, A., 2013. The dynamic allocation of attention to emotion: simultaneous and independent evidence from the late positive potential and steady state visual evoked potentials. Biol. Psychol. 92 (3), 447–455.

Harry, J.C., 2008. Cheaters "real" reality television as melodramatic parody. J. Commun. Inq. 32 (3), 230–248.

Hartwright, C.E., Apperly, I.A., Hansen, P.C., 2012. Multiple roles for executive control in belief–desire reasoning: distinct neural networks are recruited for self-perspective inhibition and complexity of reasoning. Neuroimage 61 (4), 921–930.

Hawk, S.T., Fischer, A.H., Van Kleef, G.A., 2011. Taking your place or matching your face: two paths to empathic embarrassment. Emotion 11 (3), 502–513.

Heinrichs, N., Rapee, R.M., Alden, L.A., Bögels, S., Hofmann, S.G., Ja Oh, K., Sakano, Y., 2006. Cultural differences in perceived social norms and social anxiety. Behav. Res. Ther. 44 (8), 1187–1197.

Hervé, P.Y., Razafimandimby, A., Jobard, G., Tzourio-Mazoyer, N., 2013. A shared neural substrate for mentalizing and the affective component of sentence comprehension. PLoS ONE 8 (1), e54400.

Hooker, C.I., Verosky, S.C., Germine, L.T., Knight, R.T., D'Esposito, M., 2010. Neural activity during social signal perception correlates with self-reported empathy. Brain Res. 1308, 100–113.

Hynes, C.A., Baird, A.A., Grafton, S.T., 2006. Differential role of the orbital frontal lobe in emotional versus cognitive perspective-taking. Neuropsychologia 44 (3), 374–383.

Kjus, Y., 2009. Idolizing and monetizing the public: the production of celebrities and fans, representatives and citizens in reality TV. Int. J. Commun. 3, 277–300.

Klapwijk, E.T., Goddings, A.L., Burnett Heyes, S., Bird, G., Viner, R.M., Blakemore, S.J., 2013. Increased functional connectivity with puberty in the mentalising network involved in social emotion processing. Horm. Behav. 64 (2), 314–322.

Klimecki, O.M., Leiberg, S., Lamm, C., Singer, T., 2013. Functional neural plasticity and associated changes in positive affect after compassion training. Cereb. Cortex 23 (7), 1552–1561.

Krach, S., Cohrs, J.C., de Echeverría Loebell, N.C., Kircher, T., Sommer, J., Jansen, A., Paulus, F.M., 2011. Your flaws are my pain: linking empathy to vicarious embarrassment. PLoS ONE 6 (4), e18675.

Lamm, C., Decety, J., Singer, T., 2011. Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. Neuroimage 54 (3), 2492–2502.

Larsson, J., Landy, M.S., Heeger, D.J., 2006. Orientation-selective adaptation to first- and second-order patterns in human visual cortex. J. Neurophysiol. 95 (2), 862–881.

Lawrence, E.J., Shaw, P., Giampietro, V.P., Surguladze, S., Brammer, M.J., David, A.S., 2006. The role of 'shared representations' in social perception and empathy: an fMRI study. Neuroimage 29 (4), 1173–1184.

Lewis, M., Haviland-Jones, J.M., Barrett, L.F. (Eds.), 2010. Handbook of Emotions. Guilford Press.

Li, W., Mai, X., Liu, C., 2014. The default mode network and social understanding of others: what do brain connectivity studies tell us. Front. Hum. Neurosci. 8, 74.

Lickel, B., Schmader, T., Curtis, M., Scarnier, M., Ames, D.R., 2005. Vicarious shame and guilt. Group Process. Intergroup Relat. 8 (2), 145–157.

Marcus, D.K., Wilson, J.R., Miller, R.S., 1996. Are perceptions of emotions in the eye of the beholder? A social relations analysis of judgments of embarrassment. Personality and Social Psychology Bulletin 22, 1220–1228.

Martin, A., Chao, L.L., 2001. Semantic memory and the brain: structure and processes. Curr. Opin. Neurobiol. 11 (2), 194–201.

Miller, R.S., 1987. Empathic embarrassment: situational and personal determinants of reactions to the embarrassment of another. J. Pers. Soc. Psychol. 53 (6), 1061–1069.

