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# How sexual objectification marks the brain: fMRI evidence of self-objectification and its harmful emotional consequences

Bianca Monachesi [a,b,*], Alice Deruti [c], Jeroen Vaes [b], Paolo Leoni [b], Alessandro Grecucci [b,d,**]

[a] Neuroscience and Society Laboratory, Neuroscience Area, SISSA, Via Bonomea, 265, Trieste 34136, Italy
[b] Department of Psychology and Cognitive Sciences, University of Trento, Italy
[c] Fondazione IRCCS Istituto Neurologico Carlo Besta, Milano, Italy
[d] Centre for Medical Sciences, CISMed, University of Trento, Italy

A R T I C L E I N F O

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A B S T R A C T

Female Sexual Objectification refers to perceiving and treating women based on their body appearance. This phenomenon may serve as a precursor for dysfunctional behaviors, particularly among females prone to *self*-objectification and experiencing shame emotions. Understanding this challenging trajectory by disclosing its neural consequences may be crucial for comprehending extreme psychopathological outcomes. However, investigations in this sense are still scarce. The present study explores the neural correlates of female participants' experiences of being objectified and their relationship with self-objectification, emotional responses and individual dispositions in self-esteem, emotion regulation abilities and self-conscious emotion proneness. To this aim, 25 female participants underwent an fMRI experimental session while they were exposed to interpersonal encounters with objectifying or non-objectifying men. Participants' experienced emotions and levels of attention shifted toward their bodies (self-objectification) was reported after each interaction. The results revealed increased brain activity in objectifying contexts, impacting cortical (frontal, occipital and temporal cortex) and subcortical regions (thalamus, and hippocampus) involved in visual, emotion, and social processing. Remarkably, the inferior temporal gyrus emerged as a crucial neural hub associated in opposite ways with self-esteem and the self-conscious emotion of shame, highlighting its role in self-referential processing during social dynamics. This study points out the importance of adopting a neuroscientific perspective for a deeper understanding of sexual objectification, and to shed light on its possible neural consequences.

## 1. Introduction

The investigation into the construct of female sexual objectification has animated researchers, firstly in the field of social psychology (Fredrickson and Roberts, 1997), and only recently in neuroscience (Cogoni et al., 2023). So far, although estimable efforts have been made to uncover the neural mechanisms involved into the perception of woman as a "sexual object" (e.g., Bernard et al. 2018, Cogoni et al. 2023, Vaes et al. 2019), studies on the neural correlates underlying the experience of being treated as such are still scarce. This lack hinders the full comprehension of what it means to experience an objectifying gaze and its consequent internalization (i.e., self-objectification), which, in turn, may constitute a dangerous step toward psychopathology (Moradi and Huang, 2008; Schaefer and Thompson, 2018). The present investigation aims to fill this gap using an event-related functional magnetic resonance imaging (fMRI) technique on women while they become targets of sexual objectification.

Objectification Theory proposes that exposure to sexually objectifying contexts, ranging from sexist stereotypes to men's sexual remarks, may lead women to internalize an objectifying gaze on the self (Fredrickson and Roberts, 1997). State self-objectification, characterized by heightened attention and concerns about one's body, has been demonstrated to contribute to subsequent cognitive (Winn & Cornelius, 2020) and interpersonal challenges (Piretti et al., 2023; Saguy et al., 2010; Shepherd, 2019). A pivotal element cutting across many of these detrimental outcomes that is strongly linked to sexual objectification is the experience of the self-conscious emotion of shame (Daniels et al., 2020; Shepherd et al., 2023; Tangney et al., 2007). Indeed, while various

* Corresponding author at: Neuroscience and Society Laboratory, Neuroscience Area, SISSA, Via Bonomea, 265, Trieste 34136, Italy.
** Corresponding author at: Department of Psychology and Cognitive Science, University of Trento, Corso Bettini, 84, Rovereto, TN 38068, Italy
*E-mail addresses:* bmonache@sissa.it (B. Monachesi), alessandro.grecucci@unitn.it (A. Grecucci).

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negative emotions may emerge during sexually objectifying encounters (e.g., anger, Shepherd, 2019), shame stands out as the most insidious and warrants increased attention (Daniels et al., 2020). Highly associated with reduced self-esteem (Budiarto and Helmi, 2021), shame may represent a crucial step to depict the trajectory from self-objectification, the resulting dysfunctional behaviours, and the potential development of psychopathologies based on body image distortion, such as eating disorders (Riva et al., 2015).

Recently, an electrophysiological (EEG) study (Monachesi et al., 2023) showed that, during sexually objectifying encounters, state self-objectification is associated with increased shame responses and less consequent punishing behaviours towards the objectifying men. Interestingly, during the sexually objectifying encounters, a distinct temporal marker in the EEG signal, specifically the Late Positive Potential (LPP) component, positively correlated with both the state of self-objectification and the frequency of shame experienced. These findings offer an initial neuroscientific understanding of the brain mechanisms underlying women's emotional experiences in sexually objectifying scenarios. Although this research represents a relevant step forward what remains to be disclosed is the brain regions involved in this phenomenon. While the EEG technique used in the study of Monachesi et al. (2023) provided insights into the time course of the women's neural responses related to the phenomenon of sexual objectification, an fMRI approach will offer a complementary perspective by focusing on the spatial information of such brain activation.

