

ORIGINAL ARTICLE

Neural dynamics of vicarious physical pain processing reflect impaired empathy toward sexually objectified versus non-sexually objectified women

Carlotta Cogoni^{1,2}  | Bianca Monachesi² | Veronica Mazza³ |
Alessandro Grecucci²  | Jeroen Vaes² 

¹Instituto de Biofísica e Engenharia Biomédica, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal

²Department of Psychology and Cognitive Sciences, University of Trento, Trento, Italy

³Center for Mind/Brain Sciences, University of Trento, Trento, Italy

Correspondence

Carlotta Cogoni, Institute of Biophysics and Biomedical Engineering, Faculty of Sciences, University of Lisbon, Campo Grande, Lisboa 1749-016, Portugal.
Email: carlottacogoni.ca@gmail.com

Bianca Monachesi and Jeroen Vaes, Department of Psychology and Cognitive Sciences, University of Trento, Corso Bettini 31, Rovereto 38068, TN, Italy.
Email: bianca.monachesi@unitn.it and jeroen.vaes@unitn.it

Funding information

Fundação para a Ciência e Tecnologia (FCT), Grant/Award Number: EXPL/PSI-GER/1148/2021 and UIDB/00645/2020; Italian Ministry of University and Research

Abstract

Sexually objectified women are perceived as dehumanized. This may affect the behavioral and neural responses underlying the observer's empathic reactions for their physical pain, although this hypothesis still lacks empirical support. In the present study, we measured the electrophysiological activity of 30 participants (14 females and 16 males), in an empathy for physical pain paradigm in which pictures of sexualized and non-sexualized women were presented in painful and non-painful situations. The behavioral results revealed that sexualized women were evaluated as experiencing less pain than non-sexualized women. Neural evidence corroborated this finding showing that the perception of vicarious physical pain is lacking for sexualized women in both event-related potentials (ERPs) and brain oscillation domains. Specifically, the P2 component and the event-related synchronization/desynchronization (ERS/ERD) on the mu frequency band differed between painful and non-painful stimulation exclusively when women were not sexualized. Our results provide the first evidence that the neurophysiological responses to the vicarious experience of *physical* pain are dampened or even absent for sexualized women. These findings expand our understanding of the neurophysiological signatures of empathic processes and highlight the detrimental effect of a sexual-objectification bias in everyday contexts.

KEYWORDS

dehumanization, event-related desynchronization, event-related potentials, Mu frequency band, P2, time-frequency

Carlotta Cogoni and Bianca Monachesi contributed equally to this work.

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2023 The Authors. *Psychophysiology* published by Wiley Periodicals LLC on behalf of Society for Psychophysiological Research.



1 | INTRODUCTION

Empathic feelings for others' physical pain are considered useful emotional reactions that guarantee successful social interactions, by reducing the pain of others. Their associated behavioral and neural responses have been investigated in different dehumanizing contexts, for example, when the individuals experiencing pain belong to different races or social groups (i.e., outgroup, Hein et al., 2010). However, no neuroscientific evidence exists when the individual experiencing the physical pain is sexually objectified. Sexually objectified targets are dehumanized (Heflick & Goldenberg, 2009; Loughnan et al., 2010; Vaes et al., 2011), being reduced to objects of sexual nature, as evidenced by behavioral and neural measures (Bernard et al., 2020). Importantly, sexual harassment and aggression increase toward sexualized women (Blake et al., 2018; Loughnan et al., 2013; Pacilli et al., 2017; Rudman & Mescher, 2012; Vasquez et al., 2017), and the dampened observer's empathic reactions may play a pivotal role in this dangerous outcome (Eisenberg et al., 2010). Two major kinds of empathy are usually investigated in the literature: empathy for social pain (e.g., social exclusion) and empathy for physical pain. In the context of sexual objectification, only empathy for social pain has been explored both behaviorally and at a neural level through a functional neuroimaging lens (Cogoni, Carnaghi, & Silani, 2018; but see also Cogoni et al., 2020, for an investigation of empathy for affective touch). However, violence of a sexual nature equally comprises a social and a physical pain component. Hence, the neural investigation of empathy for physical pain in the context of sexual objectification is necessary and represents a step forward toward the identification of the roots of violence of a sexual nature.

The investigation of the neurophysiological correlates of empathic processes is relatively recent. The two-fold neurocognitive model of pain empathy (Dvash & Shamay-Tsoory, 2014; Nummenmaa et al., 2008; Shamay-Tsoory, 2011) entails two complementary processes. First, an affective process, which is sensory-driven and involves an automatic, bottom-up response to empathic stimuli (i.e., emotion contagion and sharing of the vicarious affective state). The second is a higher-order cognitive process, which modulates the automatic affective response through a top-down mental operation (i.e., cognitive appraisal, self-other distinction, and perspective-taking). Evidence on event-related potentials (ERP) confirms that the empathic affective and cognitive components entail different time courses (Fan & Han, 2008; Sessa, Meconi, Castelli, & Dell'Acqua, 2014; Sessa, Meconi, & Han, 2014). Specifically, the simulation of the emotions (i.e., the emotional contagion and the affective sharing) involves early and mid-latency responses, including the P2, and N1-N3 ERP components (Coll et al., 2017; Decety et al., 2010;

Fan & Han, 2008; Meng et al., 2013). On the contrary, the cognitive evaluation and appraisal component of empathy involves late ERP components, including the P3 and the late positive potential (LPP; Coll et al., 2017; Decety et al., 2010; Fan & Han, 2008; Meng et al., 2013; Sessa, Meconi, & Han, 2014).

In line with the ERP results described above, non-phase-locked neural activities, investigated through time-frequency studies, are modulated by empathy for pain. In an event-related experiment, the increase or decrease in EEG rhythmic activities at certain frequency bands is known as event-related synchronization (ERS, positive values) and desynchronization (ERD, negative values), respectively (Zhang, 2019). Generally, theta band event-related synchronization (ERS) and alpha event-related desynchronization (ERD) are respectively increased and decreased for painful versus neutral stimuli (i.e., pictures of hands in painful or neutral situations, Levy et al., 2016; Mu et al., 2008). However, other studies showed that watching painful compared with non-painful stimulations of others' hands or feet, inhibited alpha-band (~10 Hz) neural oscillations or induced alpha desynchronization (Joyal et al., 2018; Perry et al., 2010; Yang et al., 2009). Specifically, widespread alpha- and beta-band depressions in response to limbs that were painful versus non-painful stimulated have been reported (Whitmarsh et al., 2011). Notably, when the alpha-band is localized in the somatosensory cortex, it is termed mu rhythm (Cheng et al., 2008; Motoyama et al., 2017; Whitmarsh et al., 2011). Mu desynchronization is thought to represent the empathic component of coding and sharing others' sensory feelings. The mu rhythm is correlated with the excitability of somatosensory cortices during first-hand pain experiences (Ploner et al., 2006) and was also observed in the sensorimotor cortex when individuals observed others' actions (Kilner et al., 2006; van Elk et al., 2008). Interestingly, the power of this frequency is susceptible to group biases, being less suppressed with targets considered as not fully human (i.e., dehumanized, Simon & Gutsell, 2021) or outgroup members (Gutsell & Inzlicht, 2010).

In the present study, we investigated how the vicarious experience of physical pain may be affected by the perceived sexual objectification of the target. Said otherwise, we intended to assess the mechanisms that are differently involved when the target of pain is sexualized versus a non-sexualized woman. To this aim, we used a combined approach that includes behavioral and neural measures (ERPs and time-frequency analyses). We adopted a pain decision task with pictures of sexualized and non-sexualized women in painful (stimulated by a needle) and non-painful (stimulated by a q-tip) situations. Following the literature on sexual objectification (Cogoni et al., 2020; Cogoni, Carnaghi, & Silani, 2018; Loughnan et al., 2010), we hypothesized that the vicarious experience of physical

pain would be modulated by the level of sexual objectification of the target. We predicted that sexually objectified women would trigger lower empathic reactions at behavioral and neurophysiological levels. We focused on the P200 and the P300 ERP components, as well as the mu band oscillations for the following reasons. First, on the basis of recent studies on empathy (Vaes et al., 2016), we expected an increased amplitude in an early temporal window (P2) and/or in a later temporal window (P3), reflecting impaired empathic processes for the sexualized women but not for the non-sexualized ones. Second, while previous studies on this topic using time-frequency analysis are scarce, on the basis of studies on empathy for dehumanized targets (i.e., other-race targets, [Simon & Gutsell, 2021]), we may expect a larger suppression of mu oscillation for non-sexualized versus sexualized targets (similar to the previously observed difference between humanized vs. dehumanized, and other-race vs. same-race pain stimulations). Alternatively, on the basis of studies on empathy for similar versus dissimilar others (Perry et al., 2010), we may find a stronger suppressed mu oscillation for the painful versus the non-painful stimulation of non-sexualized targets but not for the sexualized targets.

