



## Becoming sexy: Contrapposto pose increases attractiveness ratings and modulates observers' brain activity



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### ABSTRACT

Previous neurophysiological studies have revealed the neural correlates of human body form perception, as well as those related to the perception of attractive body sizes. In the current study we aimed to extend the neurophysiological studies regarding body perception by investigating the perception of human body posture to provide insights into the cognitive mechanisms responsive to bodily form, and the processing of its attractiveness. To achieve these aims, we used the contrapposto posture which creates an exaggeration of low waist to hip ratio (WHR), an indicator of women's attractiveness. Electroencephalogram (EEG) signals were recorded while participants completed both (i) an oddball task presenting female body forms differing in pose (contrapposto vs. standing) and viewing angle (anterior vs. posterior), and (ii) a subsequent active attractiveness judgement task. Behavioral results showed that a contrapposto pose is considered more attractive than a neutral standing pose. Results at the neural level showed that body posture modulates the visual information processing in early ERP components, indicating attentional variations depending on human body posture; as well as in late components, indicating further differences in attention and attractiveness judgement of stimuli varying in body pose. Furthermore, the LORETA results identified the middle temporal gyrus as well as angular gyrus as the key brain regions activated in association with the perception and attractiveness judgment of females' bodies with different body poses. Overall, the current paper suggests the evolutionary adaptive preference for lower WHRs as in the contrapposto pose activating brain regions associated with visual perception and attractiveness judgement.

### 1. Introduction

The human body and its various postures can both represent individuals' affective state (Grammer et al., 2004) and facilitate or influence the perception of emotional expressions (Kret, Stekelenburg, Roelofs, & De Gelder, 2013). Therefore, subtle body postures and nonverbal changes can act as gateways in interpersonal communications and influence the observers' perception (Dael, Mortillaro, & Scherer, 2012; Grammer et al., 2004; Mehrabian, 1969). While there has been research to identify the perception of such changes at the behavioral level, the neural correlates of human body posture perception remains largely unknown.

The extrastriate body area (Downing, Jiang, Shuman, & Kanwisher, 2001; Peelen & Downing, 2007) and fusiform body area (Peelen & Downing, 2005; Schwarzlose, Baker, & Kanwisher, 2005) are located in the extrastriate visual cortex, and they are identified as regions responsive to visual depictions of human body forms. Neurons in the

fusiform body area (FBA) respond selectively to visual depictions of the human whole body, while neurons in the extrastriate body area (EBA) respond to body parts (Taylor, Wiggett, & Downing, 2007). Electro-physiological studies using event-related potentials (ERP) on bodily perception have shown that pictures of the human body (without a head) elicit a negative component peaking at 190 ms (hence N190) after stimulus presentation (Thierry et al., 2006).

Recent studies have shown modulations of neural responses to variations in body size as well as neural responses related to the evaluation of body attractiveness. For example, Platek and Singh (2010) used fMRI and showed that female body configurations activate areas of men's brains that are associated with reward processing and appetitive behaviors. They showed that surgically optimized female waist to hip ratios (WHR) around 0.7 activate orbital frontal cortex, lateral occipital cortex, and the anterior cingulate gyrus (Platek & Singh, 2010; Spicer & Platek, 2010). Holliday and colleagues using computer-generated stimuli reported that body mass index (BMI), but not WHR, modulated

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activity in the higher visual areas and caudate nucleus, which are associated with the brain reward system (Holliday, Longe, Thai, Hancock, & Tovée, 2011). Furthermore, in an event-related potentials (ERP) study investigating the association of different WHRs and the dynamics of brain activation, it has been shown that attractive ratios such as 0.6 and 0.7 had higher amplitudes for the N190 and the late positive component (LPC) of the ERPs than other higher WHR ratios (Del Zotto & Pegna, 2017). Pazhoohi, Arantes, Kingstone and Pinal (2020) investigated the effect of breast size on brain electrical activity as well as the effect of WHR. They highlighted the role of primary and secondary visual cortices as well as fusiform, angular and lingual gyri in attractiveness processing of WHR and breast size with differences observed in early temporal components (e.g., N190), as well as later components (P300 and LPC), indicating differences in attentional and stimulus' categorization processes.