To gather insights on the neural correlates of Sexual or Self-Objectification, we need to delve into the clinical literature. Some authors connected Objectification theory and self-objectification to the hypothesis that eating disorders, especially Anorexia Nervosa (AN), have a precursor in the form of a persistent allocentric (objective, external) negative image schema of the body that does not update from egocentric (subjective, internal) input derived from sensory perception (i.e., Allocentric Lock Hypothesis, Riva et al., 2015). The authors propose a neuropsychological framework of self-objectification in which they suggest that the neural correlates related to egocentric and allocentric spatial references and involving a bilateral fronto-parietal and occipito-temporal networks, respectively, overlap with those altered in AN patients and are commonly associated with body image distortions. In a similar vein, a recent paper (Lucherini Angeletti et al., 2022) reviewed task-induced activity studies in AN. Conclusions suggest that this disorder and its associated self-objectification are due to a reduced intero-exteroceptive integration and to a general increased activity in response to sensory/body image stimuli, especially in the regions of the interoceptive-self, which span from cortical (e.g., medial orbitofrontal cortex/MOFC, prefrontal cortex/PFC) to subcortical areas (e.g., putamen, caudate, thalamus). Further, investigating the resting-state brain activity and connectivity in a sample of healthy students, Du et al., (2023) found that the inferior frontal gyrus/IFG might represent the neural substrate explaining the relationship between self-objectification and interoceptive sensitivity.

All together, these studies represent significant efforts to explore the brain substrates of the phenomenon of self-objectification. However, the findings remain limited to clinical samples and to the study of exteroceptive and interoceptive mechanisms. The social and affective aspects, crucial in fully comprehending self-objectification and its potential trajectory towards psychopathology, are still neglected (Riva et al., 2015). Indeed, as far as we know, no one has attempted to uncover the neural mechanisms of self-objectification by using fMRI and during simulated interpersonal scenarios that women often encounter in their daily lives. This new neuroscientific approach entails interpreting individual symptomatology within a social context, specifically that of sexual objectification, wherein the toxic dynamics can be rooted and intertwined with emotional experiences.

To provide new evidence in this direction, the current study aimed to investigate the relationship between state self-objectification, emotional responses, and the underlying functional brain activity of female participants as they engaged in an fMRI-adapted version of the Objectification Task employed in Monachesi et al. (2023). In this task, participants are exposed to social interactions where men either objectified them or not. These interpersonal encounters are built up by using the computer presentation of neutral faces of men associated with objectifying or non-objectifying sentences (see the Supplementary material for examples of the sentences). The instructions explicitly ask participants to immerse themselves in the presented social interactions imaging to interact with the men for real. According to that, participants are prompted to consider the sentences as directed to them, or generally to women - but always in their presence. Measures about the type of experienced emotion, and the level of self-objectification are contextually registered. For the latter concept, we chose to measure the extent to which participants directed their attention toward their own physical appearance (on a 4-point Likert scale). This approach aligns with the definition of self-objectification in terms of "appearance-focused […] and manifest body surveillance" used by Moradi and Huang (2008, pg. 378) and avoids an explicit reference to the term "objectification", which could potentially bias participants.

At the behavioural level, we expect to confirm the effectiveness of the OT in eliciting sexually objectifying contexts, associated with more frequent experiences of negative emotions relative to the non-objectifying contexts. At the neural level, we expect to find increased brain activity in the medial prefrontal cortex (MPFC), Cingulate cortex, and in the right fusiform gyrus, according to previous fMRI studies using a similar procedure and stimuli (i.e., emotional sentences and neutral faces, Schwarz et al., 2013) and those investigating the neural correlates of affective mechanisms and emotional responses of shame and anger/disgust (Bastin et al., 2016; Piretti et al., 2023; Zhu et al., 2019). Further, we expect identifying brain regions associated with body processing in terms of spatial references (Riva et al., 2015) and/or interoceptive mechanisms (Du et al., 2023). However, we cannot predict precisely which regions will be implicated, as this is the first time we are employing this paradigm with fMRI measures. Finally, to enrich the investigation of contextual and transient experiences by assessing potentially more stable profiles, we investigated whether individual dispositions in terms of shame and guilt proneness, self-esteem as well as of emotion regulation ability will better explain female behavioural and neural responses. There is evidence that the ability in emotion regulation mediates the relationship between the experience of shame and the symptomatology related to eating disorders (Gupta et al., 2008). Additionally, the use of two specific emotion regulation strategies, reappraisal (which refers to appraise the situation to alter its meaning and emotional impact) and suppression (which refers to inhibit or reduce ongoing emotion-expressive behaviour), leads to the prediction of different implications for multiple domains of adaptive affective, cognitive ad social functioning (Ghomroudi et al., 2023). Namely, reappraisal commonly has more beneficial consequences than suppression (Zanella et al., 2022). Therefore, we expect that higher levels of self-objectification and the related neural activations will be associated with lower self-esteem, increased proneness to self-conscious emotions, and greater reliance on dysfunctional emotion regulation strategies.

## 2. Method

### 2.1. Participants

Twenty-five heterosexual, right-handed women took part in the experiment as volunteers (age: $M = 23$, SD = 2.92, education years: $M = 14.72$, SD = 2.09). The sample size is consistent with previous fMRI studies using a similar paradigm, analyses, and self-reported measures (i.e., Schwarz et al. 2013). All the participants gave their written informed consent to take part in the study and received a monetary compensation of 45€ at the end of the experimental session. The entire experimental procedure was carried out in accordance with the Declaration of Helsinki and approved by the ethical review board of the

University of Trento.