2 | METHOD

2.1 | Participants

Thirty-five Italian native speakers (17 females and 18 males) took part in the experiment (age: $M=22.8$, $SD=3.6$). All participants reported normal or corrected-to-normal vision and no previous neurological or psychiatric diseases. In line with previous research on sexual objectification, data from four participants who reported being homosexual/bisexual were not included in the analysis. Due to technical issues during recording, data from an additional participant were excluded from the EEG analysis but kept for the behavioral one ($N=30$, 14 female and 16 males; $M=22.71$, $SD=3.42$). A power sensitivity analysis using PANGAEA (for details see www.jakewestfall.org/pangea/) allowed us to determine that we had sufficient power (.80) to detect an effect size of $d=0.52$ ($\eta^2=.06$) and an $\alpha=.05$ for the main effect of sexualization [$F(1, 30)=4.63$, $p=.040$, $\eta_p^2=.134$]; as well as sufficient power (.80) to detect an effect size of $d=0.52$ ($\eta^2=.06$) and an $\alpha=.05$ for the main effect of stimulation [$F(1, 30)=167.92$, $p<.001$, $\eta_p^2=.848$] resulted in the behavioral effects analysis. Also, we had sufficient power (.80) to detect an effect size of $d=0.68$ ($\eta^2=.104$) and an $\alpha=.05$ for the sexualization \times stimulation interaction effect [$F(1, 29)=6.82$, $p=.014$, $\eta_p^2=.190$] used in the neural effects analysis. Thus, our experimental set-up allowed

us to reliably detect medium to large effects. Participants gave their written informed consent to take part in the study and received monetary compensation of 10€. The entire experimental procedure was carried out under the protocol (protocol 2016-004) that was approved by the ethical review board of the University of Trento.

2.2 | Stimuli and apparatus

The target stimuli were pictures (size 314×344 pixels) of 15 female models appearing in swimsuit/underwear, for the sexualized condition, and fully clothed, for the non-sexualized condition. All models were depicted from the knees up and were looking straight into the camera. The original pictures of the models were adapted from the study of Vaes et al. (2019) and validated in a pre-test. The pre-test showed no significant differences between sexualized and non-sexualized photographs in terms of beauty ($p=.48$) and intelligence ($p=.13$), whereas sexualized models were evaluated as sexier ($M=3.94$, $SD=0.73$) and more objectified ($M=3.41$, $SD=0.94$) than non-sexualized models ($M=3.39$, $SD=0.77$ and $M=2.63$, $SD=0.96$, respectively), $ps<.001$. The main effects of the evaluators' gender and their interactions with all these factors were not significant ($ps>.2$). Each picture was further edited to depict the specific stimulation for each condition at the level of the neck by a q-tip for the no-pain condition, and by a syringe for the pain condition (see Figure 1). Syringe and q-tip stimulation appeared equally on the left and the right side of the model. The final set of stimuli consists of a total of 120 pictures resulting from the factorial combination of 15 models \times 2 sexualization conditions \times 2 pain conditions \times 2 side of the stimulation.

Stimuli were presented in a 23.6-inch color monitor (1920×1080 , 120 Hz) through the MATLAB Psychtoolbox (Kleiner et al., 2007).

2.3 | Tasks and procedure

After completion of the consent form and EEG electrodes montage, each participant was individually welcomed in a sound-attenuating, dimly lit, and electrically shielded booth. Here, the participant sat at a distance of 80 cm from the screen and performed the pain task, followed by the face evaluation task. After electrodes were removed, the experimental session ended with the administration of several questionnaires.

To ensure a correct categorization of the stimuli, before the start of the pain task, participants were presented with two images on the screen depicting a hand with a syringe and a hand with a q-tip, generically described as painful and non-painful stimuli. Subsequently, the two stimuli

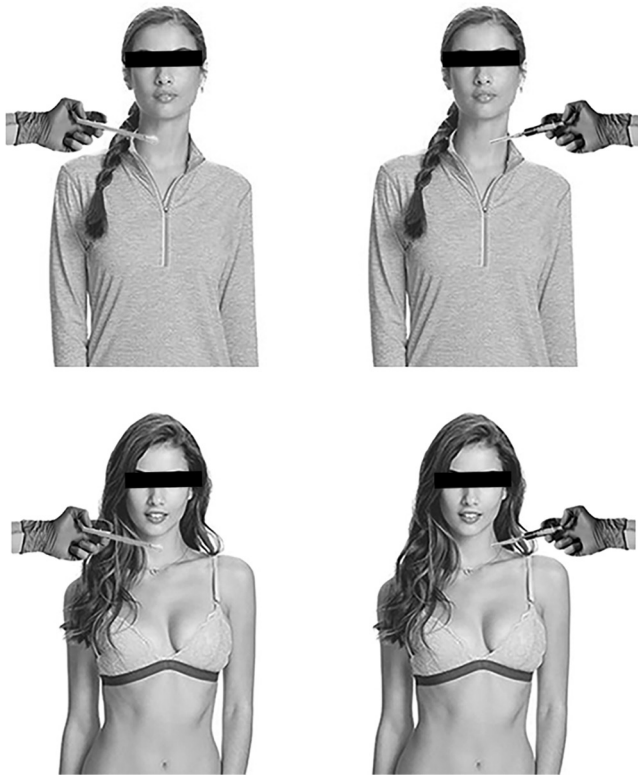


FIGURE 1 Example of target stimuli. Non-sexualized (above) and sexualized (below) women in painful (right) and non-painful (left) stimulation conditions. Note that in the experiment, the pictures were displayed without the black bar on the face.

were presented one at a time and the participant was asked to verbally label them as painful or non-painful. The main pain task consisted of 1436 experimental trials, divided into four blocks with 359 trials each. In two blocks, models were presented in the sexualized condition, whereas in the other two blocks, models were presented in the non-sexualized condition. The two types of blocks (sexualized and non-sexualized; S and NS respectively) were presented in alternated order and counterbalanced by two versions of the experiment (Version 1: S-NS-S-NS; Version 2: NS-S-NS-S). The number of pain and no-pain stimuli with left- and right-side stimulation was counterbalanced and randomized across blocks and models' IDs.

Each trial started with a fixation cross that remained on the screen between 800 and 1000 ms (jittered by steps of a few milliseconds). Then, the target stimulus was presented for 1500 ms and it was randomly followed by the continuous scale for the pain intensity evaluation, ranging from 0 (no pain) to 100 (very high pain). The participant was required to press the left mouse button on the scale point to evaluate the amount of pain the woman was feeling. The occurrence of the pain evaluation as a function of the stimulus type was counterbalanced across blocks resulting in 15 evaluations for each factorial combination of the three factors (sexualization, pain, and stimulation

side, i.e., 120 pain evaluations in total). Participants' task was to look at the serially presented stimuli and, when required, to evaluate the extent of pain experienced by the model depicted in the last picture presented.

Upon a short break, the face evaluation task was performed. In this task, the pictures of each model in the sexualized (15 pictures) and non-sexualized (15 pictures) conditions were presented for 1000 ms and participants had to evaluate the positivity of the face on a scale from -100 (negative) to 100 (positive, $0 =$ neutral).

Finally, participants filled in the two questionnaires (see below) and finished the session. The order of the administration of the questionnaires was randomized across participants.

2.4 | Questionnaires

In the Beliefs on Sexuality Scale (BSS), participants indicated their agreement ($1 =$ totally disagree; $7 =$ totally agree) to 28 items selected from Snell (Snell et al., 1993) tapping the extent to which sex is a performance for men/women, men/women orchestrate sex, men/women are always ready for sex, touching leads to sex for men/women, sex equals intercourse for men/women, and sex requires orgasm for men/women.

The Interpersonal Reactivity Index (IRI, Davis, 1980, 1983) was used to evaluate individual differences in the ability to respond empathically. IRI is a 28-item scale consisting of four 7-item subscales measuring different, but related, dimensions of interpersonal reactivity: *Fantasy* refers to the tendency to imagine feelings; *perspective-taking* refers to the spontaneous tendency to adopt another person's psychological viewpoint; *Empathic concern* comprises the "other-oriented" feelings of sympathy or worry, and *personal distress* concerns the "self-oriented" feelings of personal anxiety and unease in intense interpersonal settings. The first two dimensions are *cognitive* in the way they represent the antecedent of the experienced vicarious emotion, whereas the second two dimensions are two emotional dimensions as they are involved in the participation in other people's emotions.

2.5 | EEG recordings and analyses

The EEG signal was continuously recorded from the scalp with 64 electrodes, three of which were external electrodes: a left and a right mastoid (used as online reference), and a VEOG placed below the left eye. AFz served as ground. Electrode impedance was maintained below $10 \text{ k}\Omega$ for the 64 electrodes, below $4 \text{ k}\Omega$ for the VEOG, and below $2 \text{ k}\Omega$ for the mastoids. The signal was recorded with a time

constant of 10s as low cutoff filter and 250 Hz as high cutoff filter, and digitized with a sampling rate of 1000 Hz.

Pre-processing of EEG data and ERP analyses were conducted using the EEGLAB (Delorme & Makeig, 2004) and ERPLAB toolbox (Lopez-Calderon & Luck, 2014), whereas the time-frequency analysis was conducted using Field Trip (Oostenveld et al., 2011). Raw data were resampled at 250 Hz and digitally filtered with a high-pass filter of 0.5 Hz (zero-phase FIR-filter with cut-off frequency [−6dB]: 0.25 Hz). The EEG data were re-referenced offline to the average of the right and left mastoid electrodes. The signal was segmented in 2300 ms-long epochs that began 800 ms prior to stimulus onset and up to 1500 ms after. An independent component analysis (ICA; Infomax ICA algorithm) was applied to each participant's session to correct for vertical (blinks) and horizontal ocular artifacts. Furthermore, bad epochs with channel exceeding $\pm 70 \mu\text{V}$ in the relevant temporal range of −400 to 1000 ms for time-frequency analysis, and of −200 to 800 ms for ERP analysis, were rejected.

