Check for updates

Received: 17 June 2023 | Revised: 27 December 2023 | Accepted: 1 March 2024

DOI: 10.1111/psyp.14568

PSYCHOPHYSIOLOGY SPR WILEY

ORIGINAL ARTICLE

Gender effect in affective processing: Alpha EEG source analysis on emotional slides and film-clips

Zaira Romeo[1] | **Alessandro Angrilli**[1,2] | **Chiara Spironelli**[1,2]

[1]Department of General Psychology, University of Padova, Padova, Italy

[2]Padova Neuroscience Center, University of Padova, Padova, Italy

Correspondence
Chiara Spironelli, Department of General Psychology, University of Padova, Padova, Italy.
Email: chiara.spironelli@unipd.it

Funding information
Italian Ministry for University and Research (MIUR), Grant/Award Number: 20178NNRCR_003; Department of General Psychology

Abstract

Past research on gender-related brain asymmetries in emotions was limited and not univocal. The present study analyzed EEG alpha activity (indexing cortical deactivation) from 64 scalp sites in 20 women and 20 men during a counterbalanced block presentation of emotional slides and short video-clips. Stimuli consisted of 45 brief clips of 13 s, divided into 15 erotic (pleasant), 15 neutral and 15 fear (unpleasant) contents. Slides consisted in 45 photo shots (presented for 13 s each) extracted from the videos. As expected, women perceived fear stimuli as more arousing and more unpleasant compared to men. Alpha EEG source analysis revealed gender effects depending on stimulus. Emotional film-clips elicited in both groups a pattern of greater right than left occipital activation. Instead, emotional pictures activated opposite occipital regions, as women showed greater activation in the left, men in the right hemisphere. Men also showed greater activation to Erotic compared to Fear stimuli (i.e., pictures/clips) in the posterior parietal complex. Results point to the relevance of emotional stimulus type to reveal gender effects: clips are ecological, dynamic and engaging, and forced a unified pattern of emotional responses that reset individual differences. Emotional pictures, less engaging, allowed individual differences to emerge and interact with the stimulus category.

KEYWORDS

emotion, pictures, sex difference, sLORETA, video clips

1 | INTRODUCTION

Experiencing emotions is characterized by a series of behavioral, cognitive and physiological changes (Matsumoto & Hwang, 2012; Phelps, 2004; Vuilleumier, 2005), and it is supported by specific neural substrates. Functional neuroimaging studies showed that several regions, within both hemispheres, are recruited during the processing of pleasant and unpleasant emotional information including, among other brain areas, amygdala, insula, anterior cingulate, temporal and visual areas (Davidson & Irwin, 1999; Lane & Nadel, 2002; Phan et al., 2002). At electrophysiological level, EEG alpha asymmetry has been widely investigated as a marker of emotional experience and psychopathology (for a review, see Reznik & Allen, 2018). In particular, it has been proposed that the processing of positive and negative emotions might be associated with frontal hemispheric asymmetry (Davidson, 1979) and that frontal EEG asymmetry might underly the motivational tendencies to approach and withdrawal (Harmon-Jones, 2003; Harmon-Jones et al., 2010). However, other contributions showed that emotions modulate the cortical activity of both slow and fast frequency bands (Balconi & Lucchiari, 2006; de Cesarei & Codispoti, 2011; Maffei et al., 2019; Müller

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.
© 2024 The Author(s). *Psychophysiology* published by Wiley Periodicals LLC on behalf of Society for Psychophysiological Research.

et al., 1999; Sarlo et al., 2005). Although these findings increased our knowledge on the emotional brain organization, the heterogeneity of results left many questions unanswered. The differences emerged in the last decades of research (e.g., engagement of left versus right regions; contribution of different EEG rhythms) may depend on the kind of stimuli used for inducing emotional reactions (e.g., pictures, faces, clips). Notably, the presentation of static pictures and dynamic clips elicited different EEG patterns of activation in the same group of participants (Romeo et al., 2022). Moreover, ecological and multimodal materials (e.g., movie clips) are more effective in prompting subjective and physiological emotional responses compared to images (Gross & Levenson, 1995; Palomba et al., 2000; Rottenberg et al., 2007; Schaefer et al., 2010). Another crucial aspect in the study of emotions is participants' gender. Most of the behavioral and psychophysiological results report the average emotional responses of men and women, without considering gender as covariate or providing separate analyses for controlling for the possible gender bias. However, gender-specific differences were widely documented in several fields, including neuroanatomy/functional connectivity (Biswal et al., 2010; Ingalhalikar et al., 2014; Kret & De Gelder, 2012; Tomasi & Volkow, 2012), hormonal levels (Bianchin & Angrilli, 2012; Kret & De Gelder, 2012), cognitive functioning (Hirnstein et al., 2019; Young et al., 2013; Zell et al., 2015), social behavior (Eagly & Wood, 1991; Troisi, 2001), empathy (Hoffman, 1977; Schulte-Rüther et al., 2008) and also emotional psychophysiological responses (Bianchin & Angrilli, 2012; Brebner, 2003; Kemp et al., 2004; Kret & De Gelder, 2012; Whittle et al., 2011; Wrase et al., 2003).

Perception of salient stimuli from the environment is fundamental for attributing meaning to situations, for recognizing a particular emotion and for identifying affective states in other people. The idea that men and women could process information in a different way is thus particularly relevant for the study of emotions. We can therefore assume that, in the same emotional context, subjective responses are influenced by gender, resulting in different behaviors and neural activation. However, it is also possible that only particular emotional states (pleasant or unpleasant) elicit greater reactions in one group (men vs. women) compared to the other, and this could be supported by increased/decreased activity in similar brain areas or could be the result of activation in other set of regions. Behavioral results showed advantages in women compared to men in perceiving facial expressions, prosody, and in emotional detection tasks (Montagne et al., 2005; Neff & Karney, 2005; Rosip & Hall, 2004). In addition, women reported more intense reactions to unpleasant materials (e.g., fear, traumatic or stressful stimuli) than men (Bianchin & Angrilli, 2012; Lang et al., 1993; Whittle et al., 2011). Nevertheless, other studies assessed similar behavioral performance (e.g., valence/arousal ratings for aversive stimuli) in men and women groups, but found out distinct neural activation (Domes et al., 2010; Williams et al., 2005). In particular, women exhibited greater activity than men in the amygdala, right middle frontal gyrus, right dorsolateral prefrontal cortex and left middle temporal gyrus (Domes et al., 2010; Williams et al., 2005). Another study also found greater brain activity in women than men for negative pictures, but in the anterior and medial cingulate (Wrase et al., 2003). On contrary, other findings showed that fear-inducing pictures mainly activated the left fusiform gyrus and amygdala (bilaterally) in men compared to women (Schienle et al., 2005). Considering pleasant emotional visual stimuli, men showed stronger activity in the left amygdala, in bilateral inferior and medial frontal gyrus, fusiform gyrus (Wrase et al., 2003) as well as anterior cingulate, medial frontal gyrus, superior frontal gyrus and superior temporal gyrus (right hemisphere only) (Fine et al., 2009). Electrophysiological data also suggests that, taken out common processes, between men and women distinct brain responses can distinguish their emotional processing. For example, an event-related potential study found greater amplitude and longer latency of late positive component in women compared to men during the processing of happy and sad faces (Orozco & Ehlers, 1998). A recent study focusing on early and late ERP components (the P1 and P300) showed gender-related asymmetries during automatic emotional processing only: greater P1 amplitude of right vs. left parietal sites was observed for women, and bilateral activation for men, almost for each emotional category (Romeo & Spironelli, 2023). Moreover, unpleasant visual stimuli elicited higher N100 and N200 amplitude (in midline and left hemisphere electrodes) for women compared to men (Lithari et al., 2010). Other results showed that negative pictures induce larger P300 amplitude in women's left hemisphere and in men's right hemisphere (Gasbarri et al., 2007). It has been also proposed that EEG asymmetry might support gender differences in emotional processing, with a significantly greater relative right activation for emotional vs. non-emotional stimuli, only for females (Davidson et al., 1976). Notably, some fMRI and EEG studies showed that men and women responses to affective materials can be influenced by the gender of the actors represented in the experimental stimuli, thus suggesting that also stimuli gender – usually neglected – must be important in emotional research (for a review see Kret & De Gelder, 2012).