#### 2.1.1. Stimuli

The visual stimuli were made up of phrases and images of male faces. Verbal stimuli consisted in 80 experimental sentences, 40 objectifying and 40 non-objectifying, plus 4 sentences (2 objectifying and 2 non-objectifying) that served as stimuli for the practice trials. Objectifying sentences referred to “pick-up lines” or typical “sexist stereotypes” and, in both cases, focus was on woman’s aesthetic qualities. Non-objectifying sentences matched objectifying ones in syntactic and grammatical terms, and – importantly, they had no reference to aesthetic or physical aspects and tended to be as neutral as possible. All sentences were selected from an original pre-validated set (see the Supplementary material for details on validation).

The male faces consisted in 80 coloured photos of White males with neutral emotional expression, which were selected from the Chicago Face dataset (CFD; Ma, Correll, & Wittenbrink, 2015) and kept in their original form. The faces were divided into 4 subsets, balanced for brightness, attractiveness, reliability, masculinity, dominance, perceived emotions of anger and joy, in agreement with the normative data of the CFD (all comparisons performed by independent *t*-tests were nonsignificant, $p > 0.2$).

Task was implemented using OpenSesame software (Mathôt, Schreij, & Theeuwes, 2012), which also served for the recording of the answer. Participants’ responses inside the scan were provide using the right hand on a responses box with four buttons.

#### 2.1.2. Questionnaires

In this study, we used the Italian version of the Emotion Regulation Questionnaire (ERQ, Balzarotti et al., 2010) to verify individual differences in using reappraisal or suppression strategies. The questionnaire consists of 10 items (6 for reappraisal and 4 for suppression) in which the individual’s way to regulate/manage the emotions is rated on a 7-point-Likert scale (from strongly disagree to strongly agree). In the Italian adaptation of ERQ ($N = 416$), the two-scale ERQ structure was confirmed by confirmatory factor analysis, and both showed good internal consistency (Balzarotti et al., 2010).

To assess the participant’s predisposition to feel self-conscious emotions, we administered the Italian version of the Test of Self-Conscious Affect-3 Scale (TOSCA-3, Tangney, et al., 1989). TOSCA consists of 16 common scenarios in which individuals are asked to imagine themselves and then indicate how likely they would be to react in three different ways, representative of specific emotional states of shame, guilt, or other blame. In the present study, only the subscale of shame and guilt have been considered. Psychometric information of the subscales (Cronbach’s alphas and test-retest reliabilities) are available in Panero et al. (2022).

Finally, the Italian version of the Scale of Rosemberg (Prezza et al., 1997) was used to evaluate the participants’ global self-esteem. The scale is composed of 10 items rated on a 4-point-Likert scale (from strongly agree to strongly disagree). The final score ranges from 0 to 30, with higher scores indicate higher self-esteem. Psychometric information of the scales (Cronbach’s alphas and test-retest correlation) are available in Prezza et al. (1997).

#### 2.1.3. Procedure

Before entering in the scan, each participant filled in the questionnaires. Once in the scan, the participant performed a revised version of the Objectification Task (OT, see Monachesi et al. 2023) and two sequences of resting state were recorded (one at the start and one at the end of the OT task). In each trial of the OT, participants were presented with a central fixation point (1000 ms), followed by the target screen lasting 5000 ms. The target screen represented a simulated social interaction, and it was composed of the face stimulus, presented above the verbal stimulus, that could be an objectifying or a non-objectifying sentence. The face had to be intended as the pronouncer of the sentence. After the target screen, participants were required to respond to two questions, referring to the social interaction they just experienced: (1) how much did you shift your attention to your physical appearance on a 4-points Likert scale (1 = not at all, 4 = very much), and (2) which emotion did you feel among anger, disgust, shame, and a neutral emotion (the emotions were randomly listed, and participant could select only one of them). After the participant’s response or max after 7000 ms the Inter Trial Interval (ITI) started, lasting between 1000 and 2500 ms (randomized with 500ms-steps) (see Fig. 1).

The whole task was composed of 80 trials divided into two blocks, the order of which was counterbalanced across participants. In each block, 20 trials were objectifying, and 20 trials were not objectifying (trial condition was randomized). In addition, each block was associated to two sets of male faces. For each experimental session, the two sets of male faces were randomly associated to the objectifying or the non-objectifying condition. Yet, each face in the set was randomly associated to each sentence of each objectification condition.

#### 2.1.4. fMRI data acquisition

Functional images of the whole brain were acquired using a full-body 3-Tesla MRI scanner (MAGNETOM Prisma; Siemens, Erlangen, Germany). Volumetric T1-weighted MRI scans were acquired in the sagittal plane using a multi-echo MPRAGE sequence [time of repetition (TR): 2530 ms, time of echo (TE 1, 2, 3 and 4): 1.69, 3.55, 5.41 and 7.27 ms, flip angle (FA): 7°, matrix: 64×64, slices and thickness: 176 and 1 mm, field of view (FoV): 256 mm, voxel size: 1 × 1 × 1 mm]. T2*-weighted echo-planar imaging (EPI) sequences were acquired based on blood oxygen level-dependent (BOLD) protocol [time of repetition (TR): 2000 ms, time of echo (TE): 28 ms, flip angle (FA): 75°, matrix: 64×64, slices and thickness: 69 and 2 mm, field of view (FoV): 200 mm, voxel size: 2 × 2 × 2 mm].

#### 2.1.5. Behavioural data analysis

The frequency of each experienced emotion and the mean level of self-objectification were computed as a function of the Objectification condition (Objectifying vs Non-objectifying contexts). The latter variable was then analysed with a paired-sample *t*-test, whereas the frequencies of emotions were analysed in an ANOVA with Emotion (anger, disgust, shame, and neutral) and Objectification as within-participant factors. All pairwise comparisons were FDR (False Discovery Rate) corrected.