For ERP analyses, epochs rejection resulted in more than 250 artifact-free epochs for each experimental condition in each participant, that is, the minimum of 76%–85% and a maximum of 100%–100% of the trials, respectively, entered the analysis (across conditions, there were no differences between the number of the remaining trials, $p > .094$). For time frequency, epochs rejection resulted in more than 100 artifact-free epochs for each experimental condition in each participant, that is, the minimum of 43%–51% and a maximum of 100%–100% of the trials, respectively, entered the analysis (across conditions, there were no differences between the number of the remaining trials, $p > .092$).

For ERP analyses, a further low-pass filter at 40 Hz was applied to the signal. Time intervals relative to the P2 and N3 components corresponded to the following intervals 170–230 ms and 360–600 ms post-stimulus, respectively. The mean amplitude of both ERP components was analyzed over the parieto-occipital electrodes (POz and Oz) according to visual inspection and previous work (Fabi & Leuthold, 2018; Vaes et al., 2019). Time interval and electrodes for P2 and N3 were selected according to previous studies on empathy for pain and objectification (Fan & Han, 2008; Vaes et al., 2019).

Time-frequency decomposition was performed using a Hanning taper with a time-fixed window length of 500 ms. Power was analyzed from 4 to 30 Hz in 2-Hz steps and in successive 20-ms time steps during the analysis epoch. The increase (Event-related synchronization, ERS) or decrease (Event-related desynchronization, ERD) in time-frequency power (TFP) was subsequently expressed as the relative power change to baseline activity at a time-frequency bin compared with the mean power over the baseline epoch (from −300 to −50 ms: 250 ms pre-stimulus onset) for that frequency ($\text{TFP} = (P_{t-f} - P_{b_f}) / P_{b_f} \times 100$, where P_{t-f} = the

power at time t and frequency f , and P_{b_f} = the mean activity at frequency f over the baseline epoch).

2.6 | Statistical analyses

For behavioral data, the average pain intensity evaluation was computed for each combination of sexualization and stimulation conditions (left and right-side stimulation conditions were averaged), and analyzed using a 2×2 repeated measure ANOVA with sexualization (sexualized vs. non-sexualized models) and stimulation (painful vs. non-painful) as within-participants variables. In addition, the mean of the models' face positivity evaluation was computed for sexualized versus non-sexualized targets and compared with a t test.

For electrophysiological data, a repeated measures ANOVA with electrodes (POz, Oz), sexualization, and stimulation as within-participants variables was computed for each ERP component (P2, N3). For the time-frequency analysis, we performed a whole-brain nonparametric cluster-based permutation test on the power from 0 to 800 ms, averaged for the three frequency bands: mu (8–12 Hz), low-beta (12–18 Hz), and high-beta (18–30 Hz). In this test, for every triplet combining channel, frequency and time, two conditions are compared by a series of t tests. The samples with t values associated with p values lower than a chosen threshold (here $p < .05$) are selected and clustered based on temporal, spatial, and spectral adjacency. Cluster-level statistics are computed by summing the t values in each cluster. Cluster p values are then computed relative to a null distribution of the t values obtained based on 5000 permutations. The final cluster p value is represented by the proportion of permutations including a larger test statistic compared with the observed one, with a two-tailed alpha level determined at $p = .025$. This approach reliably controls for multiple comparisons at the cluster level. Since in this test, only two experimental conditions can be compared at once, for the interaction analyses between sexualization (non-sexualized vs. sexualized condition) and stimulation (painful vs. non-painful stimulation), the difference between pain and non-pain stimulation was computed within the two levels of sexualization and compared by the same test described above. That is, the cluster-based permutation test compared the sexualized (painful–non-painful) versus non-sexualized (painful–non-painful) conditions.

To study the potential relationship between behavioral, EEG responses, and individual dispositions to empathic responsiveness, a correlation analysis was conducted (using SPSS) between the scores of the four subscales of the IRI versus the means of pain evaluation, ERP (POz and Oz) amplitude and EEG oscillations in the pain condition for both non-sexualized and sexualized women.

3 | RESULTS

3.1 | Behavioral results

3.1.1 | Pain intensity evaluation

ANOVA showed that the evaluations of pain intensity experienced by models were influenced by both sexualization ($F[1, 30]=4.63, p=.040, \eta_p^2=.134$) and stimulation type ($F[1, 30]=167.92, p<.001, \eta_p^2=.848$) but not by their interaction ($F[1, 30]=0.70, p=.41$, see [Figure 2](#)). Overall, stimulation was evaluated as more painful when associated with a syringe ($M=0.72, SE=0.04$) than when associated with a q-tip ($M=0.13, SE=0.02$). In addition, models in the sexualized condition were generally evaluated as experiencing less pain ($M=0.41, SE=0.02$) than when they were depicted in the non-sexualized condition ($M=0.43, SE=0.02$).

3.1.2 | Relationship between feeling evaluation and dispositional ratings

No significant correlations emerged between the feeling evaluations and both the IRI subscales and BSS (all $ps > .11$).

3.1.3 | Facial expression evaluation

The non-sexualized and sexualized face stimuli were not perceived as different $t(30)=.52, p=.604$, confirming that the faces of the models were judged equally positive regardless of whether they were depicted in a bikini or fully clothed.

3.2 | Electrophysiological results

3.2.1 | ERP analyses

P2

Results showed that a main effect of electrodes, $F(1, 29)=9.40, p=.005, \eta_p^2=.245$, and a main effect of sexualization, $F(1, 29)=12.22, p=.002, \eta_p^2=.296$, were qualified by their significant interaction, $F(1, 29)=4.90, p=.035, \eta_p^2=.145$. Pairwise comparisons showed that the non-sexualized women in both POz ($M=7.71, SE=0.72$) and OZ ($M=9.03, SE=0.80$) engendered larger amplitude than sexualized women (POz: $M=7.07, SE=0.69$; Oz: $M=8.23, SE=0.78; p=.006$ and $p<.001$, respectively). Most interestingly, the main effect of sexualization was also qualified by a significant interaction with stimulation, $F(1, 29)=6.82, p=.014, \eta_p^2=.190$ (see [Figure 3a,c](#)). Pairwise comparisons revealed that for non-sexualized women, mean amplitude in the painful condition ($M=8.51, SE=0.72$) was larger than the mean amplitude in the non-painful condition ($M=8.23, SE=0.74$), $p=.017$. For sexualized women, no difference occurred between the non-painful ($M=7.60, SE=0.72$) and painful conditions ($M=7.70, SE=0.69$), $p=.32$ ([Figure 4a](#)).

N3

Results showed a main effect of electrodes, $F(1, 29)=35.83, p<.001, \eta_p^2=.553$, revealing that the amplitude in POz ($M=2.06, SE=0.57$), was smaller than the amplitude in Oz ($M=3.74, SE=0.61$). In addition, there was a main effect of sexualization, $F(1, 29)=5.60, p=.025, \eta_p^2=.162$, due to the amplitude for non-sexualized women being less negative ($M=3.12, SE=0.60$) than the amplitude for sexualized women ($M=2.69, SE=0.55$; see [Figures 3b,c](#) and [4b](#)). All other main effects or interaction were not significant, $p > .67$.

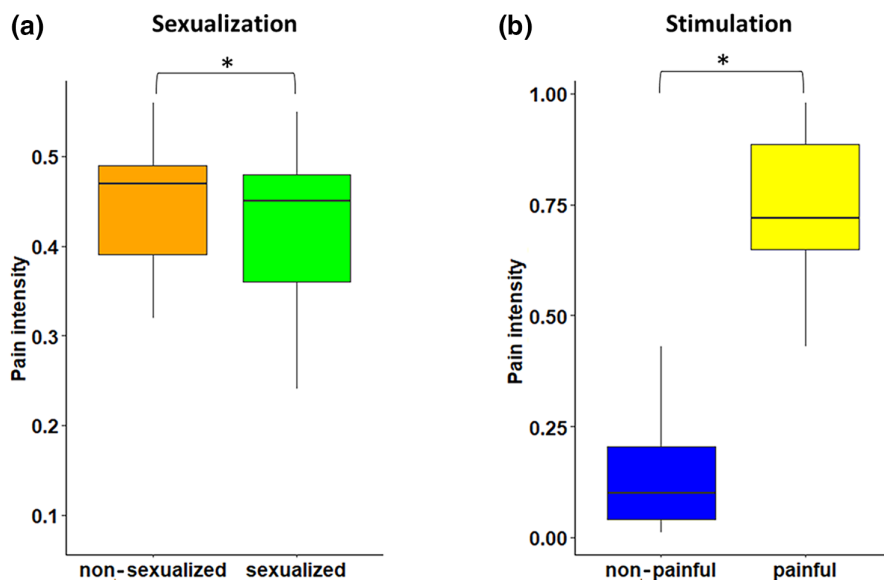


FIGURE 2 Pain intensity evaluations. (a) Main effect of sexualization on the pain intensity evaluation. Note that to have a better visual representation of the sexualization main effect, the pain intensity range in the graph is zoomed in the windows from 0.1 to 0.5 intensity scores. (b) Main effect of stimulation on the pain intensity evaluation. Error bars are $\pm SE$.