Overall, the above-mentioned results indicated that emotional processing in men and women is supported by specific and distinct electrophysiological mechanisms (e.g., amplitude of ERP components). However, to the

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

best of our knowledge, EEG bands power modulation of emotional information was less investigated in male and female populations, in particular, with respect to alpha asymmetry. To address this gap, we carried out an EEG experiment in which both men and women viewed pleasant/unpleasant emotional and neutral stimuli (pictures and clips). We matched the two groups for age, education level and trait empathy, to control for possible confounding effects on emotional processing. Moreover, the presentation of both static pictures and dynamic film clips allowed us to test how gender differences are facilitated or canceled by a particular modality. The brain activation induced by our experimental manipulation was assessed through data-driven source localization analysis in the range of alpha frequency band, with the purpose to explore its symmetric or asymmetric distribution in male and female brains. Based on previous evidence, we expected to observe a different alpha activation between groups and conditions (Davidson et al., 1976). Source localization was computed by means of sLORETA, the most widely used approach in the field because of its accuracy and speed of computation (Asadzadeh et al., 2020; Pascual-Marqui, 2002). sLORETA is also widely used in emotional research (Ertl et al., 2013; Maffei et al., 2019; Romeo et al., 2022; Romeo & Spironelli, 2023).

The present study aims to investigate the behavioral and neural responses elicited by emotional static and dynamic contents in groups of men and women. In particular, our experimental design allows to better understand whether positive and negative emotions elicit distinct reactions in men and women and whether these differences are also supported by specific neural correlates.

2 | MATERIALS AND METHODS

2.1 | Participants

Two hundred and sixty-four young adults completed an online questionnaire, consisting in demographical, medical information and psychological indices. Starting from this pool of subjects, we excluded the not-heterosexual participants because of the presence of only heterosexual couples in our pleasant (erotic) emotional stimuli. Participants with neurological/psychiatric disorders or specific phobias (e.g., phobia for arms, knifes, blood) were also dropped. Forty subjects (20 females, mean age: years, ±2.69; 20 males, mean age: years, ±2.69) with normal or corrected-to-normal vision were recruited and gave their written informed consent to take part in the study, according to the Declaration of Helsinki. The sample size was determined using the G-power software, considering an a priori effect size of 0.75 for the ANOVA, repeated measures, within-between interaction.[1] The experimental procedure was approved by the Ethics Committee of the Department of General Psychology (University of Padova) (protocol n. 3886).

2.2 | Behavioral measures

The online screening consisted in a series of batteries assessing both phobias and empathy traits. Participants were asked to complete the short Italian version of the Fear Survey that include items referring to situations or things that may cause unpleasant feelings (e.g., animals, social stimuli, tissue damage or illness) (Wolpe & Lang, 1964). The internal consistency coefficients were all, without any exception, of high magnitude (Cronbach's alpha ranging between 0.75 to 0.90) for the Italian validation (Arrindell et al., 2003) For the assessment of empathic traits, all participants filled the Interpersonal Reactivity Index (IRI) questionnaire, consisting in 4 subscales: *empathic concern*, *personal distress*, *fantasy*, and *perspective taking* (PT) (Davis, 1983). Notably, the test–retest reliability values ranged between 0.61 and 0.81 over a 60/75-day interval, and the internal consistency Cronbach's alpha ranged between 0.68 and 0.79 for the total score and the four IRI subscales, according to the Italian validation of the Interpersonal Reactivity Index (Albiero et al., 2006). A separate score was computed for each subscale and their sum contributed to the total IRI score. The day of the EEG experiment, participants were also administered three additional questionnaires: the State–Trait Anxiety Inventory Y (STAI Y) 1 and 2, measuring the state and trait anxiety, respectively (Spielberger et al., 1983) and the Positive and Negative Affect Schedule (PANAS), measuring the participants' positive and negative feelings (Watson et al., 1988). The latter was repeated at the end of the experiment for assessing eventual mood changes induced by our emotional stimuli. All these questionnaires showed reliable internal consistency coefficients, the STAI Cronbach's alpha ranging from 0.86 to 0.95 (Spielberger et al., 1983), and the PANAS Cronbach's alpha being 0.89 (95% CI = 0.88–0.90) for the PA scale, and 0.85 (95% CI = 0.84–0.87) for the NA scale (Crawford & Henry, 2004).

[1]The effect size of 0.75 was a priori set-up considering the results found in a previous sample of young adults, who participated in another experiment with emotional pictures (i.e., Romeo & Spironelli, 2023). The gender (men/women) by stimulus (erotic/neutral/fear) interactions were significant for both SAM dimensions, i.e., valence and arousal, leading to Cohen's *d* effect sizes of 0.792 and 0.996. An a priori effect size of 0.75 is, therefore, justified.

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

2.3 | Experimental paradigm

The experiment was carried out in a dedicated EEG laboratory. As EEG data were collected during the Covid-19 pandemic, participants were requested to wear face masks for the whole experimental setting. Experimenters wore face masks with eye shields, and gloves during the procedure that allowed them to prepare each participant for EEG recording.

The experimental procedure was the same applied in the study by Romeo et al. (2022) and consisted in the passive viewing of static and dynamic stimuli from two emotional categories: pleasant (i.e., erotic scenes) or unpleasant (i.e., fear scenes), as well as neutral stimuli (e.g., scenes representing landscapes, documentaries, or daily activities) as control condition. As mentioned above, pleasant stimuli represented images or short clips of erotic heterosexual couples, engaged in a sexual intercourse. On the contrary, in most of the fear stimuli (13 out of 15) the person who threatened was a man, while the person threatened was a woman. This particular aggressor/victim imbalanced ratio depends on the existing filmography on thriller/horror contents, in which women are typically the predestinated victims. Indeed, the short clips come from commercial movies or documentaries, whereas the static images represented a screenshot of each movie. This was done to obtain comparable levels of the visual components of the stimuli (e.g., brightness, contrast, color levels) in both conditions. Stimuli were all presented for 13 s to keep the duration constant in the static and dynamic conditions. Both pictures and clips conditions consisted of 45 stimuli (15 neutral, 15 erotic, and 15 fear). After each image/clip presentation, participants were asked to judge the valence and the arousal elicited by each stimulus using the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) and pressing a digit ranging from 1 (low valance/arousal) to 9 (high valence/arousal) in a numeric keypad. After each rating, a new stimulus appeared on the screen (for details, Romeo et al., 2022). Importantly, no sounds were presented during the static images' appearance, however in the emotional (i.e., erotic and fear) clips we kept the original audio, while neutral clips had a musical score only. The static and dynamic conditions were counterbalanced between subjects: the first 20 participants first viewed the pictures and then the movie clips, while the remaining 20 participants first viewed the movie clips and then the pictures.

2.4 | EEG data recording and preprocessing

During emotional stimuli presentation, EEG cortical activity was recorded using a standard 64 channels cap (Acticap, Brain Product system). EEG was collected in DC mode and the activity of each electrode was online referred to FCz. The sampling rate was set at 1000 Hz and the impedance was kept below 5 kΩ. Data were off-line re-referenced to the average reference, and the activity of FCz was reconstructed. The triangulation and linear interpolation method, implemented in the Brain Vision Analyzer software (Brain Products GmbH, Germany), was used for the interpolation of bad channels. Signal analyses were carried out using Brainstorm toolbox (Tadel et al., 2019) and included: (i) data filtering using a band-pass filter (lower cutoff = 0.5 Hz; upper cutoff = 125 Hz; stop band attenuation = 60 db); (ii) independent component analysis (ICA) to identify artifactual components (method = Infomax EEGLAB/RunICA); (iii) the removal of components associated with eye artifacts (blinks, horizontal and vertical eye movements); (iv) artifact-free data segmentation in epochs of 2 s, to obtain up to 6 epochs for each stimulus (as we analyzed 12 out of 13 seconds of both pictures and clips); (v) the removal of residual noise using a peak-to-peak procedure (−150 to +150 μV) that reject the entire epoch; (vi) data visual inspection. Preliminarily, we also decided to analyze Alpha power effects at the sensor level (e.g., Schubring & Schupp, 2021), including condition, stimulus and laterality as factors in separate ANOVAs for men and women (see Appendix S1; in addition, midline sensors were considered in a separate ANOVA including gender, condition and stimulus as factors, see Appendix S1). All valid epochs were exported to be analyzed with the standardized low resolution brain electromagnetic tomography (sLORETA) method (Pascual-Marqui, 2002).

2.5 | Behavioral and EEG analyses

Sociodemographic data (age and handedness) as well as anxiety levels, positive and negative affect (PANAS) and empathy scores were analyzed using separate two-tailed *t* tests, with group (men vs. women) as between-subject factor.

Behavioral data were analyzed using a 2 (conditions: pictures vs. clips) × 3 (stimuli: erotic vs. neutral vs. fear) within-subject ANOVA, with group (men vs. women) as between-subject factor, both for the valence and arousal self-reports. Statistics were computed using the Statistica software, version 6.1 (StatSoft GmbH). Post-hoc comparisons were performed using the Newman–Keuls method ($p < .05$), and the Greenhouse–Geisser correction was applied when necessary ($df > 2$).