In addition, we performed correlational analyses between the behavioural measure of self-objectification level in the Objectifying condition and the individual differences in self-esteem (SdR), in the TOSCA trait subscales of shame and guilt, and in emotion regulation (ERQ). The correlation analyses were FDR corrected.

All behavioural and correlational analyses were performed using IBM SPSS Statistic-25.

#### 2.1.6. fMRI data preprocessing and analysis

All data were analyzed using SPM12 (Statistical Parametric Mapping: The Wellcome Department of Imaging Neuroscience, London, UK, http:/www.fil.ion.ucl.ac.uk/ spm/ software/ spm2/), a tool of Matlab R2022b (The MathWorks, Natick, MA, USA). The scans were not corrected for slice timing due to the relatively short TR (2 s), as this could potentially lead to artifacts (Poldrack, Mumford, & Nichols, 2011). Then, all the files were firstly converted from DICOM to Nifti format. The origin was set to the anterior commissure, and all the volumes were reoriented according to the EPI template. The reoriented images were checked for motion adjustment, data repair, and noise filtering, using the ARTrepair toolbox for SPM (http://cibsr.stanford.edu/tools/human-brain-project/artrepair-software.html) and then realigned using the INRIAlign toolbox (http://www-sop.inria.fr/epidaure/software/INRIAlign/). The resulting images were normalized to the standard Montreal Neurological Institute (MNI) space by using as source images the mean images of each subject, obtained from the INREAlign tool, and as

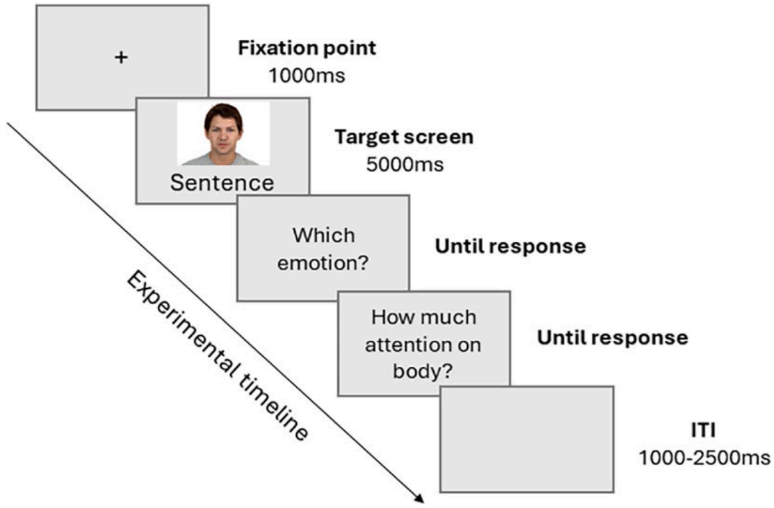


**Fig. 1.** Example of trial in the Objectification Task (OT). Sentences could be objectifying or non-objectifying. The questions are simplified for visualization constrains. In question 1, the four emotions (anger, shame, disgust and neutral emotion) were displayed and listed in random order. In question 2, the 4-point Likert scale was displayed.

template images the EPI image used before. The normalized images were spatially smoothed by convolution with an 8-mm full-width at half-maximum (FWHM) of the Gaussian kernel.

At the single subject-level analysis, the time-window of stimulus presentation (i.e., 5000 ms) was separately selected for the two experimental conditions (Objectifying and Non-objectifying) and convolved with the canonical hemodynamic response function (HRF) concatenating the two blocks. The two images were then contrasted using two paired-sample *t*-tests to reveal the brain activations specific for each condition, that is, during the objectifying (Objectifying > Non-objectifying) and Non-objectifying (Non-objectifying > Objectifying) scenarios.

At the group level, we proceeded with two different but complementary analyses allowing us to have a comprehensive understanding of the relationship between brain activity, behavioural task responses and individual dispositions. Firstly, we analysed the maps of the two contrasts (Objectifying > Non-objectifying and Non-objectifying > Objectifying) using a paired-sample *t*-test to verify the presence of specific activations for the two social scenarios and to assure the effectiveness of the manipulation. We then examined the direct relationship between brain activity and the subjective(transient) task responses by performing correlation analyses between each significant cluster of activation that emerged in the Objectifying > Non-objectifying contrast and the behavioural measures related to the frequencies of the experienced emotions of anger, shame, and disgust, as well as the level of self-objectification (4 variables in total, all reported in the Objectifying condition). To this aim, we extracted the whitened and filtered y-values of all the significant clusters (surviving the correction) using SPM.

Secondly, to investigate the relationship between brain activity in the objectifying scenarios and more stable participants' individual dispositions to emotional abilities, we performed a second paired sample *t*-test for the Objectifying > Non-objectifying contrast. Here, to control for potential confounding effects due to task performance, we entered the frequencies of the angry, shame, and disgust emotions, as well as the level of self-objectification (all reported in the Objectifying condition) as covariates (4 in total). We then extracted the whitened and filtered y-values of clusters that emerged as significant and survived the correction, and for each of them we ran a correlational analysis with the measures of self-esteem (SdR), shame and guilt proneness (subscales of TOSCA), and emotion regulation strategies (ERQ).

All whole brain analyses have been run in SPM and are reported with a Family Wise Error (FWE) corrected threshold of $p < 0.05$ at the cluster-level. For anatomical and cytoarchitectonic interpretation, clusters coordinates are reported in terms of brain areas according to automated anatomical labeling (AAL) atlas by the tool MRIcron (https://github.com/neurolabusc/MRIcron). Surf Ice (https://github.com/neurolabusc/surf-ice) was used to visualize data.