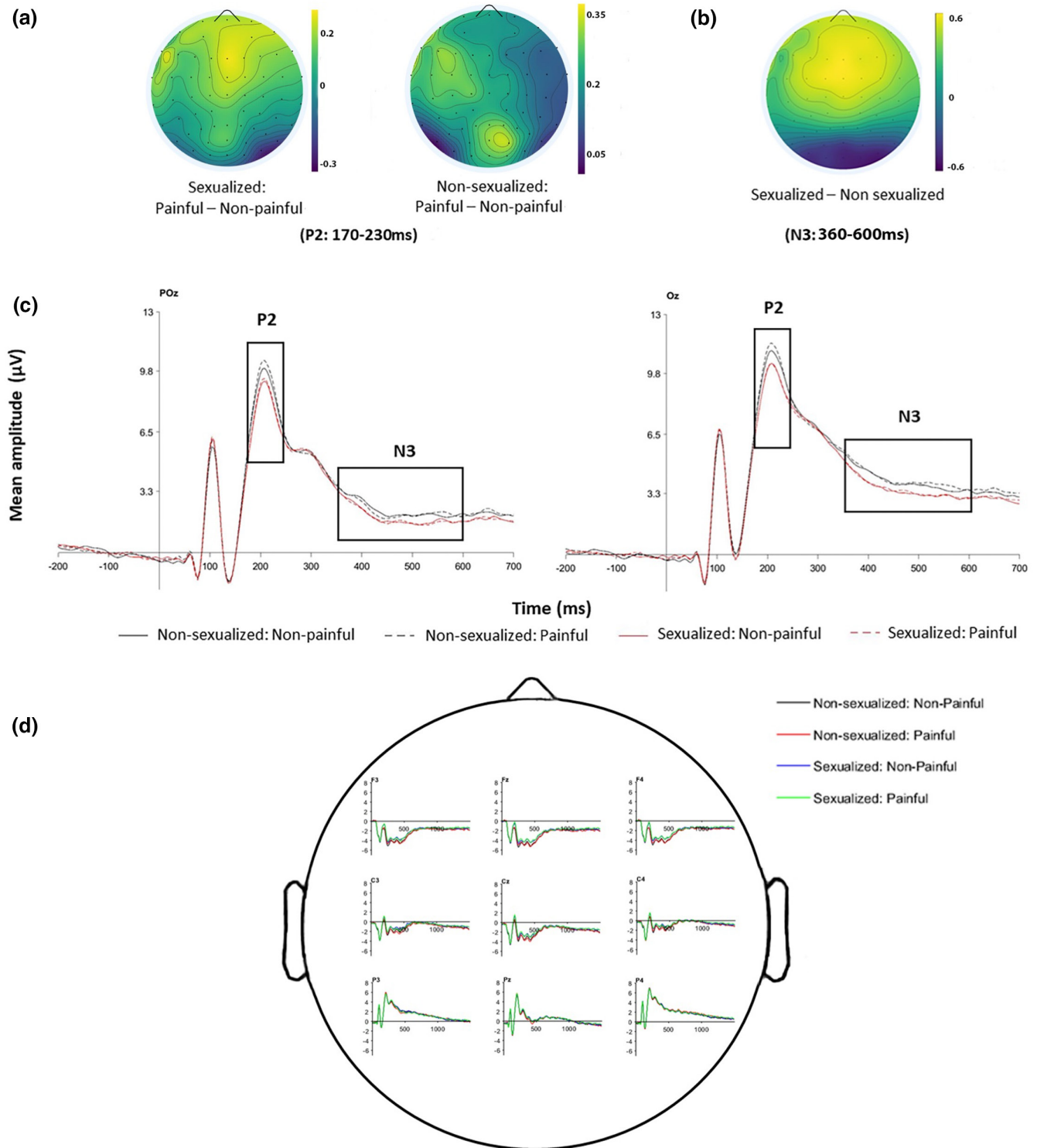


FIGURE 3 Interaction of sexualization \times stimulation in ERP analyses. (a) Scalp distributions represent the difference between painful and non-painful stimulation in sexualized (left) and non-sexualized (right) women in the time window of the P2. (b) Scalp distribution represents the difference between sexualized and non-sexualized women in the N3. (c) Grand average waveforms for POz (left panel) and Oz (right panel) as a function of sexualization (non-sexualized vs. sexualized women) and stimulation (pain vs. non-painful stimulation). Black rectangles highlight the time window for the two relevant ERP components: P2 (170–230 ms) and N3 (360–600 ms). (d) plot in frontal (F3, Fz, F4), central (C3, Cz, C4) and parietal (P3, Pz, P4) electrodes, with a time window of 0–1500 ms (i.e., the whole target presentation time) useful to visually inspect where the component reaches its maxim amplitude on the scalp.

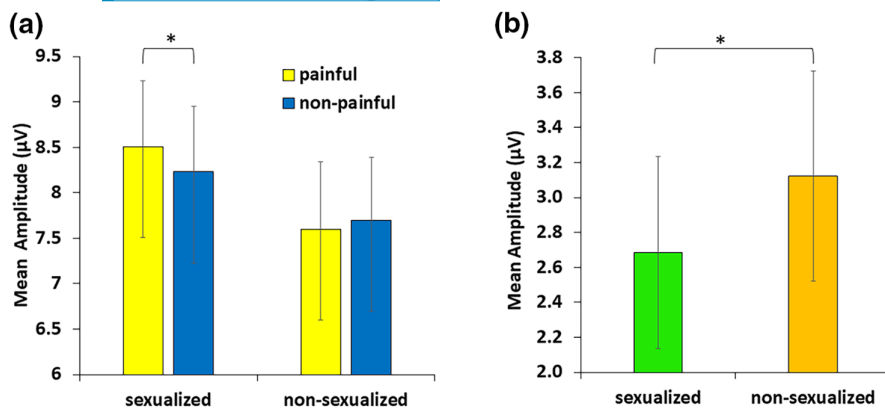


FIGURE 4 Bar plot for P2 and N3 modulations. (a) Interaction between sexualization and stimulation type on P2. (b) Main effect of sexualization on N3. Error bars are \pm SE. (*) = significant difference.

3.2.2 | Relationship between ERP component and dispositional ratings

For the P2 component in POz, results showed a positive correlation between the perspective-taking (PT) subscale of IRI and the painful stimulation in non-sexualized ($r = .379$, $p = .039$) but not in the sexualized condition ($r = .346$, $p = .061$). For the Oz, the PT subscale correlated positively with pain and non-pain stimulation, regardless of the sexualization condition ($r_s > .446$, $p_s < .011$). The BBS negatively correlated with pain stimulation in non-sexualized conditions for Oz ($r = -.364$, $p = .048$). No other significant correlations emerged (all $p_s > .05$).

For the N3 component, results showed a negative correlation between the personal distress subscale of IRI and every factorial combination of pain and sexualization in POz and Oz ($r_s > .457$, $p_s < .011$). No other significant correlations emerged with the other subscales or the BSS (all $p_s > .10$).

A graphical representation of the correlations is provided in the [Figure S1](#) of the Supporting Information. Note that these results are uncorrected for multiple comparisons.

3.2.3 | Time-frequency analyses—nonparametric analysis

ERD in the mu frequency band

The cluster-based permutation test showed no significant clusters for either the main effect of stimulation ($p_s > .2$) or sexualization ($p_s > .1$). Importantly, a significant positive cluster ($p = .01$) from 60 to 460 ms in electrodes spanning from fronto-central to parieto-central sites emerged in the interaction effect (see [Figure 5](#), panel a). Follow-up comparisons between painful and non-painful stimulation were conducted separately within the non-sexualized and sexualized conditions. In the non-sexualized condition, a positive cluster tended to significance ($p = .026$) in a time window between 140 and 540 ms, with a distribution mostly focused on central sites (see [Figure 5](#), panel b). The

cluster revealed that the ERD in the painful condition was smaller than the ERD in the non-painful condition (see [Figure 5](#), panel c). In the sexualized women condition, instead, no cluster was significant ($p_s > .040$).

ERD in the low-beta frequency band (12–18 Hz)

No significant main effect or interaction occurred ($p_s > .21$).

ERD in the high-beta frequency band (18–30 Hz)

No significant main effect or interaction occurred ($p_s > .10$).

3.2.4 | Relationship between power in the mu band and dispositional ratings

No significant correlations emerged between the subscales of the IRI and BBS and the power in the two clusters for non-sexualized (painful–non-painful) and sexualized women (painful–non-painful; $p > .61$).

4 | DISCUSSION

Empathy plays a critical role in preventing aggressive behaviors and sexual violence (Pacilli et al., 2017; Rudman & Mescher, 2012; Vasquez et al., 2017). Previous neuroimaging evidence showed that emphatic reactions to social pain are reduced for sexualized women compared with non-sexualized women (Cogoni, Carnaghi, & Silani, 2018), making empathy a possible candidate to explain the harmful relation between sexual objectification and violence (Gervais & Eagan, 2017). Our study extends this body of research by examining the impact of sexual objectification on empathy for physical pain. Specifically, we sought to delve more deeply into the behavioral and neurobiological mechanisms underlying the vicarious experience of physical pain when the target is a sexualized versus a non-sexualized woman.