This previous research has mainly considered behavioral and neural correlates of human body attractiveness and human mate preference using photographs of models adopting neutral standing body postures. Nevertheless, in normal social circumstances humans display different postures and use them for non-verbal communication (Dael et al., 2012; Grammer et al., 2004). One such human posture is contrapposto, which is a position of the human body that involves twisting along the vertical axis so that the hips, shoulders, and the head are turned in slightly different directions as the weight is borne by a single leg. The contrapposto pose has captured humans' attention from antiquity to today, as demonstrated by the ubiquitous examples of contrapposto pose in ancient artists' paintings (e.g., *The Birth of Venus* by Sandro Botticelli and *Leda and the Swan* by Cesare da Sesto) and sculptures (e.g., *Venus de Milo* and *Temperance* by Giovanni Caccini) and present day's photos of models and actresses. Indeed, it is noteworthy that goddesses of beauty are often depicted in contrapposto pose in their artistic representations (e.g., *Venus de Milo* and *Aphrodite of Knidos*).

The attractiveness of the contrapposto pose to humans can be explained in the light of a supernormality effect on WHR in such a posture (Derenne, Breitstein, & Cicha, 2008; Doyle, 2009; Pazhoohi, Macedo, Doyle, & Arantes, 2019). The concept of supernormal stimuli refers to those non-natural or artificially exaggerated stimuli that produce greater responsiveness in animals and humans than their natural releasing stimuli, and was introduced to the study of psychology and behavior from ethology more than seven decades ago (Ghirlanda & Enquist, 2003; Staddon, 1975; Tinbergen, 1948). Since then, researchers have investigated this effect for various human physical features. The concept of supernormal stimuli have been considered in the augmentation of facial features such as eyes, lips, and lower face roundness in self-portraiture (Costa & Corazza, 2006), the physical dimensions of breasts (Doyle & Pazhoohi, 2012), WHR silhouettes (Derenne et al., 2008) and photos (Doyle, 2009), as well as from movement patterns such as walking gaits (Doyle, 2009; Morris, White, Morrison, & Fisher, 2013) and proceptive movements (Pazhoohi, Doyle, Macedo, & Arantes, 2018).

In this frame, contrapposto could be considered a posture derived exaggeration of WHR. That is, one side of the contrapposto pose shows higher view-dependent WHR and the other side presents an exaggeratedly low view-dependent WHR. Therefore, as the curvier edge gathers more attention, contrapposto pose artificially creates a greater contrast between high and low view-dependent WHRs, contributing to increase its attractiveness ratings when compared to a standing posture (Pazhoohi et al., 2019). Furthermore, beyond being rated as more attractive than standing stimuli, participants had longer dwell times on lower rather than higher view-dependent WHRs of contrapposto images in an eye-tracking experiment (Pazhoohi et al., 2019).

In the current study, we aim to extend the neurophysiology investigation of human body perception and the supernormality effect of certain postures by examining the behavioral and neurophysiological correlates of the contrapposto pose, providing insights into the cognitive mechanisms responsive to perception of body posture and the

supernormality effects of contrapposto. To this aim, we examine neurophysiological responses to different contrapposto and standing poses through the ERP components elicited by female body forms in healthy heterosexual men and women. Note that women, as well as men, are good evaluators of other women's attractiveness (Fink, Klappauf, Brewer, & Shackelford, 2014). However, previous research has provided neural evidence for a sex difference regarding perception of attractiveness (Cloutier, Heatherton, Whalen, & Kelley, 2008; Hamann, Herman, Nolan, & Wallen, 2004; Rupp & Wallen, 2008; Vartanian, Goel, Lam, Fisher, & Granic, 2013). Therefore, an additional goal of the present work was to investigate potential sex differences in the brain activity associated with processing female body postures. We used an oddball task (Squires, Squires, & Hillyard, 1975) to acquire electroencephalographic (EEG) signals during the perception of female body forms differing in posture (contrapposto or standing) while participants were engaged in a task where body posture was irrelevant. In a subsequent session, participants were asked to rate the attractiveness of the stimuli while EEG signals were recorded. Furthermore, Principal Component Analysis (PCA) was used to objectively and statistically unmask the components of the EEG activity related to viewing and judging the attractiveness of female body forms in the two different postures.