All correlations analyses were FDR corrected and performed in SPSS software.

## 3. Results

### 3.1. Behavioural results

According to the *t*-test, the level of self-objectification was significantly ($t(24) = 7.67$, $p < 0.001$, $d = 1.53$) greater in the objectifying condition ($M = 2.31$; $SD = 0.70$) than in the non-objectifying condition ($M = 1.27$; $SD = 0.55$).

ANOVA results showed a significant main effect of emotion, $F(3,72) = 111.24$, $p < 0.001$, $\eta_p^2 = 0.82$, revealing that the frequency of neutral emotions ($M = 18.6$, $SD = 1.87$) was the highest, all $ps < 0.001$, followed by those of anger ($M = 9.7$, $SD = 3.11$) and disgust emotions ($M = 8.96$, $SD = 3.24$) that did not differ, $p > 0.99$, and with shame ($M = 2.74$, $SD = 2.25$) being the least frequent emotion, $ps < 0.001$. The main effect of emotion was qualified by a significant interaction with objectification ($F(3,72) = 440.01$, $p < 0.001$, $\eta_p^2 = 0.95$). As expected, pairwise comparisons showed that the mean frequency of the three negative emotions in the objectifying condition were significantly greater than those in the non-objectifying context (Shame: $M_{obj} = 4.76$, $SD = 4.31$, $M_{Non\text{-}obj} = 0.72$, $SD = .98$; Anger: $M_{obj} = 17.48$, $SD = 5.01$, $M_{Non\text{-}obj} = 1.92$, $SD = 2.9$; Disgust: $M_{obj} = 16.44$, $SD = 5.33$, $M_{Non\text{-}obj} = 1.48$, $SD = 2.2$), all $ps < 0.001$. While the average of the frequency of neutral emotions was significantly greater in the non-objectifying ($M = 35.88$, $SD = 4.45$) compared to the objectifying condition ($M = 1.32$, $SD = 1.54$), $p < 0.001$ (see Fig. 2).

### 3.2. Relationship between behavioural measures and individual dispositions

The correlation analysis revealed that the level of state self-objectification in the Objectifying condition negatively correlated with self-esteem ($r = -0.49$, $p = 0.035_{\text{FDR-corrected}}$, see Fig. 3) (NB: the correlation between self-esteem and the level of state self-objectification in the Non-objectifying was not significant). No other significant correlations were found among behavioural measures or between these measures and individual differences.

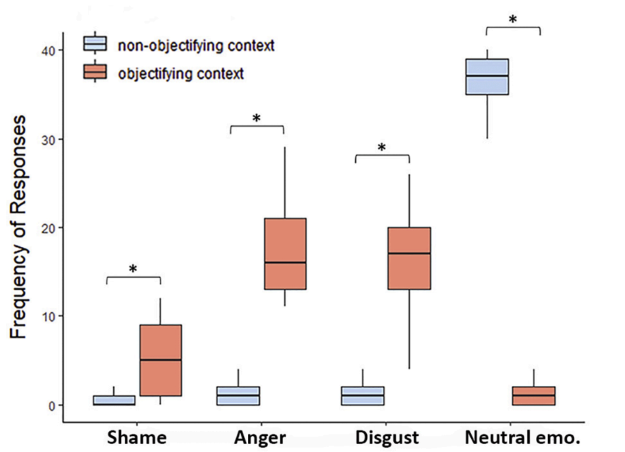


**Fig. 2.** Graph displaying the frequency of emotional responses as function of Objectification and Emotion. (*) = $p < 0.05$. Neutral emo. = Neutral emotion.

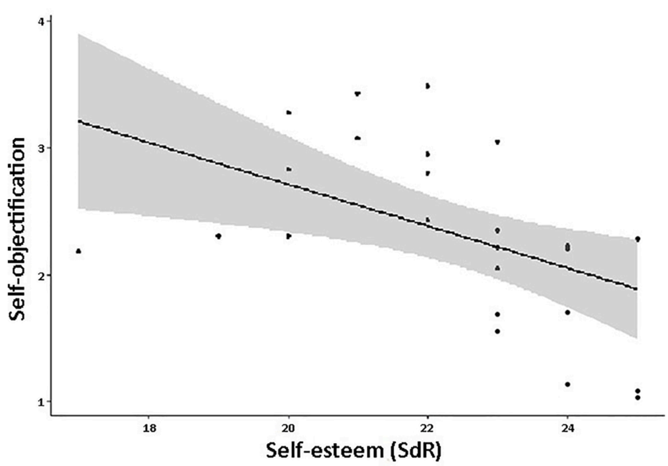


**Fig. 3.** Correlational graph displaying the relationship between the level of state self-objectification in Objectifying condition (y-axis) and self-esteem (x-axis), measured by the Scale of Rosenberg (SdR).

### 3.3. Neural results

#### 3.3.1. Effect of objectification (Objectifying > Non-objectifying, Non-objectifying > Objectifying)

The first analysis focused on the neural effects of the objectification manipulation. The hemodynamic responses in the Objectifying and Non-objectifying condition were compared to reveal brain specific activations for the two social scenarios. The Objectifying > Non-objectifying contrast showed that in the objectifying contexts there was enhanced activity in 6 clusters, spanning from frontal to occipital areas, and one peak in the hippocampus (see Table 1). In the contrast Non-objectifying > Objectifying condition, neither clusters nor peaks emerged significantly.