Neural sources were estimated within the alpha rhythm (8–12 Hz) using sLORETA method for qEEG analysis (Pascual-Marqui, 2002). sLORETA estimates the smoothest possible 3D distributed source density solution in gray matter

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

after 5000 permutations. Starting from all good epochs available from each participant and category, a single, 64×64 complex-valued, cross-spectral matrix for each participant and condition was computed for the alpha frequency range. All cross-spectral matrices were then converted in sLORETA transformation matrices to reduce noise associated with measurement, to minimize the dependence of the source current density on individual subjects, and to eliminate components in the EEG spectra that were common to both groups. This transformation algorithm uses the three-shell spherical head model registered to the Talairach Human Brain Atlas (Talairach & Tournoux, 1988) available as MNI coordinates. To localize the effects of the emotional processing in the static and dynamic conditions, we contrasted emotional and neutral stimuli in men and women groups separately, because sLORETA allows users to compare two conditions (or groups) at a time. For each analysis, sLORETA provides a critical threshold value, estimated by 5000 permutations ($p < .05$), that should be achieved or exceeded for obtaining a significant result. We compared the source data, computed by sLORETA as "log of F-ratio", and in Table 2 we reported the threshold value (after 5000 permutations), the actual log of F-ratio value, and the corresponding p value (two-tailed) for each contrast, i.e., fear vs. neutral, erotic vs. neutral and fear vs. erotic stimuli, both for pictures and clip presentations. Significant results are reported in MNI coordinates.

3 | RESULTS

3.1 | Group characteristics

Participants did not differ for age and handedness (details in Table 1). Men and women had similar levels of both state anxiety and trait anxiety, and positive affect (PANAS-PA). On the contrary, negative affect scores (PANAS-NA) were higher in women than men, before and after task execution (Table 1). Considering empathy levels, comparisons of the IRI indices did not show group differences for the total IRI, and for the Fantasy Scale (FS), Empathic Concern (EC) and PT subscales. However, *Personal Distress* levels were statistically marginally significant ($p = .05$), women reaching higher scores compared to men (Table 1).

3.2 | SAM ratings

The ANOVA carried out on the valence dimension showed the main effect of the stimulus ($F_{(2,76)} = 137.61$, $p < .0001$, $\eta^2_p = 0.78$, Cohen's $d = 3.806$). As expected, pleasant contents elicited greater valence scores compared to both neutral and unpleasant ones (all $ps < .001$). The difference between neutral and fear stimuli was also significant, showing greater valence for neutral than unpleasant stimuli ($p < .001$). We also observed an interaction between stimuli and gender ($F_{(2,76)} = 4.34$, $p = .016$, $\eta^2_p = 0.10$, Cohen's $d = 0.676$), showing that both groups provided higher preferences for pleasant than neutral (all $ps < .01$), and in turn, than unpleasant stimuli (all $ps < .001$). However, viewing of fear stimuli resulted in lower valence reported by women relative to men ($p < .01$; Figure 1a).

The ANOVA computed on the arousal judgments revealed the main effect of the stimulus ($F_{(2,76)} = 20.72$, $p < .0001$, $\eta^2_p = 0.35$, Cohen's $d = 1.477$): emotional (erotic and fear) stimuli induced higher self-perceived arousal compared to neutral ones (all $ps < .001$). Figure 1b shows the further significant interaction between stimulus

TABLE 1 Mean ± standard deviation (SD) of socio-demographical data, anxiety levels, positive and negative affect scores, and empathy scores separated for men and women.

	Men ($n = 20$)	Women ($n = 20$)	Statistics	*p*-value
Age	22.40 ± 2.41 years	23.45 ± 2.91 years	$t_{(38)} = -1.24$	n.s.
Handedness	71.50 ± 32.54	78.62 ± 28.02	$t_{(38)} = -0.74$	n.s.
STAI-Y1	32.55 ± 4.36	32.45 ± 7.24	$t_{(38)} = 0.05$	n.s.
STAI-Y2	39.20 ± 9.28	41.00 ± 10.17	$t_{(38)} = -0.58$	n.s.
PANAS-PA (before)	32.60 ± 5.75	32.55 ± 7.53	$t_{(38)} = 0.02$	n.s.
PANAS-NA (before)	19.10 ± 5.36	23.00 ± 6.25	$t_{(38)} = -2.12$	$p = .04$
PANAS-PA (after)	30.40 ± 5.59	31.50 ± 7.99	$t_{(38)} = -0.50$	n.s.
PANAS-NA (after)	17.50 ± 5.93	22.60 ± 7.65	$t_{(38)} = -2.35$	$p = .02$
IRI (total)	96.00 ± 10.15	100.7 ± 8.40	$t_{(38)} = -1.59$	n.s.
Fantasy Scale (FS)	24.95 ± 3.73	25.65 ± 4.26	$t_{(38)} = -0.55$	n.s.
Empathic Concern (EC)	27.20 ± 3.44	28.90 ± 3.01	$t_{(38)} = -1.66$	n.s.
Perspective Taking (PT)	26.80 ± 3.97	26.80 ± 3.89	$t_{(38)} = 0.00$	n.s.
Personal Distress (PD)	17.05 ± 4.33	19.35 ± 2.62	$t_{(38)} = -2.03$	$p = .05$

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

TABLE 2 Within group sLORETA analysis computed for each group (men/women), condition (pictures/clips) and comparison (fear vs. neutral, erotic vs. neutral, and fear vs. erotic stimuli).

Contrast	Threshold value (5000 perm., $p < .05$)	Log of *F*-ratios	*p* value (two-tailed)	MNI coordinates			Anatomical label
				X	*Y*	*Z*	
Fear vs. neutral pictures							
Men	0.187	−0.237	<.001	20	−85	5	Right V2 (BA 18)
Women	0.183	−0.229	<.001	−15	−90	15	Left V2 (BA 18)
Erotic vs. neutral pictures							
Men	0.250	−0.319	<.001	25	−75	10	Right V1 (BA 17)
Women	0.170	−0.260	<.001	−20	−90	15	Left V2 (BA 18)
Fear vs. erotic pictures							
Men	0.159	0.239	<.001	−15	−45	50	Left Precuneus (BA7)
Women	0.211	0.147	N.S.	−5	−50	50	Left Precuneus (BA7)
Fear vs. neutral clips							
Men	0.151	−0.227	<.001	15	−80	15	Right V2 (BA 18)
Women	0.194	−0.307	<.001	20	−95	15	Right V2 (BA 18)
Erotic vs. neutral clips							
Men	0.223	−0.373	<.001	25	−75	15	Right visual-associative area (BA 31)
Women	0.243	−0.376	<.001	15	−90	15	Right V2 (BA 18)
Fear vs. erotic clips							
Men	0.243	0.244	.049	15	−45	40	Right dorsal PCC (BA 31)
Women	0.278	0.270	N.S.	−15	−50	50	Left Precuneus (BA7)

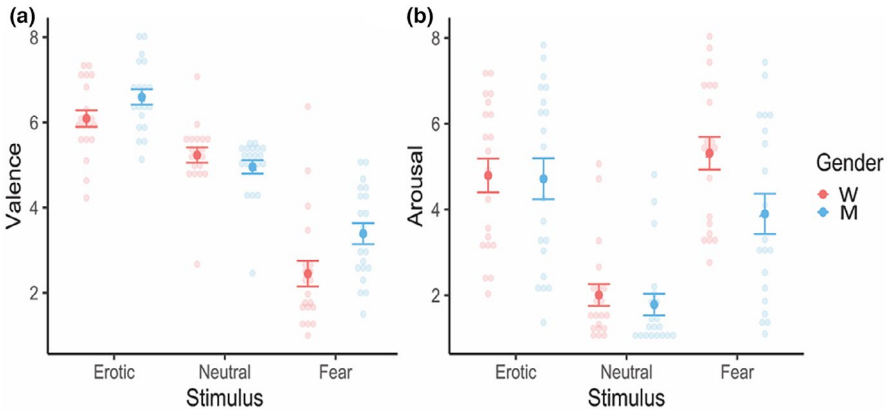

FIGURE 1 Subjective evaluations assessed with the Self-Assessment Manikin (SAM), showing (a) the valence and (b) the arousal scores to erotic, neutral and fear stimuli in men (sky) and women (pink). Bars represent standard errors (SE).

and gender ($F_{(2,76)} = 4.22$, $p = .018$, $\eta^2_p = 0.10$, Cohen's $d = 0.666$). In particular, arousal was greater for erotic and fear stimuli compared to neutral ones in both groups (all $ps < .001$), but women reported increased arousal for unpleasant pictures/clips than men ($p < .001$; Figure 1b).