In line with the behavioral study of contrapposto pose effect on perceived attractiveness (Pazhoohi et al., 2019), we hypothesize that contrapposto is considered more attractive than a neutral standing pose. Accordingly, we hypothesize that the contrapposto pose and standing pose would be differently processed as evidenced by amplitudes of both early components associated with visual perception as well as late components signifying cognitive processing.

## 2. Material and methods

### 2.1. Participants

Participants were recruited from University of Minho students and its surrounding community. Those participants that reported history of major psychiatric or neurological disorders, as well as consumption of medication or psychoactive drugs during the month prior to their participation were excluded. Based on a-priori G\*power (Faul, Erdfelder, Lang, & Buchner, 2007) sample size estimations for a mixed ANOVA including within and between subjects factors allowing to detect medium sized effects (Cohen's  $f = 0.25$ ) with a statistical power of 0.8 (note also that sphericity was assumed, very low correlation between measurements  $-0.05$  - was considered, and the alpha level was set to 0.05). Fifty-two heterosexual individuals (28 females) within the age range of 18–37 years old ( $M = 23$ ;  $SD = 4.36$ ) were recruited and completed the experimental session. All participants had normal or corrected to normal vision and received course credit or 10 Euros gift cards in exchange for participation. The experiment was approved by the Ethical Committee of the University of Minho and was conducted in accordance with the Declaration of Helsinki as it pertains to research with human participants.

After participants consented to taking part in the study, they were asked to fill a brief battery of questionnaires; namely, socio-demographic questions; NEO-FFI-20 personality inventory validated in European Portuguese language (Bertoquini & Pais-Ribeiro, 2006), which is a short version of the NEO-PI-R (Costa & McCrae, 1995); Brief Symptoms Inventory (BSI; Derogatis, 1993) validated also in Portuguese (Canavarro, 1999); Edinburgh Handedness Inventory (Oldfield, 1971); and, Graffar Social Classification Scale (GSC; Graffar, 1956). All participants, but one, were right-handed. There were no differences between male and female participants in any of the aforementioned tests (see Table 1).

**Table 1**  
Independent group *t*-test results comparing male and female participants for socio-demographic, personality and neuropsychological variables.

	Male (n = 20)		Female (n = 28)		<i>t</i>	<i>p</i>
	Mean	SD	Mean	SD		
Age (in years)	24.15	5.16	22.18	3.56	1.57	.124
GSC Score	12.95	2.14	13.25	2.08	-.49	.629
Neo-FFI-20						
Neuroticism	7.05	2.19	6.86	2.53	.27	.785
Extraversion	10.70	2.30	9.86	2.03	1.34	.186
Openness	10.70	4.17	11.04	2.43	-.35	.727
Kindness	10.80	2.46	9.93	2.79	1.12	.269
Self-Consciousness	12.80	1.91	12.25	1.62	1.08	.288
BSI						
Global Symptom Index	.43	.25	.52	.38	-.94	.351

## 2.2. Stimuli

The stimuli were generated using DAZ 3D studio version 4.6 (Daz Productions, Inc., Salt Lake City, UT, USA). Four stimuli were generated using a female model with two body poses of contrapposto and standing, and two viewing angles (anterior and posterior). To avoid any possible perceptual one-side bias for the contrapposto pose (i.e. differences between the left and right contrapposto pose), the mirror images of the stimuli were used, so the contrapposto side was counterbalanced with half of the trials showing a right contrapposto pose and half displaying a left contrapposto pose. The mirror images were created by flipping the original stimuli along the vertical midline (see Fig. 1a–d for the example of the stimuli). For the oddball task, another set of stimuli were created with a shawl around the waist of the stimuli (see Fig. 1e for an example). The stimuli were in black and white and their luminance were homogenized to avoid exposure and luminance effects on perception (Pinel, Piazza, Le Bihan, & Dehaene, 2004).