When the objectifying context was controlled for the perceived emotion and state self-objectification (Objectifying > Non-objectifying contrast with the behavioural variables entered as covariates), we found increased activity in 9 clusters spanning from frontal to parietal and occipital brain areas (see Table 2, Fig. 4). Most of the brain regions overlapped with previous contrasts except for the lingual gyrus, the fusiform gyrus, and the middle frontal gyrus.

#### 3.3.2. Correlational analyses

For what concerns the relationship between brain activity during

**Table 1**
Results for Objectification > Non-objectification contrast. (*) significant at peak-level ($p < 0.05$). $L$ = left; $R$ = right.

| | Anatomical label | BA | H | K | Z score | $P_{FWE\text{-}corr}$ | x,y,z (mm) |
|---|---|---|---|---|---|---|---|
| 1 | Hippocampus | 20 | R | 2083 | 4.97 | < 0.001* | 34, −28, −8 |
| 2 | Cingulum | 32 | R | 465 | 4.64 | 0.001 | 16, 40, 6 |
| 3 | Middle orbital gyrus | 11 | L | 249 | 4.18 | 0.019 | −30, 46, −12 |
| 4 | Inferior temporal gyrus | 20,37 | L | 292 | 4.16 | 0.010 | −46, −42, −16 |
| 5 | Caudate | – | R | 347 | 4.16 | 0.004 | 18, 22, 8 |
| 6 | Occipital gyrus | 19 | R | 294 | 4.04 | 0.009 | 32, −80, 12 |

**Table 2**
Analysis results on Objectifying > Non-objectifying contrast and all the other variables as covariates. (*) significant at peak-level ($p < 0.05$); $H$ = hemisphere; $L$ = left; $R$ = right.

| | Anatomical label | BA | H | K | Z score | $P_{FWE\text{-}corr}$ | x,y,z (mm) |
|---|---|---|---|---|---|---|---|
| 1 | Cingulum | 32 | R | 1438 | 4.81 | < 0.001* | 16, 44, 8 |
| 2 | Hippocampus | 20 | R | 1433 | 4.65 | < 0.001 | 32, −26, −8 |
| 3 | Thalamus | 48 | L | 254 | 4.23 | 0.015 | −20, 18, −2 |
| 4 | Inferior temporal gyrus | 20 | R | 426 | 4.21 | 0.001 | 50, −2, −38 |
| 5 | Inferior temporal gyrus/ Fusiform gyrus | 37 | L | 278 | 4.08 | 0.010 | −44, −46, −24 |
| 6 | Fusiform gyrus | 47,11 | L | 220 | 4.06 | 0.027 | −30, 46, −12 |
| 7 | Inferior occipital gyrus | 19 | R | 211 | 4.03 | 0.032 | 44, −78, 0 |
| 8 | Middle frontal gyrus | 45 | R | 271 | 4.00 | 0.011 | 42, 42, 6 |
| 9 | Lingual gyrus | 18,19 | R | 192 | 3.73 | 0.045 | 14, −92, −12 |

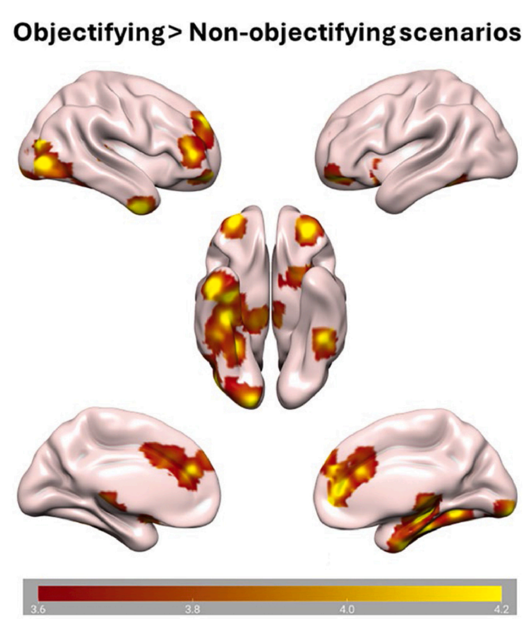


**Fig. 4.** Clusters showing increased activity in the Objectifying > Non-objectifying contrast with all the behavioural variables as covariates. Activations are thresholded for $p < 0.05$ FWE corrected.

objectifying contexts and behavioural responses, we found a positive correlation between experienced anger and occipital gyrus ($r = 0.499$, $p = 0.024$).

Regarding the relationship between individual dispositions and the objectifying context controlled for the behavioural measures, we found the inferior temporal gyrus (ITG) to be positively correlated with the reappraisal strategy (ERQ, $r = 0.46$, $p = 0.025$), and self-esteem (SdR, $r = 0.36$, $p = 0.05$). In addition, the ITG negatively correlated with the suppression strategy (ERQ, $r = -0.66$, $p < 0.001$) and shame proneness (shame subscale of TOSCA, $r = -0.40$, $p = 0.040$). See Fig. 5 for visual representation of all correlational graphs. Reported results are all FDR corrected.