3.3 | Correlations with IRI scores

The results of the ANOVA analysis suggests that unpleasant stimuli are the only ones that elicited different responses in the two groups of participants: indeed, women reported lower valence and higher arousal than men to fear pictures and clips. In view of that, IRI individual scores were post hoc correlated with the SAM self-reports (valence and arousal for fear pictures and clips), corrected with Bonferroni method. Results showed a significant negative correlation between women's PT scores and the valence associated to fear clips ($r_{(18)} = -.55$, $p = .044$). In other words, the greater the women's ability to take on the point of views of other people, the lower the subjective pleasantness levels perceived during fear dynamic stimuli watching (Figure 2).

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

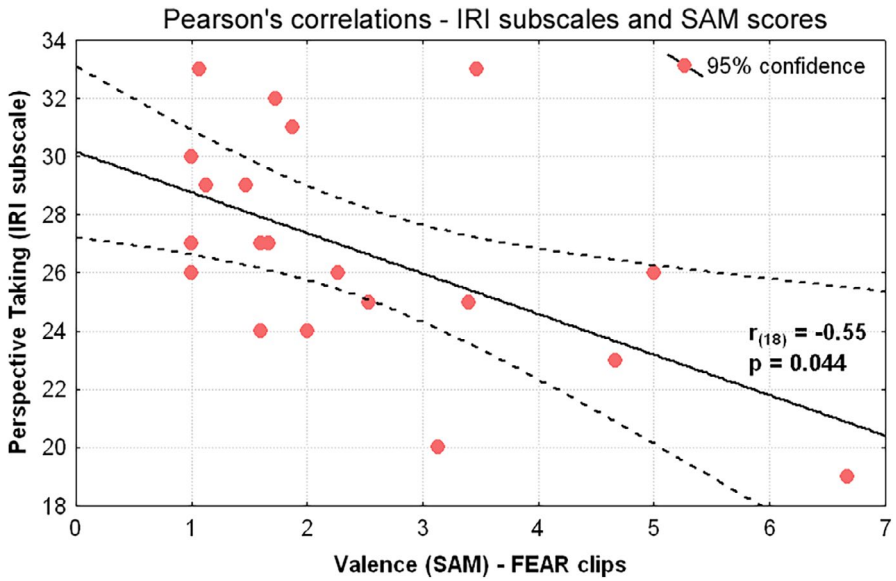

FIGURE 2 Women's significant Pearson correlations between the PT (IRI) subscale scores and SAM valence ratings to fear clips.

No significant correlations were found for men group.

3.4 | EEG source localization[2]

A within group sLORETA analysis was computed for each condition (static vs. dynamic) and for each stimuli comparison (fear vs. neutral, erotic vs. neutral, and fear vs. erotic) (Table 2; Figures 3 and 4).

In the men group, the contrast between fear neutral and stimuli showed lower alpha activity (i.e. indexing greater cortical arousal) in the right secondary visual area for both fear pictures ($p < .001$) and fear clips ($p < .001$) compared to neutral ones (Table 2 and Figure 3, panel a in sky). However, women showed lower alpha in the left secondary visual area for fear than neutral pictures ($p < .001$) and in the right secondary visual area ($p < .001$) for fear than neutral clips (Table 2 and Figure 3, panel a in pink).

The contrast between pleasant and neutral contents revealed similar results (Figure 3, panel b): men showed lower alpha in the right primary area for erotic vs. neutral pictures ($p < .001$) and in the right visual associative area for erotic than neutral clips ($p < .001$) (Table 2 and Figure 3, panel b in sky), whereas women reported lower alpha in the left secondary visual area for erotic vs. neutral images ($p < .001$) and in the right secondary visual area for erotic compared to neutral clips ($p < .001$) (Table 2 and Figure 3, panel b in pink). Figure 4 also shows the contrast between the two emotional stimuli, revealing significantly higher alpha rhythm during unpleasant than pleasant emotional processing in the men group only (Table 2).

In particular, fear pictures elicited greater alpha amplitude in the left precuneus ($p < .001$), whereas fear clips induced greater alpha than erotic clips in the right dorsal posterior cingulate cortex ($p < .001$) (Table 2 and Figure 4, in sky). No significant results emerged for women group (Table 2 and Figure 4, in pink).

4 | DISCUSSION

The present study investigated the gender effect on emotional processing from behavioral and electrophysiological perspectives. Our aim was to clarify if particular emotional states produce similar or different responses in men and women and to identify the neural underpinnings of the emotional experience. We also aimed to investigate whether ecological naturalistic stimuli represented by film clips interact with emotional content and gender. In general, we expected the film clips to be more engaging than slides in inducing specific emotions (Romeo et al., 2022). Indeed, pictures presentation is widely used in the emotional research (e.g., IAPS database: Lang et al., 1997), however past literature evidenced that dynamic videos, containing both visual and auditory information, elicit a more ecological, real-to-life, vivid and intense reaction in participants (Gross & Levenson, 1995; Rottenberg et al., 2007). Our analyses provided several results supporting distinct mechanisms underlying emotional processing in men

[2]As some studies (e.g., Messerotti Benvenuti et al., 2019; Schubring & Schupp, 2021) provided evidence of decreased Alpha power in the first second (or 1 second and half) of emotional picture processing compared with neutral images in occipitoparietal sensors (Schubring & Schupp, 2021) we carried out a complimentary analysis of Alpha EEG rhythm on pictures only, considering the first 4 s after stimulus onset to ensure that an atypically long temporal window (i.e., 12-s long) does not alter the source analysis estimation carried out with sLORETA. Results are summarized in Appendix S1.