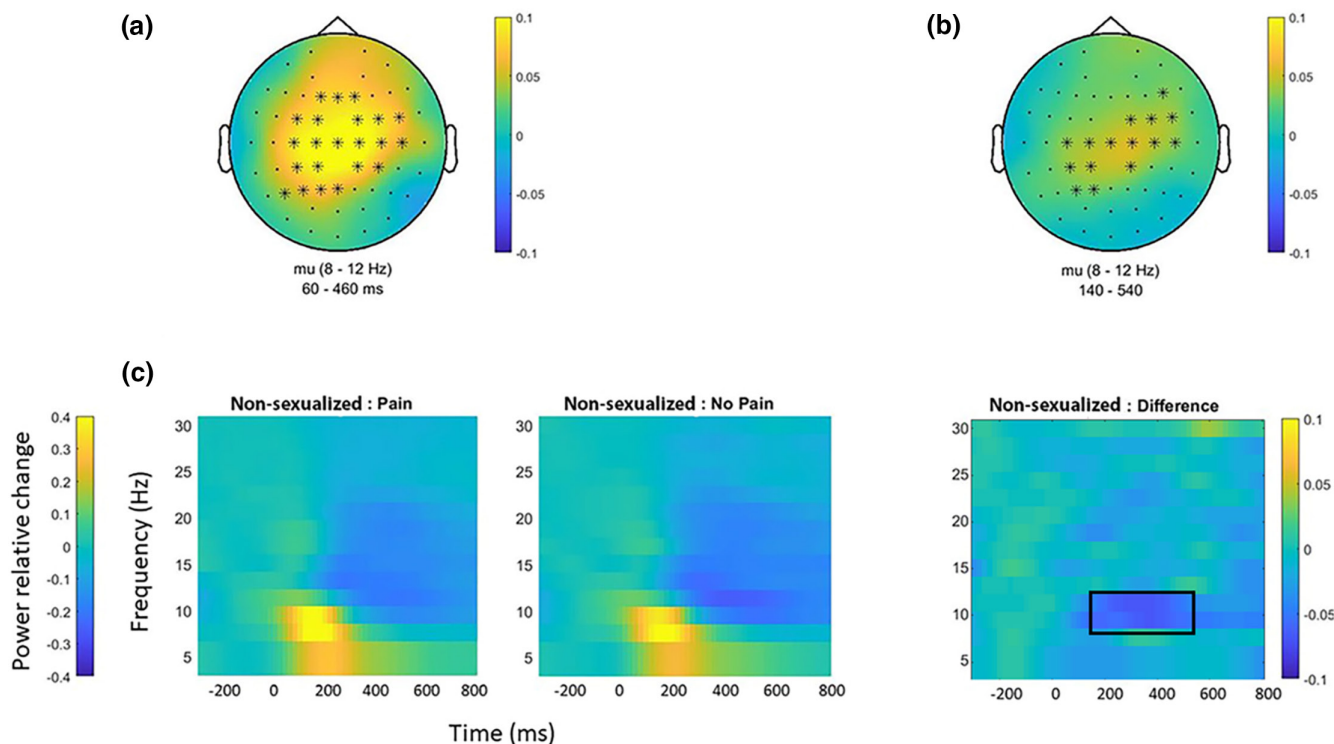


FIGURE 5 Interaction of stimulation by sexualization in the Time-frequency analysis. (a) Topography representation of the significant positive cluster emerged in the interaction between non-sexualized (painful–non-painful) and sexualized (painful–non-painful) conditions. The topographies display the power of the mu band (8–12 Hz) in the interval 60–460 ms. The electrodes highlighted (*) were part of the cluster for more than 50% of samples: F1, Fz, F2, FC3, FC1, FCz, FC2, FC4, FC6, C3, C1, C2, C4, C6, CP3, CP1, CP2, P5, P3, P1, Pz, Cz. (b) Topography representation of the positive cluster emerged in the follow-up for the non-sexualized women condition (painful–non-painful). The topographies display the power of the mu band (8–12 Hz) in the time interval of 140–540 ms. The electrodes highlighted (*) were part of the cluster for more than 50% of samples: F6, FC2, FC4, FC6, C3, C1, C2, C4, C6, CP3, CP1, CP2, P3, P1, Cz. (c) Power spectral representation as a function of pain in non-sexualized condition. The black rectangle reflects time frequency coordinates of the positive cluster revealing the significant differences between non-painful and painful in non-sexualized women condition. Time-frequency power spectra were obtained by averaging activity in the electrodes displayed in (b).

Behavioral results showed that the images displaying a syringe stimulation were evaluated as more painful than the images displaying a q-tip stimulation, confirming that the painful and non-painful conditions were successfully distinguished. Interestingly, sexualized women were evaluated as experiencing less pain than non-sexualized women regardless of the type of stimulation. This result suggests that sexualized women are deemed less touch-sensitive than non-sexualized women (see also Loughnan et al., 2010 for similar results), although the fact that they are more undressed and the increased visibility of their skin might have potentially led to perceive increased physical sensitivity (Gray et al., 2011). Such a decrease in pain experience for sexualized women occurred in the face of an equal emotional evaluation of sexualized and non-sexualized models' faces, proving no influence of the emotional expression of the models on the pain evaluation.

Neural results corroborated and extended behavioral ones showing that the perception of vicarious physical pain is lacking for sexualized women. Indeed, in both

ERP and time-frequency analyses, the distinction between painful and non-painful stimulation exclusively held when women were not sexualized. More specifically, ERP results showed that during the early 200 ms (P2) after stimulus onset the mean amplitude over parieto-occipital sites increased for painful stimulation relative to non-painful stimulation, but only in non-sexualized women. As for the neural oscillations, the time-frequency analysis revealed that in the mu frequency band over central electrodes, ERD for non-painful stimulation tended to be larger than ERD for painful stimulation in a time interval ranging from 140 to 540 ms after stimulus onset. Again, this effect occurred only for non-sexualized women.

The overall consistency of these results is important since it represents the first clear evidence that sexual objectification affects neuro-behavioral mechanisms related to empathy for physical pain. Moreover, these results are complementary with previous findings that demonstrated a diminished empathy for social pain toward sexually objectified women (Cogoni, Carnaghi, & Silani, 2018).

Finally, these results are in line with previous reports emphasizing that mind and humanness perceptions—noticeably reduced in sexualized contexts (Loughnan et al., 2010; Rudman & Mescher, 2012; Vaes et al., 2011), are crucial for empathy to occur (Vaes et al., 2016; Zaki, 2014). In this light, empathic mechanisms for sexualized women resemble those occurring in other dehumanizing contexts, like racial disparities (Zhou & Han, 2021).

An increased amplitude in early ERP components due to the perception of vicarious experiences of painful compared with non-painful stimulation has been largely reported (Decety et al., 2010; Fan & Han, 2008). Reflecting the same pattern that emerged for sexualized women in our study, the pain-related modulations on early ERPs have proven to decrease for other-race individuals (Fabi & Leuthold, 2018; Sessa, Meconi, Castelli, & Dell'Acqua, 2014) and non-human entities (e.g., cartoons, Fan & Han, 2008, or robots, Suzuki et al., 2015). It is worth noticing that empathic neural responses to expressions of pain (vs. neutral situations) are modulated by the racial identity already at 100–400 ms after stimulus onset (Han et al., 2016; Sheng et al., 2013; Sheng & Han, 2012).

Empathic ERP modulations occurring at around 200 ms are considered to reflect the affective stage of empathy, in which the observer shares the vicarious emotional state (Decety & Lamm, 2006; Fan & Han, 2008). Therefore, the modulation of this early ERP component, the P2, by the interaction of pain and sexualization in our study can indicate that sexually objectifying information is processed rapidly (see also Bernard et al., 2018), mirroring the automaticity of the bottom-up component of empathy described as an early effect in the context of racial bias studies (Fabi & Leuthold, 2018; Sessa, Meconi, Castelli, & Dell'Acqua, 2014). That this effect occurred in parieto-occipital sites instead of typical fronto-central ones is not uncommon (Fabi & Leuthold, 2018; Fan & Han, 2008). To note, previous EEG studies found that the effect of sexual objectification affects neural responses in parieto-occipital sites, although in different experimental contexts (Bernard et al., 2018; Vaes et al., 2019). In addition, an increased posterior positive deflection at 200 ms has been reported in response to negative emotional stimuli (Carretié et al., 2001; Meng et al., 2009) indicating that the findings of a positive P2 shift for non-sexualized women can also be indicative of a greater negative valence or threatening perception of these stimuli (Dennis & Chen, 2007). This is coherent with the overall higher pain evaluation for non-sexualized women at a behavioral level.

Besides this first interpretation of a bottom-up modulation of the affective empathic stage, the results of this study allow us to draw a more complex picture of the time course of the empathic processes. More specifically, a vast literature (Decety et al., 2010; Fan & Han, 2008; Meng

et al., 2013; Sessa, Meconi, & Han, 2014, see Coll, 2018 for a meta-analysis) has reported that the top-down component of empathy for physical pain is linked to later ERP components reflected in a positive shift in P3 for painful rather than non-painful stimuli. In our study, instead, the later ERP was qualified by a negative, relative to a more positive deflection (i.e. the N3). Yet, this component was not modulated by pain, whereas sexual objectification influenced it by increasing its negativity. A negative deflection around 300 ms in parieto-occipital electrodes is not new in the dehumanizing context, but the top-down empathy component is usually not affected by race or humanity biases (Coll, 2018; Contreras-Huerta et al., 2014; Fan & Han, 2008). Indeed, Fan and Han (2008), reported a similar long negative deflection after a posterior P2 for pictures of humans as well as their cartoon version.