## 2.3. Task design and paradigm

The experiment consisted of two blocks. In the first block, participants completed an oddball task while EEG was recorded. Participants looked at the stimuli varying in body pose and viewing angle, and they were instructed to press the “M” key on the computer’s keyboard whenever they saw a shawl around the waist of the stimuli (oddball event). Standard stimuli were repeated 30 times for a total of 120 standard stimuli trials, while oddball stimuli were repeated 10 times for a total of 40 oddball stimuli trials. Standard and oddball stimuli trials were presented in random order. Each of the task’s trials started with the presentation of a fixation cross in the center of a black background for a jittered interval between 300 and 500 ms, followed by the stimulus presentation in the center of the black screen for 750 ms. Consecutive trials were separated by an inter-trial interval ranging between 900 and 1200 ms during which the fixation cross remains

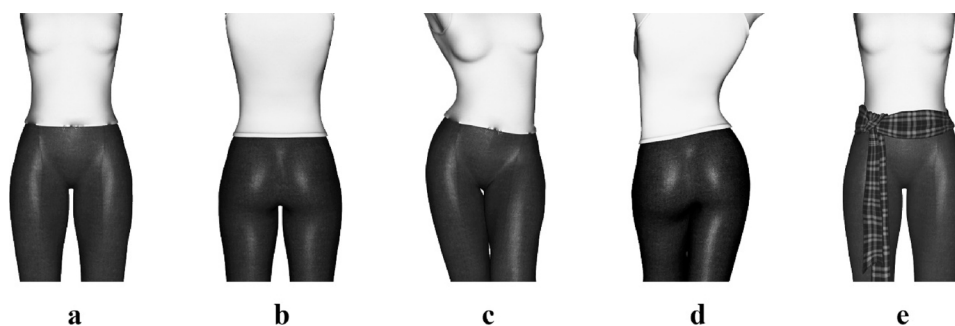
visible on screen (Fig. 2A).

In the second block, participants completed an active attractiveness judgement task while EEG was recorded. Stimuli varying in body pose and viewing angle were presented in a random order at the center of the monitor (104 trials). Each trial consisted of 600–900 ms pre-stimulus interval, followed by stimulus presentation for 750 ms before a 7-point Likert scale replace it. The Likert scale was present on the screen until a participant’s response indicating how attractive s/he found the stimulus. Responses were made by clicking the corresponding keyboard button among the digits; 1 to indicate the stimulus was not attractive at all, up through to 7 indicating the stimulus was the most attractive. A 100 ms black screen intertrial interval separated two consecutive trials (Fig. 2B). The attractiveness judgement task was always completed after the oddball task. Stimuli were presented and responses were recorded using Presentation® software (Neurobehavioral Systems, Inc., Albany, CA, USA).

## 2.4. EEG recording and processing

EEG was recorded with 64 active electrodes inserted in an electrode cap (BioSemi ActiveTwo mk2, BioSemi B.V., The Netherlands), and placed at standard positions of the international 10–10 system using a Common Mode Sense (CMS) recording montage. In order to later correct EEG signals for ocular movements artifacts the electrooculogram (EOG) signals were monitored via two electrodes in the outer canthi of the eyes and a third one below left eye. EEG signals were amplified and digitized at 512 Hz rate and the signal was bandpass filtered online between 0.001 Hz and 100 Hz. All electrodes were adjusted to maintain their offset lower than 30 mV.