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

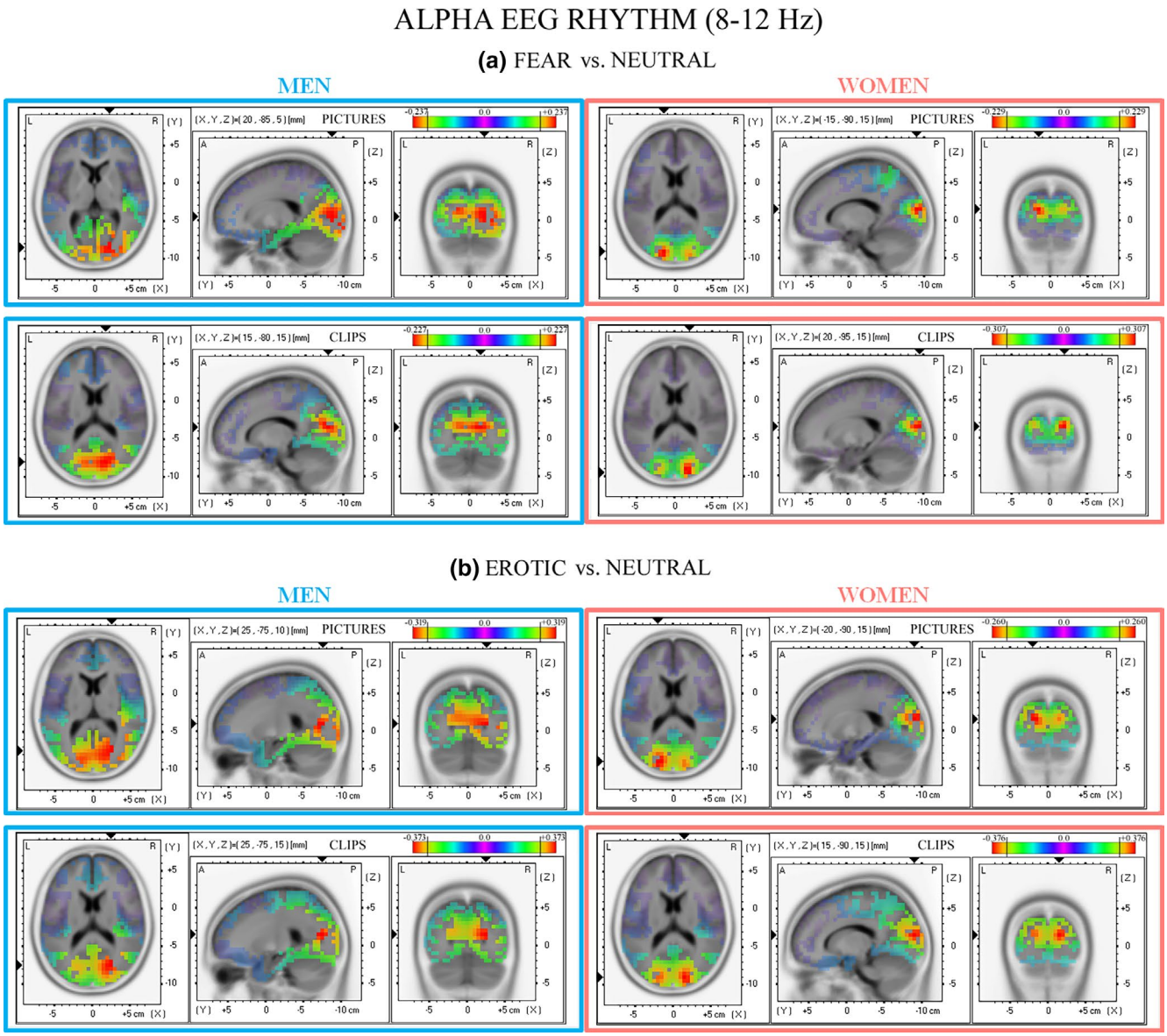

FIGURE 3 Neural source estimation for pictures and clips in Alpha EEG frequency range (8–12 Hz). Each panel shows a different contrast for men (sky color) and women (pink color): (a) fear vs. neutral and (b) erotic vs. neutral stimuli. In each panel, the threshold obtained after 5000 permutation ($p < .05$) is represented with a vertical black line. sLORETA provided the anatomical view showing the maximum log of *F*-ratio value (two-tailed) for each contrast.

and women. In particular, the self-report data, provided after each stimulus presentation, suggest a clear effect of the unpleasant fearful material in discriminating men and women. Men' valence evaluations of fear pictures and clips were significantly higher compared to women, while no group differences in self-reports was found for the Neutral and Erotic categories. Moreover, the analysis of self-perceived arousal showed a consistent pattern of results: women reported greater arousal to fear pictures and clips compared with men. These findings are in line with previous results showing that women perceive negative material as less pleasant and more arousing compared to men (Bianchin & Angrilli, 2012). Similar results were found both using static pictures (i.e., IAPS) (Bradley et al., 2001), but also videoclips (Codispoti et al., 2008). Our data suggest that, regardless of the presentation modality, unpleasant contents (i.e., scenes depicting fear situations or imminent threat), produced lower valence and greater arousal in women relative to men. Viewing a threat scene could prompt the emotional reactions of female viewers who could empathize more with the victim, compared to men. Indeed, most of our threatening stimuli depicted a man and a woman on the same scene, but almost invariably the predestinated victim was the latter. Therefore, the viewer's attention is attracted by the female figure present in the scene. This feature may have

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

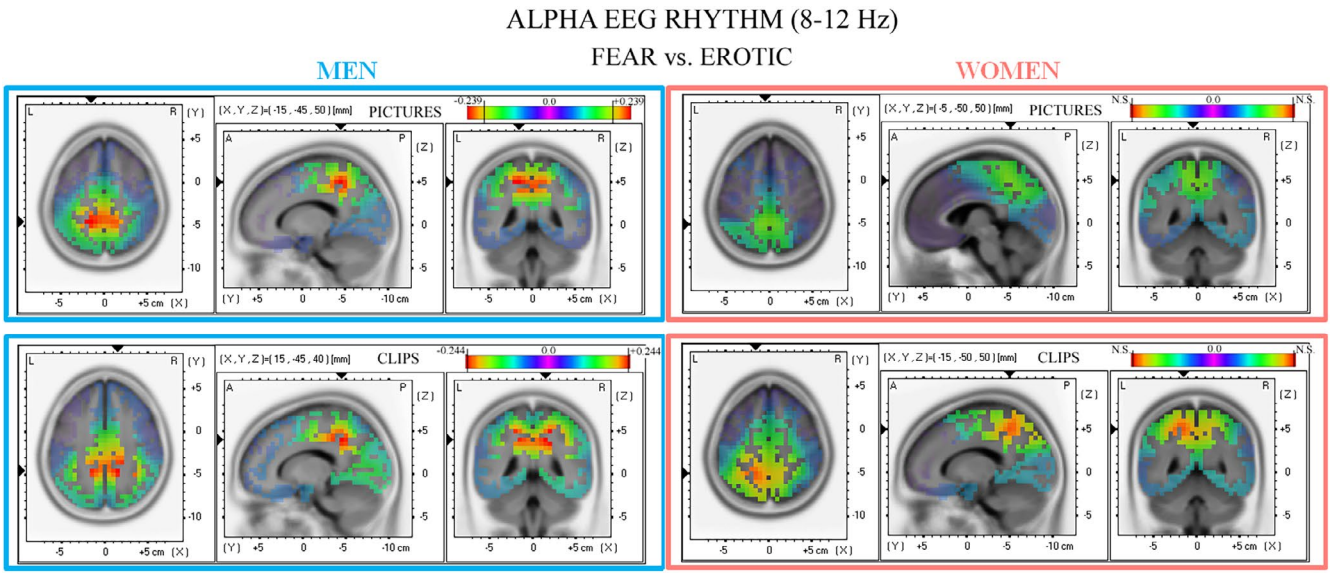

FIGURE 4 Neural source estimation for fear vs. erotic pictures (top panel) and clips (bottom panel) in Alpha EEG frequency range (8–12 Hz) for men (sky color) and women (pink color). In each panel, the threshold obtained after 5000 permutation ($p < .05$) is represented with a vertical black line. sLORETA provided the anatomical view showing the maximum log of *F*-ratio value (two-tailed) for each contrast. Note that results were statistically significant for men only.

fostered identification in our female participants, but not in males. On the other hand, as shown from several databases based on IAPS, men are relatively less reactive to threatening scenes (typically men report lower arousal and greater valence than women). This greater women's sensitivity to unpleasant situations is also supported by the negative correlation found (only in the women group) between valence for fear clips and the PT subscale of IRI test. Given that higher PT score indicates the attitude to adopt the point of view of others, our data supports the idea that women showing this cognitive emphatic trait are more sensitive to unpleasant information and evaluate this kind of stimuli with extremely low valence scores (i.e., greater unpleasantness). Notably, men did not show any correlation between valence/arousal dimension for fear images/clips and their emphatic profile, possibly because for them fear film clips were relatively less engaging than for most women.

Our experimental manipulation evidenced remarkable differences also in the electrophysiological domain. When contrasting neutral and fear stimuli we always found increased alpha power to neutral than to fear stimuli in the two groups. Alpha decreasing for emotional (pleasant and unpleasant) than neutral information was previously observed (Schubring & Schupp, 2019, 2021) and suggests that the processing of emotional, high-arousing stimuli is associated to greater cortical activation compared with neutral material. Indeed, alpha oscillations, at rest and in most passive perception paradigms, reflect cortical inhibition that reduce the processing capability of a specific brain area (Jensen & Mazaheri, 2010). However, while men activated the same region (right secondary visual cortex) during both emotional pictures and emotional clips presentation, women showed a left lateralized activation in the secondary visual cortex for the pictures and a right lateralized activation in the homologous region for the clips. The involvement of visual cortices during emotional processing has been widely documented (Allen et al., 2008; Britton et al., 2006; Kale Edmiston et al., 2013; Lang et al., 1998). In particular, it has been proposed that perception of and attention to salient emotional stimuli is mediated by amygdala that, through to its backward projections, modulates the visual cortex processing (Tamietto & De Gelder, 2010). Our data suggests that both positive and negative emotional stimuli recruit the visual cortices (BA 17, 18, 31), in line with past research with fMRI methods and emotional slides (Lang et al., 1998), while when gender was introduced as variable we observed different patterns of lateralization in the two groups. Hemispheric asymmetries in visual processing are supported by neuroimaging studies showing more abstract/conceptual processing in the left occipital cortex and a more form-specific/perceptual processing in the right occipital cortex (Gazzaniga, 2000; Simons et al., 2003; Stevens et al., 2012; Stevens & Spreng, 2014; Vuilleumier et al., 2002). The main gender differences we found concerned the slide processing as the emotional video clips induced similar emotion-related right occipital activation in the two groups. This points to a strong activation modality-related carried out by the video clips

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

that overcame most gender differences. Thus, most gender differences were found for picture processing, probably because these stimuli are less strong and are not completely tracking the cortical responses, allowing groups to differently elaborate emotional pictures. The right posterior activation in males and the left activation in women to Fear stimuli have been found with Evoked Potentials (P300) also in a past study (Gasbarri et al., 2007), but for pleasant stimuli no significant effects were found. We interpret the right dominant emotional occipital activation observed during film clips in both genders as due to the strong attention grabbing of dynamic moving stimuli which would involve the dorsal visual way (V5 for the movement represented in videoclips) and the right occipito–parietal regions (BA 18).