A potential interpretation of the null effect of pain on the N3 in the backdrop of the significant effect of sexual objectification is twofold. On the one hand, it can be due to the combination of the salience of the painful information (Schiano Lomoriello et al., 2018) and the type of social stimuli used (Li et al., 2019). Indeed, modulations of empathy-related ERPs disappear when the painful stimulus size is reduced (a manipulation adopted to increase social distance), (Schiano Lomoriello et al., 2018). Literature studies on empathy for physical pain usually use cropped emotional faces or zoomed body parts as stimuli. In our study, instead, we used models' bodies from head to waist, which increases the human stimulus' complexity and possibly dampens the visibility of the stimulation. Although not affecting the accuracy in recognizing painful and non-painful stimuli, the salience of the stimulation might have been reduced and the attention shifted toward the images' social information such as the models' sexualization. As a consequence, the sexual objectification effect resulted to be stronger than the effect of the pain stimulation in affecting the later N3 component. Alternatively—or in addition to these perceptual aspects—the absence of a pain modulation in a later ERP component may be due to the fact that in specific social contexts, like sexual objectification, the cognitive empathic component of the process occurs earlier, overlapping with the affective empathic components (Miller et al., 2020). The current brain oscillation results seem to foster this second hypothesis and bring new light to the still limited and mixed literature on how empathy is encoded by brain oscillations.

The perception of others' pain, relative to a non-painful control condition, has been usually associated with decreased ERD in alpha (Mu et al., 2008) and mu bands (Cheng et al., 2008; Whitmarsh et al., 2011; Yang et al., 2009). In the race bias context, Fabi and Leuthold (2018) reported increased beta ERD for painful relative to the neutral condition, but they failed in finding

an effect of race, whereas other authors found that beta ERD for painful stimuli increased in ingroup rather than in outgroup conditions (Riečanský et al., 2015). Importantly, a recent magnetoencephalographic study provided evidence that same-race painful, versus a non-painful stimulation was associated with an early decreased mu ERD (Zhou & Han, 2021) mirroring the decreased pain-related mu ERD for non-sexualized women in our study. The authors found that the conjunction effect of pain and race gradually spanned over the praecuneus/parietal cortices to the insula and temporoparietal junction (TPJ). Although they remarked that this effect occurred earlier than usual, its brain localization has been interpreted as an indication that the mu band and related brain areas undergo top-down attentional control. The TPJ is especially involved in the cognitive component of empathy, underpinning perspective-taking and a self-other distinction (Frith & Frith, 2001; Miller et al., 2020; Shamay-Tsoory, 2011; Zaki & Ochsner, 2012). In addition, a previous study found that empathic top-down mechanisms may down-modulate the mu frequency band (Hoenen et al., 2013). Based on this evidence, we speculate that the cognitive component of empathy may have been anticipated in our study and/or overlapped with the affective one.

The associations between EEG early responses to pain and individual differences provided further support in this sense. We found that the neural response (i.e., P2) to pain in the parieto-occipital site (i.e., Oz) negatively correlated with the BBS score only for non-sexualized women, suggesting that people with high beliefs on stereotypical masculine sexuality reacted to the painful stimulation of the non-sexualized woman as if it was less negative. Also, the P2 amplitude (in POz) increased as the spontaneous tendency to adopt another person's psychological viewpoint was higher (perspective-taking subscale of the IRI), but not for sexualized women. Since perspective-taking has been suggested to play a pivotal role in aggressive interpersonal behavior (Richardson et al., 1994) and, more directly, in empathy (Decety & Lamm, 2006), the reduced involvement of this empathic mechanism reinforces our interpretation of a reduced pain-empathy response toward sexualized women. In studies investigating the race bias influence on empathy (Fabi & Leuthold, 2018; Sessa, Meconi, Castelli, & Dell'Acqua, 2014), the empathic concern IRI subscale was found to correlate with early ERP components elicited by own-race stimuli, strengthening the interpretation of an association between the early-affective component of empathy and the modulation of early ERPs. In our study, then, the association between early P2 and perspective-taking, usually related to the later, cognitive aspect of empathy, may be unexpected (Galang et al., 2021; Li & Han, 2010). However, some authors suggest that mechanisms underlying perspective-taking can

be automatic (Iacoboni et al., 2005), or highly spontaneous, occurring rapidly, unconsciously, and involuntarily. In addition, other authors provided recent evidence that neural correlates of perspective-taking are also involved in affective aspects of empathy (Miller et al., 2020), suggesting that affective and cognitive components of empathy are not so strictly independent. Both hypotheses account for the present findings, consistently explaining our behavioral, electrophysiological, and correlational results. Some authors (Decety & Lamm, 2006; Fan & Han, 2008) put forward a model of empathy for pain in which an early (~200 ms), automatic emotional processing stage is followed by a later (>300 ms), more controlled, processing stage. However, those sexualization and other dehumanizing-related evaluations (Fabi & Leuthold, 2018; Fan & Han, 2008; Sessa, Meconi, Castelli, & Dell'Acqua, 2014; Sheng et al., 2013; Zhou & Han, 2021) modulate early ERPs and an early mu frequency band challenges this model mining the hypothesis of a strict distinction between these two stages, especially in temporal terms.

Although this study is one of the few aiming at understanding the perceiver's empathy in the context of sexual objectification, it does not come without limitations. First, the sexualized stimuli are potentially more intrinsically salient than the non-sexualized ones, and this might have influenced the attention allocated to the stimulation (painful and non-painful) and consequently the empathy elicited toward the sexualized women. It has already been shown, through the help of eye-tracking devices, that when sexualized stimuli are visually processed, an attention shift occurs from the face toward other body parts (Cogoni, Carnaghi, Mitrovic, et al., 2018; Cogoni, Carnaghi, & Silani, 2018) and we have no reason to believe the sexualized images of this study would elicit a different process. However, the "Pain Intensity Evaluation" results indicate that similar amount of attention was directed toward both sexualized and non-sexualized stimuli, since the elicited intensity was similar when displayed with painful stimulations. Most likely, participants had enough time to focus on the stimulation in both conditions excluding the confounding effect of the sexualized stimuli in the task execution. A follow-up study having a stimulus's pain categorization task versus a task where categorization is based on a non-stimulus's pain characteristics (e.g., a colored border as used in Vaes et al., 2019), could provide supportive evidence on the role of attention on the empathy for pain when the target is sexually objectified. Second, the relationship between ERP components and dispositional ratings is discussed as uncorrected for multiple comparisons. For this reason, their interpretation can only be classified as speculative and further investigations using a bigger sample size are warranted to confirm our current interpretation.

5 | CONCLUSION

To conclude, the importance of the present findings is twofold: We provided evidence that specific social contexts may affect the distinction between the early-affective and later-cognitive components of empathy for others' physical pain, yielding a potential overlap. Since the distinction between the time course of the two empathy components goes beyond the primary interests of the current study, future research should verify this hypothesis in more detail in the context of sexual objectification and other related contexts, further clarifying the relative independence of these two empathic phases. Most importantly, we provided the first evidence that the neuropsychological responses to the vicarious experience of *physical* pain are dampened or even absent for sexualized women. This paves the way to better understand the relationship between sexual objectification and sexual violence (Blake et al., 2018; Loughnan et al., 2013; Pacilli et al., 2017; Rudman & Mescher, 2012; Vasquez et al., 2017) in terms of reduced empathy for physical pain (Gervais & Eagan, 2017).

AUTHOR CONTRIBUTIONS

Carlotta Cogoni: Conceptualization; data curation; funding acquisition; investigation; methodology; project administration; writing – original draft. **Bianca Monachesi:** Data curation; formal analysis; visualization; writing – original draft. **Veronica Mazza:** Resources; supervision; writing – review and editing. **Alessandro Grecucci:** Supervision; writing – review and editing. **Jeroen Vaes:** Funding acquisition; project administration; resources; supervision; writing – review and editing.

ACKNOWLEDGMENTS

We thank Massimo Vescovi for his assistance in the experiment set-up and programming, Tommaso Mastropasqua for his invaluable help in the data analysis, and Lavinia Miriam Pedretti and Fabio Cipresso for their assistance during data collection.

FUNDING INFORMATION

The work was supported by grants from the Fundação para a Ciência e Tecnologia (FCT) Ref. EXPL/PSI-GER/1148/2021 to C.C. and the grant from the Italian Ministry of University and Research (Excellence Department Grant awarded to the Department of Psychology and Cognitive Science, University of Trento, Italy) to B.M. This work was also supported by the FCT's UIDB/00645/2020 grant.

CONFLICT OF INTEREST STATEMENT


None.

DATA AVAILABILITY STATEMENT

Materials and data for the experiment are available online at the link <https://osf.io/2c6ts>.