Morita, T., Itakura, S., Saito, D.N., Nakashita, S., Harada, T., Kochiyama, T., Sadato, N., 2008. The role of the right prefrontal cortex in self-evaluation of the face: a functional magnetic resonance imaging study. J. Cogn. Neurosci. 20 (2), 342–355.

Müller, N.G., Bartelt, O.A., Donner, T.H., Villringer, A., Brandt, S.A., 2003. A physiological correlate of the "zoom lens" of visual attention. J. Neurosci. 23 (9), 3561–3565.

Nabi, R.L., Stitt, C.R., Halford, J., Finnerty, K.L., 2006. Emotional and cognitive predictors of the enjoyment of reality-based and fictional television programming: an elaboration of the uses and gratifications perspective. Media Psychol. 8 (4), 421–447.

Nummenmaa, L., Hirvonen, J., Parkkola, R., Hietanen, J.K., 2008. Is emotional contagion special? An fMRI study on neural systems for affective and cognitive empathy. Neuroimage 43 (3), 571–580.

Ouelette, L., Murray, S., 2004. Introduction. In: Murray, S., Ouelette, L. (Eds.), Reality TV: Remaking Television Culture. New York University Press, New York, pp. 1–16.

Paulus, F.M., Müller-Pinzler, L., Westermann, S., Krach, S., 2013. On the distinction of empathic and vicarious emotions. Front. Hum. Neurosci. 7, 196.

Paulus, F.M., Müller-Pinzler, L., Jansen, A., Gazzola, V., Krach, S., 2014. Mentalizing and the role of the posterior superior temporal sulcus in sharing others' embarrassment. Cereb. Cortex (Epub ahead of print).

Prehn, K., Wartenburger, I., Mériau, K., Scheibe, C., Goodenough, O.R., Villringer, A., Heekeren, H.R., 2008. Individual differences in moral judgment competence influence neural correlates of socio-normative judgments. Soc. Cogn. Affect. Neurosci. 3, 33–49.

Premack, D., Woodruff, G., 1978. Does the chimpanzee have a theory of mind? Behav. Brain Sci. 1 (4), 515–526.

Premkumar, P., Ettinger, U., Inchley-Mort, S., Sumich, A., Williams, S.C., Kuipers, E., Kumari, V., 2012. Neural processing of social rejection: the role of schizotypal personality traits. Hum. Brain Mapp. 33 (3), 695–706.

Risko, E.F., Laidlaw, K.E., Freeth, M., Foulsham, T., Kingstone, A., 2012. Social attention with real versus reel stimuli: toward an empirical approach to concerns about ecological validity. Front. Hum. Neurosci. 6, 143.

Samson, D., Apperly, I.A., Kathirgamanathan, U., Humphreys, G.W., 2005. Seeing it my way: a case of a selective deficit in inhibiting self-perspective. Brain 128 (5), 1102–1111.

Schaefer, M., Heinze, H.J., Rotte, M., 2012. Embodied empathy for tactile events: interindividual differences and vicarious somatosensory responses during touch observation. Neuroimage 60 (2), 952–957.

Scheepers, D., Derks, B., Nieuwenhuis, S., Lelieveld, G.J., Van Nunspeet, F., Rombouts, S.A., De Rover, M., 2013. The neural correlates of in-group and self-face perception: is there overlap for high identifiers? Front. Hum. Neurosci. 7, 528.

Schnell, K., Bluschke, S., Konradt, B., Walter, H., 2011. Functional relations of empathy and mentalizing: an fMRI study on the neural basis of cognitive empathy. Neuroimage 54 (2), 1743–1754.

Schulte-Rüther, M., Markowitsch, H.J., Fink, G.R., Piefke, M., 2007. Mirror neuron and theory of mind mechanisms involved in face-to-face interactions: a functional magnetic resonance imaging approach to empathy. J. Cogn. Neurosci. 19 (8), 1354–1372.

Schurz, M., Aichhorn, M., Martin, A., Perner, J., 2013. Common brain areas engaged in false belief reasoning and visual perspective taking: a meta-analysis of functional brain imaging studies. Front. Hum. Neurosci. 7, 712.