A further gender effect was found in the direct comparison of Fear vs. Erotic conditions in male group, for which Erotic induced greater cortical activation (i.e., lower alpha amplitude) than fear with both stimulus presentation modalities, while for women there was no difference. This suggests that, for men, erotic stimuli are highly exciting and arousing and, in women, they can be relatively inhibited or at the same level than the unpleasant ones, an effect observed in past studies with emotional pictures or clips (Huynh et al., 2012; Sabatinelli et al., 2004).

This result can be interpreted starting from the evidence that erotic stimuli, in general, induce appetitive action tendency, that is an approach towards the pleasant stimulus. In particular, left precuneus showed higher alpha during fear pictures processing and the right dorsal posterior cingulate cortex showed increased alpha during fear clips processing. A set of regions including left precuneus, the posterior cingulate and the prefrontal areas was found to be involved in the attribution of emotions to the self or others (Ochsner et al., 2004). The dorsal portion of the posterior cingulate (a region strongly connected with the prefrontal cortex) is instead involved in monitoring the focus of attention (Leech & Sharp, 2016). In the present study, men showed reduced activity when viewing negative (fear) stimuli compared to positive (erotic) ones, showing that pictures processing recruits regions associated with attribution of emotional message, while dynamic and more complex clips modulate the activity of a right parietal region involved in attentional control.

Taken together, our findings support the hypothesis that gender can influence the behavioral and neural responses to emotional information. In particular, unpleasant emotions are differently perceived by men and women, in terms of valence and arousal. Moreover, source analysis showed that viewing static pictures and dynamic clips recruits different circuits across genders, with a right occipital activation in men in both conditions and a left (pictures) vs. right (clips) occipital activation in women. These results suggest that men and women elaborate emotional stimuli in different ways and these interact with stimulus modality: while video clips are strong emotional elicitors that recruit right posterior cortices common to men and women (thus tracking emotional processing and canceling gender differences), pictures are weaker stimuli during which sex differences emerged more easily with emotional processing occurring in different hemispheres across genders. Results show the relevance of stimulus modality in evidencing gender differences, a complex interaction that might explain why hemispheric differences across genders were not much consistent among past studies.

AUTHOR CONTRIBUTIONS

Zaira Romeo: Data curation; formal analysis; investigation; methodology; software; writing – original draft. **Alessandro Angrilli:** Conceptualization; methodology; resources; supervision; writing – review and editing. **Chiara Spironelli:** Conceptualization; formal analysis; funding acquisition; resources; supervision; writing – review and editing.

FUNDING INFORMATION

The study was funded by a PRIN grant from the Italian Ministry for University and Research (MIUR) to CS (20178NNRCR_003). This research was also supported by a grant from MIUR (Dipartimenti di Eccellenza DM May 11, 2017 n.262) to the Department of General Psychology.

CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ORCID

Zaira Romeo https://orcid.org/0000-0002-0144-5840
Alessandro Angrilli https://orcid.org/0000-0002-5571-7637
Chiara Spironelli https://orcid.org/0000-0002-8547-2431

REFERENCES

Albiero, P., Ingoglia, S., & Lo Coco, A. (2006). Contributo all'adattamento italiano dell'Interpersonal Reactivity Index. *Testing Psicometria Metodologia*, *13*(2), 107–125.

Allen, P., Larøi, F., McGuire, P. K., & Aleman, A. (2008). The hallucinating brain: A review of structural and functional neuroimaging studies of hallucinations. *Neuroscience and Biobehavioral Reviews*, *32*, 175–191. https://doi.org/10.1016/j.neubiorev.2007.07.012

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Arrindell, W. A., Eisemann, M., Richter, J., Oei, T. P. S., Caballo, V. E., Van Der Ende, J., Sanavio, E., Bagés, N., Feldman, L., Torres, B., Sica, C., Iwawaki, S., Edelmann, R. J., Crozier, W. R., Furnham, A., Hudson, B. L., Aguilar, G., Bentall, R., Bridges, K. R., … Zaldívar, F. (2003). Phobic anxiety in 11 nations: Part I: Dimensional constancy of the five-factor model. *Behaviour Research and Therapy*, *41*(4), 461–479. https://doi.org/10.1016/S0005-7967(02)00047-5

Asadzadeh, S., Yousefi Rezaii, T., Beheshti, S., Delpak, A., & Meshgini, S. (2020). A systematic review of EEG source localization techniques and their applications on diagnosis of brain abnormalities. *Journal of Neuroscience Methods*, *339*, 108740. https://doi.org/10.1016/j.jneumeth.2020.108740

Balconi, M., & Lucchiari, C. (2006). EEG correlates (event-related desynchronization) of emotional face elaboration: A temporal analysis. *Neuroscience Letters*, *392*(1–2), 118–123. https://doi.org/10.1016/j.neulet.2005.09.004

Bianchin, M., & Angrilli, A. (2012). Gender differences in emotional responses: A psychophysiological study. *Physiology and Behavior*, *105*(4), 925–932. https://doi.org/10.1016/j.physbeh.2011.10.031

Biswal, B. B., Mennes, M., Zuo, X. N., Gohel, S., Kelly, C., Smith, S. M., Beckmann, C. F., Adelstein, J. S., Buckner, R. L., Colcombe, S., Dogonowski, A. M., Ernst, M., Fair, D., Hampson, M., Hoptman, M. J., Hyde, J. S., Kiviniemi, V. J., Kötter, R., Li, S. J., … Milham, M. P. (2010). Toward discovery science of human brain function. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(10), 4734–4739. https://doi.org/10.1073/pnas.0911855107

Bradley, M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001). Emotion and motivation II: Sex differences in picture processing. In *Emotion* (Vol. *1*(3), pp. 300–319). American Psychological Association. https://doi.org/10.1037/1528-3542.1.3.300

Bradley, M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49–59. https://doi.org/10.1016/0005-7916(94)90063-9

Brebner, J. (2003). Gender and emotions. *Personality and Individual Differences*, *34*, 387–394. https://doi.org/10.1016/S0191-8869(02)00059-4

Britton, J. C., Taylor, S. F., Sudheimer, K. D., & Liberzon, I. (2006). Facial expressions and complex IAPS pictures: Common and differential networks. *NeuroImage*, *31*(2), 906–919. https://doi.org/10.1016/j.neuroimage.2005.12.050

Codispoti, M., Surcinelli, P., & Baldaro, B. (2008). Watching emotional movies: Affective reactions and gender differences. *International Journal of Psychophysiology*, *69*, 90–95. https://doi.org/10.1016/j.ijpsycho.2008.03.004

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, *43*(3), 245–265.

Davidson, R. (1979). Frontal versus parietal EEG asymmetry during positive and negative affect. *Psychophysiology*, *16*(2), 202–203.

Davidson, R., & Irwin, W. (1999). The functional neuroanatomy of emotion and affective style. *Trends in Cognitive Sciences*, *3*(1), 11–21. https://doi.org/10.7551/mitpress/3077.003.0035

Davidson, R., Schwartz, G. E., Pugash, E., & Bromfield, E. (1976). Sex differences in patterns of EEG asymmetry. *Biological Psychology*, *4*(2), 119–137. https://doi.org/10.1016/0301-0511(76)90012-0

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

de Cesarei, A., & Codispoti, M. (2011). Affective modulation of the LPP and α-ERD during picture viewing. *Psychophysiology*, *48*(10), 1397–1404. https://doi.org/10.1111/j.1469-8986.2011.01204.x

Domes, G., Schulze, L., Böttger, M., Grossmann, A., Hauenstein, K., Wirtz, P. H., Heinrichs, M., & Herpertz, S. C. (2010). The neural correlates of sex differences in emotional reactivity and emotion regulation. *Human Brain Mapping*, *31*(5), 758–769. https://doi.org/10.1002/hbm.20903

Eagly, A. H., & Wood, W. (1991). Explaining sex differences in social behavior: A meta-analytic perspective. *Personality and Social Psychology Bulletin*, *17*(3), 306–315. https://doi.org/10.1177/0146167291173011

Ertl, M., Hildebrandt, M., Ourina, K., Leicht, G., & Mulert, C. (2013). Emotion regulation by cognitive reappraisal – the role of frontal theta oscillations. *NeuroImage*, *81*, 412–421. https://doi.org/10.1016/j.neuroimage.2013.05.044

Fine, J. G., Semrud-Clikeman, M., & Zhu, D. C. (2009). Gender differences in BOLD activation to face photographs and video vignettes. *Behavioural Brain Research*, *201*(1), 137–146. https://doi.org/10.1016/j.bbr.2009.02.009