## 4. Discussion

The widespread interpersonal scenarios marked by sexual objectification may represent prodrome contexts for dysfunctional behaviours, particularly among females prone to self-objectification and experiencing shame emotions. A more comprehensive investigation of the challenging trajectory prompted by sexual objectification is crucial for a better understanding of the potential psychopathological outcomes of such social dynamics, especially for what concerns the affective costs and the neural mechanisms involved. The present fMRI study provides the first evidence of the neural correlates underlying the experience of being objectified and the relationship with self-objectification and emotional responses in a subclinical sample of female participants. The already validated Objectification Task (Monachesi et al., 2023) has been

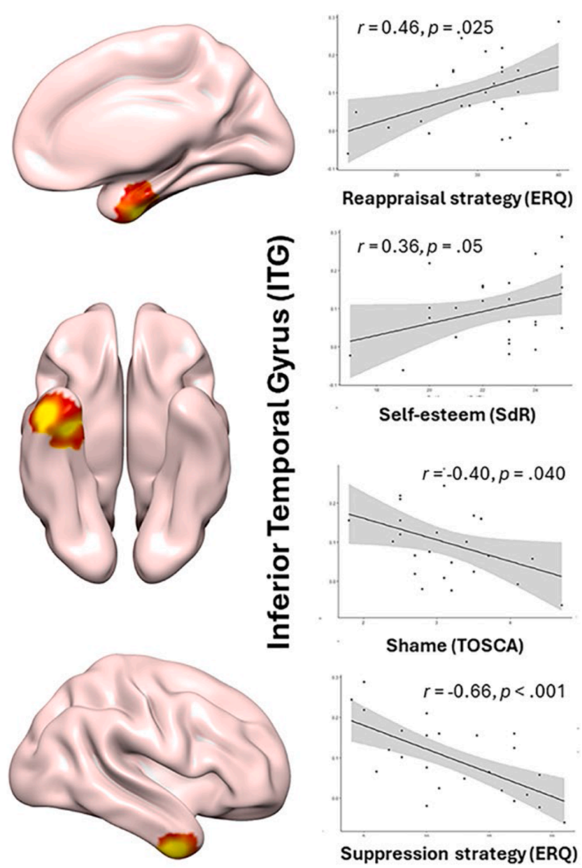


**Fig. 5.** Correlation graphs displaying relationships between Inferior Temporal gyrus (ITG) and individual dispositions. Left side of the panel: 3D representation of the cluster in the ITG. Right side of the panel: correlational analysis between ITG and (from top to bottom) Reappraisal strategy (ERQ), Self-esteem (SdR), Shame (TOSCA) and Suppression strategy (ERQ). Correlational results are FDR corrected.

employed in the MR scan to manipulate the social scenarios (objectifying vs non-objectifying) and to collect the behavioural and neural measures.

In the present study, we confirmed the effectiveness of the OT in establishing a sexually objectifying context. Women directed more attention to their physical appearance and experienced more negative emotions in objectifying social interactions compared to non-objectifying interactions, aligning with the findings of Monachesi et al. (2023). Differently from this latter, the present study did not reveal a significant association between the state self-objectification and the frequency of experienced shame. Nevertheless, we observed that higher levels of state self-objectification were linked to lower trait self-esteem. Previous studies found that self-esteem and self-objectification are tightly related, with evidence also showing that shame mediates this relationship (Choma et al., 2010). Further, low self-esteem represents a pivotal maintaining factor in mood and eating disorders (Munro et al., 2017), often associated with self-objectification as well. The lack of correlation with the experienced shame, probably a less sensitive measure compared to trait self-esteem, might be influenced by the relatively small sample size ($N = 35$ vs $N = 25$), potentially impacting the replicability of the results (see below the paragraph on study limitations for more details).

The behavioural results supporting the efficacy of the OT were corroborated at the neural level. Functional MRI findings revealed increased brain activity in the objectifying context compared to the control condition, whereas the opposite did not lead to any significant activation. When the behavioural covariates were included, the sexual objectification context induced increased activity in cortical (frontal, occipital and temporal cortex) and subcortical regions (thalamus, and hippocampus) related to visual and socio-emotional processing, respectively. As expected, the observed activation pattern primarily reflects the nature of the employed task and the underlying cognitive and perceptual processes (Schwarz et al., 2013). The inferior temporal gyrus, which is connected to the inferior occipital gyrus, plays a crucial role in the ventral stream (the 'what' stream, Ungerleider & Mishkin, 1982) and, especially along with lingual gyrus and fusiform gyrus, supports the visual recognition of words and faces (Palejwala et al., 2021), the stimuli used in our study. Notably, the ventral stream is also involved in judging the significance of the visual world, especially in terms of emotional relevance, through connections with emotion-related structures, among which orbital and frontal cortex, cingulate, and hippocampus (Fettes et al., 2017; Grecucci et al., 2022; Rudebeck and Rich, 2018) which were further areas found to be more active in the objectifying scenarios of our study. In line with these connections and in support of our results, there is evidence of greater activity in the fusiform gyrus, especially related to face processing, and in middle frontal areas during a face-in-context task, in which the display of neutral faces was associated to self-referenced information of negative valence (Schwarz et al., 2013). The overall pattern of activities found in our study suggest that sexual objectification contexts affect brain regions involved in relatively low- to high-level cognitive functions, by the recruitment of the extremely interconnected emotion-related structures. The implication of this result is twofold. Generally, it provides new evidence about the intricate and multifaceted influences between emotion and cognition in terms of inherent, not disjoint brain networks (Pessoa, 2018). More specifically, these findings mirror and build upon those emerged in the previous study by Monachesi et al. (2023) in which sexual objectification affected the neural time-course associated with visual stimuli processing, as evidenced by the modulation of the typical temporal pattern of the EEG signal, from the first (perceptive, N170) to the later (evaluation, LPP) ERP components.