Shamay-Tsoory, S.G., Aharon-Peretz, J., Perry, D., 2009. Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. Brain 132 (3), 617–627.

Shearn, D., Spellman, L., Straley, B., Meirick, J., Stryker, K., 1999. Empathic blushing in friends and strangers. Motiv. Emot. 23 (4), 307–316.

Silani, G., Lamm, C., Ruff, C.C., Singer, T., 2013. Right supramarginal gyrus is crucial to overcome emotional egocentricity bias in social judgments. J. Neurosci. 33 (39), 15466–15476.

Simon-Thomas, E.R., Godzik, J., Castle, E., Antonenko, O., Ponz, A., Kogan, A., Keltner, D.J., 2012. An fMRI study of caring vs self-focus during induced compassion and pride. Soc. Cogn. Affect. Neurosci. 7 (6), 635–648.

Somerville, L.H., Jones, R.M., Ruberry, E.J., Dyke, J.P., Glover, G., Casey, B.J., 2013. The medial prefrontal cortex and the emergence of self-conscious emotion in adolescence. Psychol. Sci. 24 (8), 1554–1562.

Stocks, E.L., Lishner, D.A., Waits, B.L., Downum, E.M., 2011. I'm embarrassed for you: the effect of valuing and perspective taking on empathic embarrassment and empathic concern. J. Appl. Soc. Psychol. 41 (1), 1–26.

Tajfel, H., Turner, J.C., 1979. In: Austin, W., Worchel, S. (Eds.), An Integrative Theory of Intergroup Conflict. Brooks/Cole, Monterey, CA, pp. 33–47.

Takahashi, H., Yahata, N., Koeda, M., Matsuda, T., Asai, K., Okubo, Y., 2004. Brain activation associated with evaluative processes of guilt and embarrassment: an fMRI study. NeuroImage 23 (3), 967–974.

Tangney, J.P., Stuewig, J., Mashek, D.J., 2007. Moral emotions and moral behavior. Annu. Rev. Psychol. 58, 345–372.

Taylor, J.G., Fragopanagos, N.F., 2005. The interaction of attention and emotion. Neural Netw. 18 (4), 353–369.

Tracy, J.L., Robins, R.W., 2004. Putting the self into self-conscious emotions: a theoretical model. Psychol. Inq. 15 (2), 103–125.

Tyler, L.K., Chiu, S., Zhuang, J., Randall, B., Devereux, B.J., Wright, P., Taylor, K.I., 2013. Objects and categories: feature statistics and object processing in the ventral stream. J. Cogn. Neurosci. 25 (10), 1723–1735.

Vachon-Presseau, E., Roy, M., Martel, M.O., Albouy, G., Chen, J., Budell, L., Rainville, P., 2012. Neural processing of sensory and emotional-communicative information associated with the perception of vicarious pain. Neuroimage 63 (1), 54–62.

van der Heiden, L., Scherpiet, S., Konicar, L., Birbaumer, N., Veit, R., 2013. Interindividual differences in successful perspective taking during pain perception mediates emotional responsiveness in self and others: An fMRI study. Neuroimage 65, 387–394.

van der Meer, L., Groenewold, N.A., Nolen, W.A., Pijnenborg, M., Aleman, A., 2011. Inhibit yourself and understand the other: neural basis of distinct processes underlying Theory of Mind. Neuroimage 56 (4), 2364–2374.

Vogeley, K., Bussfeld, P., Newen, A., Herrmann, S., Happe, F., Falkai, P., Zilles, K., 2001. Mind reading: neural mechanisms of theory of mind and self-perspective. Neuroimage 14 (1), 170–181.
Völlm, B.A., Taylor, A.N., Richardson, P., Corcoran, R., Stirling, J., McKie, S., Elliott, R., 2014. Neuronal correlates of theory of mind and empathy: a functional magnetic resonance imaging study in a nonverbal task. Neuroimage 29 (1), 90–98.
Wagner, U., N'Diaye, K., Ethofer, T., Vuilleumier, P., 2011. Guilt-specific processing in the prefrontal cortex. Cereb. Cortex 21 (11), 2461–2470.
Welten, S.C., Zeelenberg, M., Breugelmans, S.M., 2012. Vicarious shame. Cogn. Emot. 26 (5), 836–846.