Gasbarri, A., Arnone, B., Pompili, A., Pacitti, F., Pacitti, C., & Cahill, L. (2007). Sex-related hemispheric lateralization of electrical potentials evoked by arousing negative stimuli. *Brain Research*, *1138*(1), 178–186. https://doi.org/10.1016/j.brainres.2006.12.073

Gazzaniga, M. S. (2000). Cerebral specialization and interhemispheric communication. Does the corpus callosum enable the human condition? *Brain*, *123*(7), 1293–1326. https://doi.org/10.1093/brain/123.7.1293

Gross, J. J., & Levenson, R. W. (1995). Emotion elicitation using films. *Cognition and Emotion*, *9*(1), 87–108. https://doi.org/10.1080/02699939508408966

Harmon-Jones, E. (2003). Clarifying the emotive functions of asymmetrical frontal cortical activity. *Psychophysiology*, *40*(6), 838–848. https://doi.org/10.1111/1469-8986.00121

Harmon-Jones, E., Gable, P. A., & Peterson, C. K. (2010). The role of asymmetric frontal cortical activity in emotion-related phenomena: A review and update. *Biological Psychology*, *84*(3), 451–462. https://doi.org/10.1016/j.biopsycho.2009.08.010

Hirnstein, M., Hugdahl, K., & Hausmann, M. (2019). Cognitive sex differences and hemispheric asymmetry: A critical review of 40 years of research. *Laterality*, *24*(2), 204–252. https://doi.org/10.1080/1357650X.2018.1497044

Hoffman, M. L. (1977). Sex differences in empathy and related behaviors. In *Psychological bulletin* (Vol. *84*(4), pp. 712–722). American Psychological Association. https://doi.org/10.1037/0033-2909.84.4.712

Huynh, H. K., Beers, C., Willemsen, A., Lont, E., Laan, E., Dierckx, R., Jansen, M., Sand, M., Weijmar Schultz, W., & Holstege, G. (2012). High-intensity erotic visual stimuli de-activate the primary visual cortex in women. *The Journal of Sexual Medicine*, *9*(6), 1579–1587. https://doi.org/10.1111/j.1743-6109.2012.02706.x

Ingalhalikar, M., Smith, A., Parker, D., Satterthwaite, T. D., Elliott, M. A., Ruparel, K., Hakonarson, H., Gur, R. E., Gur, R. C., &

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Verma, R. (2014). Sex differences in the structural connectome of the human brain. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(2), 823–828. https://doi.org/10.1073/pnas.1316909110

Jensen, O., & Mazaheri, A. (2010). Shaping functional architecture by oscillatory alpha activity: Gating by inhibition. *Frontiers in Human Neuroscience*, *4*, 186. https://doi.org/10.3389/fnhum.2010.00186

Kale Edmiston, E., McHugo, M., Dukic, M. S., Smith, S. D., Abou-Khalil, B., Eggers, E., & Zald, D. H. (2013). Enhanced visual cortical activation for emotional stimuli is preserved in patients with unilateral amygdala resection. *Journal of Neuroscience*, *33*(27), 11023–11031. https://doi.org/10.1523/JNEUROSCI.0401-13.2013

Kemp, A. H., Silberstein, R. B., Armstrong, S. M., & Nathan, P. J. (2004). Gender differences in the cortical electrophysiological processing of visual emotional stimuli. *NeuroImage*, *21*(2), 632–646. https://doi.org/10.1016/j.neuroimage.2003.09.055

Kret, M. E., & De Gelder, B. (2012). A review on sex differences in processing emotional signals. *Neuropsychologia*, *50*(7), 1211–1221. https://doi.org/10.1016/j.neuropsychologia.2011.12.022

Lane, R. D., & Nadel, L. (2002). *Cognitive neuroscience of emotion*. Oxford University Press.

Lang, P. J., Bradley, M., & Cuthbert, B. N. (1997). *International affective picture system (IAPS): Technical manual and affective ratings*. NIMH Center for the Study of Emotion and Attention.

Lang, P. J., Bradley, M., Fitzsimmons, J. R., Cuthbert, B. N., Scott, J. D., Moulder, B., & Nangia, V. (1998). Emotional arousal and activation of the visual cortex: An fMRI analysis. *Psychophysiology*, *35*(2), 199–210. https://doi.org/10.1017/S0048577298001991

Lang, P. J., Greenwald, M. K., Bradley, M., & Hamm, A. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*(3), 261–273. https://doi.org/10.1111/j.1469-8986.1993.tb03352.x

Leech, R., & Sharp, D. J. (2016). The role of the posterior cingulate cortex in cognition and disease. *Brain*, *137*(1), 12–32. https://doi.org/10.1093/brain/awt162

Lithari, C., Frantzidis, C. A., Papadelis, C., Vivas, A. B., Klados, M. A., Kourtidou-Papadeli, C., Pappas, C., Ioannides, A. A., & Bamidis, P. D. (2010). Are females more responsive to emotional stimuli? A neurophysiological study across arousal and valence dimensions. *Brain Topography*, *23*(1), 27–40. https://doi.org/10.1007/s10548-009-0130-5

Maffei, A., Spironelli, C., & Angrilli, A. (2019). Affective and cortical EEG gamma responses to emotional movies in women with high vs low traits of empathy. *Neuropsychologia*, *133*(May), 107175. https://doi.org/10.1016/j.neuropsychologia.2019.107175

Matsumoto, D., & Hwang, H. S. (2012). Culture and emotion: The integration of biological and cultural contributions. *Journal of Cross-Cultural Psychology*, *43*(1), 91–118. https://doi.org/10.1177/0022022111420147

Messerotti Benvenuti, S., Buodo, G., Mennella, R., Dal Bò, E., & Palomba, D. (2019). Appetitive and aversive motivation in depression: The temporal dynamics of task-elicited asymmetries in alpha oscillations. *Scientific Reports*, *9*(1), 17129. https://doi.org/10.1038/s41598-019-53639-8

Montagne, B., Kessels, R. P. C., Frigerio, E., de Haan, E. H. F., & Perrett, D. I. (2005). Sex differences in the perception of affective facial expressions: Do men really lack emotional sensitivity? *Cognitive Processing*, *6*(2), 136–141. https://doi.org/10.1007/s10339-005-0050-6

Müller, M. M., Keil, A., Gruber, T., & Elbert, T. (1999). Processing of affective pictures modulates right-hemispheric gamma band EEG activity. *Clinical Neurophysiology*, *110*(11), 1913–1920. https://doi.org/10.1016/S1388-2457(99)00151-0

Neff, L. A., & Karney, B. R. (2005). Gender differences in social support: A question of skill or responsiveness? *Journal of Personality and Social Psychology*, *88*(1), 79–90. https://doi.org/10.1037/0022-3514.88.1.79

Ochsner, K. N., Knierim, K., Ludlow, D. H., Hanelin, J., Ramachandran, T., Glover, G., & Mackey, S. C. (2004). Reflecting upon feelings: An fMRI study of neural systems supporting the attribution of emotion to self and other. *Journal of Cognitive Neuroscience*, *16*(10), 1746–1772. https://doi.org/10.1162/0898929042947829

Orozco, S., & Ehlers, C. L. (1998). Gender differences in electrophysiological responses to facial stimuli. *Biological Psychiatry*, *44*(4), 281–289. https://doi.org/10.1016/S0006-3223(97)00487-3

Palomba, D., Sarlo, M., Angrilli, A., Mini, A., & Stegagno, L. (2000). Cardiac responses associated with affective processing of unpleasant film stimuli. *International Journal of Psychophysiology*, *36*(1), 45–57. https://doi.org/10.1016/S0167-8760(99)00099-9

Pascual-Marqui, R. D. (2002). Standardized low resolution brain electromagnetic tomography. *Methods and Findings in Experimental and Clinical Pharmacology*, *24 Suppl D*, 5–12.