ORCID

Carlotta Cogoni  <https://orcid.org/0000-0001-9029-0096>

Alessandro Grecucci  <https://orcid.org/0000-0001-6043-2196>

Jeroen Vaes  <https://orcid.org/0000-0003-2256-2453>

REFERENCES

- Bernard, P., Cogoni, C., & Carnaghi, A. (2020). The sexualization-objectification link: Sexualization affects the way people see and feel toward others. *Current Directions in Psychological Science*, 29(2), 134–139. <https://doi.org/10.1177/0963721419898187>
- Bernard, P., Rizzo, T., Hoonhorst, I., Deliëns, G., Gervais, S. J., Eberlen, J., Bayard, C., Deltenre, P., Colin, C., & Klein, O. (2018). The neural correlates of cognitive objectification: An ERP study on the body inversion effect associated with sexualized bodies. *Social Psychological and Personality Science*, 9(5), 550–559. <https://doi.org/10.1177/1948550617714582>
- Blake, K. R., Bastian, B., & Denson, T. F. (2018). Heightened male aggression toward sexualized women following romantic rejection: The mediating role of sex goal activation. *Aggressive Behavior*, 44(1), 40–49. <https://doi.org/10.1002/ab.21722>
- Carretié, L., Mercado, F., Tapia, M., & Hinojosa, J. A. (2001). Emotion, attention, and the 'negativity bias', studied through event-related potentials. *International Journal of Psychophysiology*, 41(1), 75–85. [https://doi.org/10.1016/S0167-8760\(00\)00195-1](https://doi.org/10.1016/S0167-8760(00)00195-1)
- Cheng, Y., Yang, C. Y., Lin, C. P., Lee, P. L., & Decety, J. (2008). The perception of pain in others suppresses somatosensory oscillations: A magnetoencephalography study. *NeuroImage*, 40, 1833–1840. <https://doi.org/10.1016/j.neuroimage.2008.01.064>
- Cogoni, C., Carnaghi, A., Mitrovic, A., Leder, H., Fantoni, C., & Silani, G. (2018). Understanding the mechanisms behind the sexualized-body inversion hypothesis: The role of asymmetry and attention biases. *PLoS One*, 13(4), e0193944. <https://doi.org/10.1371/journal.pone.0193944>
- Cogoni, C., Carnaghi, A., & Silani, G. (2018). Reduced empathic responses for sexually objectified women: An fMRI investigation. *Cortex*, 99(December), 258–272. <https://doi.org/10.1016/j.cortex.2017.11.020>
- Cogoni, C., Carnaghi, A., & Silani, G. (2020). Reduced shared emotional representations toward women revealing more skin. *Cognition and Emotion*, 1–16, 225–240. <https://doi.org/10.1080/02699931.2020.1826409>
- Coll, M.-P. (2018). Meta-analysis of ERP investigations of pain empathy underlines methodological issues in ERP research. *Social Cognitive and Affective Neuroscience*, 13, 1003–1017. <https://doi.org/10.1093/scan/nsy072>
- Coll, M.-P., Viding, E., Rütgen, M., Silani, G., Lamm, C., Catmur, C., & Bird, G. (2017). Are we really measuring empathy? Proposal for a new measurement framework. *Neuroscience and Biobehavioral Reviews*, 83, 132–139. <https://doi.org/10.1016/j.neubiorev.2017.10.009>
- Contreras-Huerta, L. S., Hielscher, E., Sherwell, C. S., Rens, N., & Cunningham, R. (2014). Intergroup relationships do not

- reduce racial bias in empathic neural responses to pain. *Neuropsychologia*, 64, 263–270. <https://doi.org/10.1016/j.neuropsychologia.2014.09.045>
- Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *JSAS Catalog of Selected Documents in Psychology*, 10, 85.
- Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, 44(1), 113–126. <https://doi.org/10.1037/0022-3514.44.1.113>
- Decety, J., & Lamm, C. (2006). Human empathy through the lens of social neuroscience. *The Scientific World Journal*, 6, 1146–1163. <https://doi.org/10.1100/tsw.2006.221>
- Decety, J., Yang, C. Y., & Cheng, Y. (2010). Physicians down-regulate their pain empathy response: An event-related brain potential study. *NeuroImage*, 50, 1676–1682. <https://doi.org/10.1016/j.neuroimage.2010.01.025>
- Delorme, A., & Makeig, S. (2004). EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, 134(9–21), 9–21. <https://doi.org/10.1016/j.jneumeth.2003.10.009>
- Dennis, T. A., & Chen, C.-C. (2007). Neurophysiological mechanisms in the emotional modulation of attention: The interplay between threat sensitivity and attentional control. *Biological Psychology*, 76(1–2), 1–10. <https://doi.org/10.1016/j.biopsycho.2007.05.001>
- Dvash, J., & Shamay-Tsoory, S. G. (2014). Theory of mind and empathy as multidimensional constructs. *Topics in Language Disorders*, 34, 282–295. <https://doi.org/10.1097/tld.0000000000000040>
- Eisenberg, N., Eggum, N. D., & di Giunta, L. (2010). Empathy-related responding: Associations with prosocial behavior, aggression, and intergroup relations. *Social Issues and Policy Review*, 4(1), 143–180. <https://doi.org/10.1111/J.1751-2409.2010.01020.X>
- Fabi, S., & Leuthold, H. (2018). Racial bias in empathy: Do we process dark- and fair-colored hands in pain differently? An EEG study. *Neuropsychologia*, 114, 143–157. <https://doi.org/10.1016/j.neuropsychologia.2018.04.024>
- Fan, Y., & Han, S. (2008). Temporal dynamic of neural mechanisms involved in empathy for pain: An event-related brain potential study. *Neuropsychologia*, 46, 160–173. <https://doi.org/10.1016/j.neuropsychologia.2007.07.023>
- Frith, U., & Frith, C. (2001). The biological basis of social interaction. *Current Directions in Psychological Science*, 10(5), 151–155. <https://doi.org/10.1111/1467-8721.00137>
- Galang, C. M., Jenkins, M., Fahim, G., & Obhi, S. S. (2021). Exploring the relationship between social power and the ERP components of empathy for pain. *Social Neuroscience*, 16(2), 174–188. <https://doi.org/10.1080/17470919.2021.1886165>
- Gervais, S. J., & Eagan, S. (2017). Sexual objectification: The common thread connecting myriad forms of sexual violence against women. *American Journal of Orthopsychiatry*, 87(3), 226–232. <https://doi.org/10.1037/ort0000257>
- Gray, K., Knobe, J., Sheskin, M., Bloom, P., & Barrett, L. F. (2011). More than a body: Mind perception and the nature of objectification. *Journal of Personality and Social Psychology*, 101(6), 1207–1220. <https://doi.org/10.1037/a0025883>
- Gutsell, J. N., & Inzlicht, M. (2010). Empathy constrained: Prejudice predicts reduced mental simulation of actions during observation of outgroups. *Journal of Experimental Social Psychology*, 46(5), 841–845. <https://doi.org/10.1016/J.JESP.2010.03.011>
- Han, X., Luo, S., & Han, S. (2016). Embodied neural responses to others' suffering. *Cognitive Neuroscience*, 7(1–4), 114–127. <https://doi.org/10.1080/17588928.2015.1053440>
- Heflick, N. A., & Goldenberg, J. L. (2009). Objectifying Sarah Palin: Evidence that objectification causes women to be perceived as less competent and less fully human. *Journal of Experimental Social Psychology*, 45(3), 598–601. <https://doi.org/10.1016/j.jesp.2009.02.008>
- Hein, G., Silani, G., Preuschhoff, K., Batson, C. D., & Singer, T. (2010). Neural responses to ingroup and outgroup members' suffering predict individual differences in costly helping. *Neuron*, 68(1), 149–160. <https://doi.org/10.1016/j.neuron.2010.09.003>
- Hoenen, M., Schain, C., & Pause, B. M. (2013). Down-modulation of mu-activity through empathic top-down processes. *Social Neuroscience*, 8(5), 515–524. <https://doi.org/10.1080/17470919.2013.833550>
- Iacoboni, M., Molnar-Szakacs, I., Gallese, V., Buccino, G., Mazziotta, J. C., & Rizzolatti, G. (2005). Grasping the intentions of others with one's own mirror neuron system. *PLoS Biology*, 3(3), e79. <https://doi.org/10.1371/journal.pbio.0030079>
- Joyal, C. C., Neveu, S. M., Boukhalfi, T., Jackson, P. L., & Renaud, P. (2018). Suppression of sensorimotor alpha power associated with pain expressed by an avatar: A preliminary EEG study. *Frontiers in Human Neuroscience*, 12. <https://doi.org/10.3389/fnhum.2018.00273>
- Kilner, J. M., Marchant, J. L., & Frith, C. D. (2006). Modulation of the mirror system by social relevance. *Social Cognitive and Affective Neuroscience*, 12, 273. <https://doi.org/10.1093/scan/nsl017>
- Kleiner, M., Brainard, D., Pelli, D., Ingling, A., Murray, R., Broussard, C., & Cornelissen, F. (2007). What's new in Psychtoolbox-3? A free cross-platform toolkit for psychophysics with Matlab & GNU/octave. *Perception*, 36(14), 1–16. <http://www.psychtoolbox.org>
- Levy, J., Goldstein, A., Influx, M., Masalha, S., Zagoory-Sharon, O., & Feldman, R. (2016). Adolescents growing up amidst intractable conflict attenuate brain response to pain of outgroup. *Proceedings of the National Academy of Sciences of the United States of America*, 113, 13696–13701. <https://doi.org/10.1073/pnas.1612903113>
- Li, W., & Han, S. (2010). Perspective taking modulates event-related potentials to perceived pain. *Neuroscience Letters*, 469(3), 328–332. <https://doi.org/10.1016/J.NEULET.2009.12.021>
- Li, X., Zhang, Y., Xiang, B., & Meng, J. (2019). Differences between empathy for face and body pain: Cognitive and neural responses. *Brain Science Advances*, 5(4), 256–264. <https://doi.org/10.26599/BSA.2019.9050022>
- Lopez-Calderon, J., & Luck, S. J. (2014). ERPLAB: An open-source toolbox for the analysis of event-related potentials. *Frontiers in Human Neuroscience*, 8(213), 213. <https://doi.org/10.3389/fnhum.2014.00213>
- Loughnan, S., Haslam, N., Murnane, T., Vaes, J., Reynolds, C., & Suitner, C. (2010). Objectification leads to depersonalization: The denial of mind and moral concern to objectified others. *European Journal of Social Psychology*, 40(5), 709–717. <https://doi.org/10.1002/ejsp.755>
- Loughnan, S., Pina, A., Vasquez, E. A., & Puvia, E. (2013). Sexual objectification increases rape victim blame and decreases