EEG data were processed and visualized using BrainVision Analyzer 2.1 (Brain Products GmbH, München, Germany). The signal was digitally filtered offline between 0.1 to 30 Hz via phase shift free Butterworth filter (24 dB/octave roll-off) with an additional notch filter at 50 Hz and re-referenced to average reference. The signals were corrected for ocular artifacts using Gratton and collaborators procedure (Gratton, Coles, & Donchin, 1983). Semi-automatic artifact rejection was also applied (e.g. rejection of epochs with voltage steps higher than 50  $\mu$ V or with voltages exceeding  $\pm 100 \mu$ V at any datapoint). EEG was segmented into epochs from 200 ms prior to stimulus onset, to 750 ms after the onset of the stimulus, and baseline corrected with the mean activity in the pre-stimulus period. Artifact free epochs were averaged across participants for the combination of the two body poses (standing and contrapposto) and the two viewing angles (anterior and posterior). Data from 4 participants were discarded due to poor quality and excessive number of artifacts. Consequently, the analyzed data corresponds to 48 heterosexual individuals (28 females) within the age range of 18–37 years old ( $M = 23$ ;  $SD = 4.36$ ). Artifact free trials per condition in the oddball task ranged between 24 and 30 ( $M = 29.27$ ,  $SD = 0.55$ ), while the range oscillates between 23 and 26 trials ( $M = 25.55$ ,  $SD = 0.36$ ) for the attractiveness judgment task. For details in each condition, please, see Tables S1 and S2).



**Fig. 1.** Examples of the stimuli used in this study: a) standing pose in anterior view, b) standing pose in posterior view, c) contrapposto pose in anterior view, d) contrapposto pose in posterior view, and e) oddball stimulus for standing anterior condition.