Phan, K. L., Wager, T., Taylor, S. F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: A meta-analysis of emotion activation studies in PET and fMRI. *NeuroImage*, *16*, 331–348. https://doi.org/10.1006/nimg.2002.1087

Phelps, E. A. (2004). Human emotion and memory: Interactions of the amygdala and hippocampal complex. *Current Opinion in Neurobiology*, *14*(2), 198–202. https://doi.org/10.1016/j.conb.2004.03.015

Reznik, S. J., & Allen, J. J. B. (2018). Frontal asymmetry as a mediator and moderator of emotion: An updated review. In *Psychophysiology* (Vol. *55*(1)). Blackwell Publishing Inc. https://doi.org/10.1111/psyp.12965

Romeo, Z., Fusina, F., Semenzato, L., Bonato, M., Angrilli, A., & Spironelli, C. (2022). Comparison of slides and video clips as different methods for inducing emotions: An electroencephalographic alpha modulation study. *Frontiers in Human Neuroscience*, *16*, 901422. https://doi.org/10.3389/fnhum.2022.901422

Romeo, Z., & Spironelli, C. (2023). P1 component discloses gender-related hemispheric asymmetries during IAPS processing. *Symmetry*, *15*, 610. https://doi.org/10.3390/sym15030610

Rosip, J. C., & Hall, J. A. (2004). Knowledge of nonverbal cues, gender, and nonverbal decoding accuracy. *Journal of Nonverbal Behavior*, *28*(4), 267–286. https://doi.org/10.1007/s10919-004-4159-6

Rottenberg, J., Ray, R. D., & Gross, J. J. (2007). Emotion elicitation using films. In J. A. Coan & J. J. B. Allen (Eds.), *The handbook of emotion elicitation and assessment*. Oxford University Press, Inc.

Sabatinelli, D., Flaisch, T., Bradley, M., Fitzsimmons, J. R., & Lang, P. J. (2004). Affective picture perception: Gender differences in

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

visual cortex? *Neuroreport*, *15*(7), 1109–1112. https://doi.org/10.1097/00001756-200405190-00005

Sarlo, M., Buodo, G., Poli, S., & Palomba, D. (2005). Changes in EEG alpha power to different disgust elicitors: The specificity of mutilations. *Neuroscience Letters*, *382*(3), 291–296. https://doi.org/10.1016/j.neulet.2005.03.037

Schaefer, A., Nils, F., Philippot, P., & Sanchez, X. (2010). Assessing the effectiveness of a large database of emotion-eliciting films: A new tool for emotion researchers. *Cognition and Emotion*, *24*(7), 1153–1172. https://doi.org/10.1080/02699930903274322

Schienle, A., Schäfer, A., Stark, R., Walter, B., & Vaitl, D. (2005). Gender differences in the processing of disgust- and fear-inducing pictures: An fMRI study. *Neuroreport*, *16*(3), 277–280. https://doi.org/10.1097/00001756-200502280-00015

Schubring, D., & Schupp, H. T. (2019). Affective picture processing: Alpha- and lower beta-band desynchronization reflects emotional arousal. *Psychophysiology*, *56*(8), e13386. https://doi.org/10.1111/psyp.13386

Schubring, D., & Schupp, H. T. (2021). Emotion and brain oscillations: High arousal is associated with decreases in alpha- and lower Beta-band power. *Cerebral Cortex*, *31*(3), 1597–1608. https://doi.org/10.1093/cercor/bhaa312

Schulte-Rüther, M., Markowitsch, H. J., Shah, N. J., Fink, G. R., & Piefke, M. (2008). Gender differences in brain networks supporting empathy. *NeuroImage*, *42*(1), 393–403. https://doi.org/10.1016/j.neuroimage.2008.04.180

Simons, J. S., Koutstaal, W., Prince, S., Wagner, A. D., & Schacter, D. L. (2003). Neural mechanisms of visual object priming: Evidence for perceptual and semantic distinctions in fusiform cortex. *NeuroImage*, *19*, 613–626. https://doi.org/10.1016/S1053-8119(03)00096-X

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety scale*. Consulting Psychologists.

Stevens, W. D., Kahn, I., Wig, G. S., & Schacter, D. L. (2012). Hemispheric asymmetry of visual scene processing in the human brain: Evidence from repetition priming and intrinsic activity. *Cerebral Cortex*, *22*, 1935–1949. https://doi.org/10.1093/cercor/bhr273

Stevens, W. D., & Spreng, R. N. (2014). Resting-state functional connectivity MRI reveals active processes central to cognition. *Wiley Interdisciplinary Reviews: Cognitive Science*, *5*(2), 233–245. https://doi.org/10.1002/wcs.1275

Tadel, F., Bock, E., Niso, G., Mosher, J. C., Cousineau, M., Pantazis, D., Leahy, R. M., & Baillet, S. (2019). MEG/EEG group analysis with brainstorm. *Frontiers in Neuroscience*, *13*, 76. https://doi.org/10.3389/fnins.2019.00076

Talairach, J., & Tournoux, P. (1988). *Co-planar stereotaxic atlas of the human brain 3-dimensional proportional system: An approach to cerebral imaging*. Georg Thieme Verlag, pp. 132.

Tamietto, M., & De Gelder, B. (2010). Neural bases of the non-conscious perception of emotional signals. *Nature Reviews Neuroscience*, *11*(10), 697–709. https://doi.org/10.1038/nrn2889

Tomasi, D., & Volkow, N. D. (2012). Gender differences in brain functional connectivity density. *Human Brain Mapping*, *33*(4), 849–860. https://doi.org/10.1002/hbm.21252

Troisi, A. (2001). Gender differences in vulnerability to social stress: A Darwinian perspective. *Physiology and Behavior*, *73*, 443–449. https://doi.org/10.1016/S0031-9384(01)00459-0

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Sciences*, *9*(12), 585–594. https://doi.org/10.1016/j.tics.2005.10.011

Vuilleumier, P., Henson, R. N., Driver, J., & Dolan, R. J. (2002). Multiple levels of visual object constancy revealed by event-related fMRI of repetition priming. *Nature Neuroscience*, *5*(5), 491–499. https://doi.org/10.1038/nn839

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.4135/9781483398839.n13

Whittle, S., Yücel, M., Yap, M. B. H., & Allen, N. B. (2011). Sex differences in the neural correlates of emotion: Evidence from neuroimaging. *Biological Psychology*, *87*(3), 319–333. https://doi.org/10.1016/j.biopsycho.2011.05.003

Williams, L. M., Barton, M. J., Kemp, A. H., Liddell, B. J., Peduto, A., Gordon, E., & Bryant, R. A. (2005). Distinct amygdala-autonomic arousal profiles in response to fear signals in healthy males and females. *NeuroImage*, *28*(3), 618–626. https://doi.org/10.1016/j.neuroimage.2005.06.035

Wolpe, J., & Lang, P. J. (1964). A fear survey schedule for use in behaviour therapy. *Behaviour Research and Therapy*, *2*(1), 27–30. https://doi.org/10.1016/0005-7967(64)90051-8

Wrase, J., Klein, S., Gruesser, S. M., Hermann, D., Flor, H., Mann, K., Braus, D. F., & Heinz, A. (2003). Gender differences in the processing of standardized emotional visual stimuli in humans: A functional magnetic resonance imaging study. *Neuroscience Letters*, *348*(1), 41–45. https://doi.org/10.1016/S0304-3940(03)00565-2

Young, K. D., Bellgowan, P. S. F., Bodurka, J., & Drevets, W. C. (2013). Functional neuroimaging of sex differences in autobiographical memory recall. *Human Brain Mapping*, *34*(12), 3320–3332. https://doi.org/10.1002/hbm.22144

Zell, E., Krizan, Z., & Teeter, S. R. (2015). Evaluating gender similarities and differences using metasynthesis. In *American psychologist* (Vol. *70*(1), pp. 10–20). American Psychological Association. https://doi.org/10.1037/a0038208

SUPPORTING INFORMATION

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

Figure S1. Spline interpolated maps of Alpha EEG power in the frequency range (8–12 Hz) for fear (left column), neutral (middle column) and erotic (right column) stimuli.

Figure S2. Alpha power analysis at sensor level: significant stimulus × laterality interaction for (a) Men and (b) Women.

Figure S3. Alpha power analysis at sensor level: significant condition × stimulus interaction for women.

Figure S4. Alpha power analysis at midline sensor level: significant gender × stimulus interaction.

Figure S5. Neural sources estimation for pictures in Alpha EEG frequency range (8–12 Hz).

Table S1. Alpha power analysis (at the sensor level) on men's group.

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table S2. Alpha power analysis (at sensor level) on women's group.
Table S3. Alpha power analysis at midline sensor level.
Table S4. Within group sLORETA analysis computed on the first 4 s after stimulus onset, for each group (men/women) and two-emotion comparisons (fear vs. neutral, erotic vs. neutral, and fear vs. erotic stimuli). Only pictures were considered.

How to cite this article: Romeo, Z., Angrilli, A., & Spironelli, C. (2024). Gender effect in affective processing: Alpha EEG source analysis on emotional slides and film-clips. *Psychophysiology*, *61*, e14568. https://doi.org/10.1111/psyp.14568

14698986, 2024, 7, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/psyp.14568 by Cochrane Colombia, Wiley Online Library on [16/10/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License