- perceived suffering. *Psychology of Women Quarterly*, 37(4), 455–461. <https://doi.org/10.1177/0361684313485718>
- Meng, J., Jackson, T., Chen, H., Hu, L., Yang, Z., Su, Y., & Huang, X. (2013). Pain perception in the self and observation of others: An ERP investigation. *NeuroImage*, 72, 164–173. <https://doi.org/10.1016/j.neuroimage.2013.01.024>
- Meng, X., Yuan, J., & Li, H. (2009). Automatic processing of valence differences in emotionally negative stimuli: Evidence from an ERP study. *Neuroscience Letters*, 464(3), 228–232. <https://doi.org/10.1016/j.neulet.2009.08.064>
- Miller, J. G., Xia, G., & Hastings, P. D. (2020). Right temporoparietal junction involvement in autonomic responses to the suffering of others: A preliminary transcranial magnetic stimulation study. *Frontiers in Human Neuroscience*, 14, 7. <https://doi.org/10.3389/fnhum.2020.00007>
- Motoyama, Y., Ogata, K., Hoka, S., & Tobimatsu, S. (2017). Frequency-dependent changes in sensorimotor and pain affective systems induced by empathy for pain. *Journal of Pain Research*, 10, 1317–1326. <https://doi.org/10.2147/JPR.S129791>
- Mu, Y., Fan, Y., Mao, L., & Han, S. (2008). Event-related theta and alpha oscillations mediate empathy for pain. *Brain Research*, 1234, 128–136. <https://doi.org/10.1016/j.brainres.2008.07.113>
- 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. <https://doi.org/10.1016/j.neuroimage.2008.08.014>
- Oostenfeld, R., Fries, P., Maris, E., & Schoffelen, J. M. (2011). FieldTrip: Open source software for advanced analysis of MEG, EEG, and invasive electrophysiological data. *Computational Intelligence and Neuroscience*, 2011, 1–9. <https://doi.org/10.1155/2011/156869>
- Pacilli, M. G., Pagliaro, S., Loughnan, S., Gramazio, S., Spaccatini, F., & Baldry, A. C. (2017). Sexualization reduces helping intentions towards female victims of intimate partner violence through mediation of moral patiency. *British Journal of Social Psychology*, 56(2), 293–313. <https://doi.org/10.1111/bjso.12169>
- Perry, A., Bentin, S., Bartal, I. B. A., Lamm, C., & Decety, J. (2010). “Feeling” the pain of those who are different from us: Modulation of EEG in the mu/alpha range. *Cognitive, Affective, & Behavioral Neuroscience*, 10, 493–504. <https://doi.org/10.3758/CABN.10.4.493>
- Ploner, M., Gross, J., Timmermann, L., Pollok, B., & Schnitzler, A. (2006). Oscillatory activity reflects the excitability of the human somatosensory system. *NeuroImage*, 32, 1231–1236. <https://doi.org/10.1016/j.neuroimage.2006.06.004>
- Richardson, D. R., Hammock, G. S., Smith, S. M., Gardner, W., & Signo, M. (1994). Empathy as a cognitive inhibitor of interpersonal aggression. *Aggressive Behavior*, 20(4), 275–289. [https://doi.org/10.1002/1098-2337\(1994\)20:4<275::AID-AB2480200402>3.0.CO;2-4](https://doi.org/10.1002/1098-2337(1994)20:4<275::AID-AB2480200402>3.0.CO;2-4)
- Riečanský, I., Paul, N., Kölbl, S., Stieger, S., Lamm, C., Riečanský, I., Paul, N., Kölbl, S., Stieger, S., & Lamm, C. (2015). Beta oscillations reveal ethnicity ingroup bias in sensorimotor resonance to pain of others. *Social Cognitive and Affective Neuroscience*, 10, 893–901. <https://doi.org/10.1093/scan/nsu139>
- Rudman, L. A., & Mescher, K. (2012). Of animals and objects: Men’s implicit dehumanization of women and likelihood of sexual aggression. *Personality and Social Psychology Bulletin*, 38(6), 734–746. <https://doi.org/10.1177/0146167212436401>
- Schiano Lomoriello, A., Meconi, F., Rinaldi, I., & Sessa, P. (2018). Out of sight out of mind: Perceived physical distance between the observer and someone in pain shapes observer’s empathic reactions. *Frontiers in Psychology*, 9, 1824. <https://doi.org/10.3389/fpsyg.2018.01824>
- Sessa, P., Meconi, F., Castelli, L., & Dell’Acqua, R. (2014). Taking one’s time in feeling other-race pain: An event-related potential investigation on the time-course of cross-racial empathy. *Social Cognitive and Affective Neuroscience*, 9, 454–463. <https://doi.org/10.1093/scan/nst003>
- Sessa, P., Meconi, F., & Han, S. (2014). Double dissociation of neural responses supporting perceptual and cognitive components of social cognition: Evidence from processing of others’ pain. *Scientific Reports*, 4(1), 7424. <https://doi.org/10.1038/srep07424>
- Shamay-Tsoory, S. G. (2011). The neural bases for empathy. *The Neuroscientist*, 17, 18–24. <https://doi.org/10.1177/1073858410379268>
- Sheng, F., & Han, S. (2012). Manipulations of cognitive strategies and intergroup relationships reduce the racial bias in empathic neural responses. *NeuroImage*, 61, 786–797. <https://doi.org/10.1016/j.neuroimage.2012.04.028>
- Sheng, F., Liu, Y., Zhou, B., Zhou, W., & Han, S. (2013). Oxytocin modulates the racial bias in neural responses to others’ suffering. *Biological Psychology*, 92(2), 380–386. <https://doi.org/10.1016/j.biopsycho.2012.11.018>
- Simon, J. C., & Gutsell, J. N. (2021). Recognizing humanity: Dehumanization predicts neural mirroring and empathic accuracy in face-to-face interactions. *Social Cognitive and Affective Neuroscience*, 16(5), 463–473. <https://doi.org/10.1093/SCAN/NSAB014>
- Snell, W. E., Fisher, T. D., & Walters, A. S. (1993). The multidimensional sexuality questionnaire: An objective self-report measure of psychological tendencies associated with human sexuality. *Annals of Sex Research*, 6(1), 27–55. <https://doi.org/10.1007/BF00849744>
- Suzuki, Y., Galli, L., Ikeda, A., Itakura, S., & Kitazaki, M. (2015). Measuring empathy for human and robot hand pain using electroencephalography. *Scientific Reports*, 5, 15924. <https://doi.org/10.1038/srep15924>
- Vaes, J., Cristoforetti, G., Ruzzante, D., Cogoni, C., & Mazza, V. (2019). Assessing neural responses towards objectified human targets and objects to identify processes of sexual objectification that go beyond the metaphor. *Scientific Reports*, 9(1), 6699. <https://doi.org/10.1038/s41598-019-42928-x>
- Vaes, J., Meconi, F., Sessa, P., & Olechowski, M. (2016). Minimal humanity cues induce neural empathic reactions towards non-human entities. *Neuropsychologia*, 89, 132–140. <https://doi.org/10.1016/j.neuropsychologia.2016.06.004>
- Vaes, J., Paladino, P., & Puvia, E. (2011). Are sexualized women complete human beings? Why men and women dehumanize sexually objectified women. *European Journal of Social Psychology*, 41(6), 774–785. <https://doi.org/10.1002/ejsp.824>
- van Elk, M., van Schie, H. T., Hunnius, S., Vesper, C., & Bekkering, H. (2008). You’ll never crawl alone: Neurophysiological evidence for experience-dependent motor resonance in infancy. *NeuroImage*, 43, 808–814. <https://doi.org/10.1016/j.neuroimage.2008.07.057>
- Vasquez, E. A., Ball, L., Loughnan, S., & Pina, A. (2017). The object of my aggression: Sexual objectification increases physical aggression toward women. *Aggressive Behavior*, 44, 5–17. <https://doi.org/10.1002/ab.21719>

- Whitmarsh, S., Nieuwenhuis, I. L. C., Barendregt, H. P., & Jensen, O. (2011). Sensorimotor alpha activity is modulated in response to the observation of pain in others. *Frontiers in Human Neuroscience*, 5, 91. <https://doi.org/10.3389/fnhum.2011.00091>
- Yang, C. Y., Decety, J., Lee, S., Chen, C., & Cheng, Y. (2009). Gender differences in the mu rhythm during empathy for pain: An electroencephalographic study. *Brain Research*, 1251, 176–184. <https://doi.org/10.1016/j.brainres.2008.11.062>
- Zaki, J. (2014). Empathy: A motivated account. *Psychological Bulletin*, 140(6), 1608–1647. <https://doi.org/10.1037/a0037679>
- Zaki, J., & Ochsner, K. N. (2012). The neuroscience of empathy: Progress, pitfalls and promise. *Nature Neuroscience*, 15(5), 675–680. <https://doi.org/10.1038/nn.3085>
- Zhang, Z. (2019). Spectral and time-frequency analysis. In *EEG signal processing and feature extraction* (pp. 89–116). Springer Singapore.
- Zhou, Y., & Han, S. (2021). Neural dynamics of pain expression processing: Alpha-band synchronization to same-race pain but desynchronization to other-race pain. *NeuroImage*, 224, 117400. <https://doi.org/10.1016/j.neuroimage.2020.117400>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Data S1.

How to cite this article: Cogoni, C., Monachesi, B., Mazza, V., Grecucci, A., & Vaes, J. (2023). Neural dynamics of vicarious physical pain processing reflect impaired empathy toward sexually objectified versus non-sexually objectified women. *Psychophysiology*, 60, e14400. <https://doi.org/10.1111/psyp.14400>