For what concerns the relationship between the observed pattern of activations and the body-related processing, it is interesting noting that the occipito-temporal cortex and the hippocampal formation also belong to the network involved in the allocentric coding of space (Zaehle et al., 2007). Yet, alterations in connectivity within these brain regions, along with the middle frontal gyrus, have been observed in individuals with AN and those in recovery (Favaro et al., 2012). Although this is the first time our paradigm is tested in an MR scan and we could not anticipate the specific effect of the task manipulation on body processing, it seems reasonable that this effect aligns with the allocentric coding of space, similar to the interiorization of the other's objectifying gaze in self-objectification. In this context, the significant clusters identified in our study add empirical support to the Neuropsychological model of self-objectification proposed by Riva and colleagues (2015). This model, which relates the Objectification theory to memory and spatial cognitive processes, suggests that when a woman self-objectifies, she adopts an allocentric spatial perspective to recall situations in which she primarily assesses herself based on bodily appearance. Interestingly, no area involved in both self-objectification and interoceptive mechanisms (i.e., inferior frontal gyrus, Du et al., 2023) has been identified in our study, except for the thalamus (Lucherini Angeletti et al., 2022). However, according to the neuropsychological model of self-objectification (Riva et al., 2015), the thalamus, along with other areas belonging to the Papez circuit, may be more directly involved in transforming the allocentric contents in an egocentric format. Based on the present results, therefore, we can speculate that the OT task and the associated social context prompt women to focus on their bodies, particularly from an external/allocentric perspective (influenced by the observer's gaze), rather than on their internal states.

Notably, the clusters of activation during objectifying scenarios and spanning over the inferior temporal gyrus related to specific individual dispositions. In line with our predictions, this brain area associated with self-esteem (Van Schie et al., 2018) and functional emotion regulation strategies (reappraisal, Yang et al., 2016; Zanella et al., 2022), were associated in opposite directions with dysfunctional emotion regulation strategies (suppression, Zanella et al., 2022) and shame proneness (Bastin et al., 2016; Budiarto and Helmi, 2021). In support of these results, decreased activity in the inferior temporal lobe has been correlated to low self-esteem (Van Schie et al., 2018) and increased activity to shame (Bastin et al., 2016). This pattern of results aligns and extends those found at the behavioural level. Reasonably, the activity observed in the objectifying scenario mirrors a women's profile characterized by large use of adaptive emotion regulation and higher self-esteem, associated in turn – behaviourally, with a reduced tendency to self-objectify along with a general increased expression of anger rather than shame. Accordingly, the higher experience of anger was reflected in the increased activity in the cluster spanning over the occipital areas, previously associated especially with the externalization of this emotion (Grecucci et al., 2023).

As for the shared neural time-course that emerged in the previous EEG study (Monachesi et al., 2023), again it is worthy to emphasise that the overlap between self-esteem and shame leads to speculate about their association with self-referred processes in the social context of Sexual objectification. This gives rise to the intriguing hypothesis about the neural signature of the intricate interplay between highly self-referential phenomena, such as self-objectification, self-esteem, and self-conscious emotions, and the highly interpersonal nature of the dynamics from which these mechanisms originate. Accordingly, self-referred processes become essential for the socio-emotional functioning, which in turn plays a crucial role in the occurrence and maintenance of clinical symptomatology (Jankowski and Takahashi, 2014). In support of that, abnormal activity in several brain regions emerged to be more active in sexually objectifying scenarios (e.g., frontal and cingulate cortex), that are also associated with AN and relative "self-destructive" behaviours (Munro et al., 2017).

As a first attempt to investigate the neural correlates of objectification, this study has some limitations that should be pointed out. Namely, although we carefully selected questionnaires to assess individuals' dispositions in terms of emotional mechanisms, we overlooked one that addresses the assessment of trait self-objectification. Previous research has shown that the availability of cognitive resources during a memory task is affected by a manipulation of "state self-objectification," and the effect is moderated (i.e., exacerbated) by "trait self-objectification" (e.g., Gay and Castano 2010). This suggests an interaction between the two measures. Therefore, future research investigating state self-objectification and its emotional consequences should also include trait self-objectification evaluations to verify whether the amplified effects on cognitive performance also occur in affective experiences. Still, it is also worth noting that Moradi and Huang (2008) have discussed that the difference between the two measures is not always clear and that the same questionnaires have been used to assess both (state and trait). Finally, as already mentioned above, a larger sample size may be beneficial for revealing smaller effects, such as the correlation between self-objectification and shame responses. In studies with larger sample sizes, this association is well established, both when shame is measured as an individual predisposition or trait (Moradi and Huang, 2008) and as a more transient state (Monachesi et al., 2023). Given the potential limitation posed by the sample size, we encourage further research to replicate the correlational findings with a larger participant pool.

To conclude, adopting a neuroscientific perspective is instrumental for gaining a more profound understanding of sexual objectification and its psychological consequences. By delving into the neural correlates of such experiences, our study helped to uncover the underlying mechanisms at play, providing insights into how these dynamics have effects at a biological level. This approach enhanced our comprehension of the social and affective processes involved and offered a more objective perspective on the trajectory toward psychopathology. We hope this study will inspire further neuroscientific investigations to contribute to the holistic understanding of sexual objectification. By deepening our knowledge of the intricate neural processes involved, we aim to inform interventions for treatment and prevention effectively.

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## CRediT authorship contribution statement

**Bianca Monachesi:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alice Deruti:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Jeroen Vaes:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Paolo Leoni:** Writing – review & editing, Software. **Alessandro Grecucci:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

## Declaration of competing interest

The authors have no known conflict of interest to disclose.

## Data availability

Raw behavioural data as well as questionnaire scores are available online at the link https://osf.io/86fvb/. The neural data are available upon request from the corresponding author.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.neuroimage.2024.120729.

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