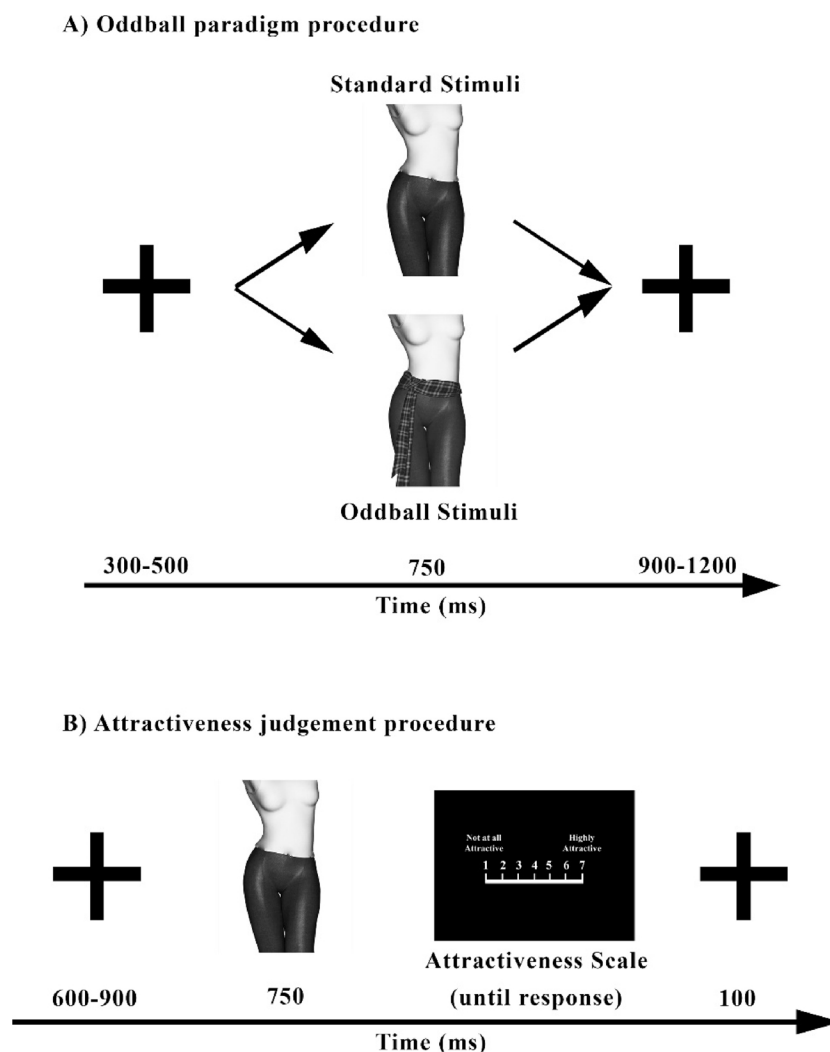


Fig. 2. Experimental procedures for A) oddball paradigm and B) attractiveness judgement task.

Temporal Principal Component Analysis (tPCA) was applied to the ERP data. Using this method, one can avoid the potential errors arising from visual inspection of the ERP waveforms during the decomposition of the ERPs into their constituent components (Dien, Beal, & Berg, 2005). tPCA results produce one matrix for factor loadings and another one for factor scores. Factor scores are the transformation of the amplitude values representing magnitudes of the latent variables (transformations of the original microvolt values for each participant, condition and electrode); and factor loadings are the data points based on the number of channels, epoch length, and frequency showing the distribution of each factor over time (Dien, 1998). We used the covariance matrix for the tPCAs and, aided by the scree test (Cattell, 1966), retained those factors from the unrotated solution explaining at least 1 % of total variance. In order to improve tPCA accuracy further and avoid misallocation of variance (Dien, 1998) Promax rotation was applied to the retained factors. The factor scores were used as alternative measures representing ERP components amplitude for statistical analysis as they are transformations of the original voltage values (Dien, 1998).

For the oddball task, six temporal factors (TFs), altogether accounting for 92.07 % of data variance were identified by the tPCA (Fig. 3A). In temporal order, TF3 appeared earliest and the largest factor loadings for this temporal factor were observed between 110 and 150 ms post-stimulus and the largest positive factor scores at parietal and occipital electrodes (Oz, O1, O2, PO7, PO8, P9 and P10), probably

corresponding with the traditional P100 component. From 150 to 190 ms post-stimulus, maximum factor loadings for TF4 were observed. It had the largest negative factor scores at parietal and parieto-temporal electrodes (TP7, TP8, P7, P8, P9 and P10), corresponding to the descending slope to N190 peak. TF5 has the highest factor loadings from 190 to 250 ms post-stimulus and the highest positive factor scores located at occipital and parieto-occipital electrodes (POz, PO3, PO4, PO7, PO8, Oz, O1 and O2), being associated with the ascending slope between N190 and P250. From 250 to 430 ms post-stimulus, TF1 had the largest factor loadings with the highest negative factor scores at frontal electrodes (Fpz, Fp1, Fp2, AFz, AF3, AF4, AF7 and AF8), identified as N300. TF6 presented the largest factor loadings between 420 and 530 ms post-stimulus and the largest negative factor scores at frontal electrodes (Fpz, Fp1, Fp2, AFz, AF3 and AF4). Finally, TF2 may correspond with a negative slow wave (NSW) as the factor loadings were maximal from 550 ms post-stimulus to the end of the recording epoch (750 ms) and the negative factor scores were maximal at frontal electrodes (Fpz, Fp1, Fp2, Fz, F1, F2 AFz, AF7 and AF8; see Supplementary Material for the graphs of all temporal factors from oddball task).

Applying the tPCA to the ERP data for the attractiveness judgement task produced six temporal factors explaining 92.93 % of the variance (Fig. 3B). In temporal order, TF3 factor loadings appeared earliest and were maximal from 120 to 145 ms post-stimulus and its positive factor scores were highest at occipital, parietal and parieto-occipital electrodes (Oz, O1, O2, PO7, PO8, P9 and P10), probably corresponding to

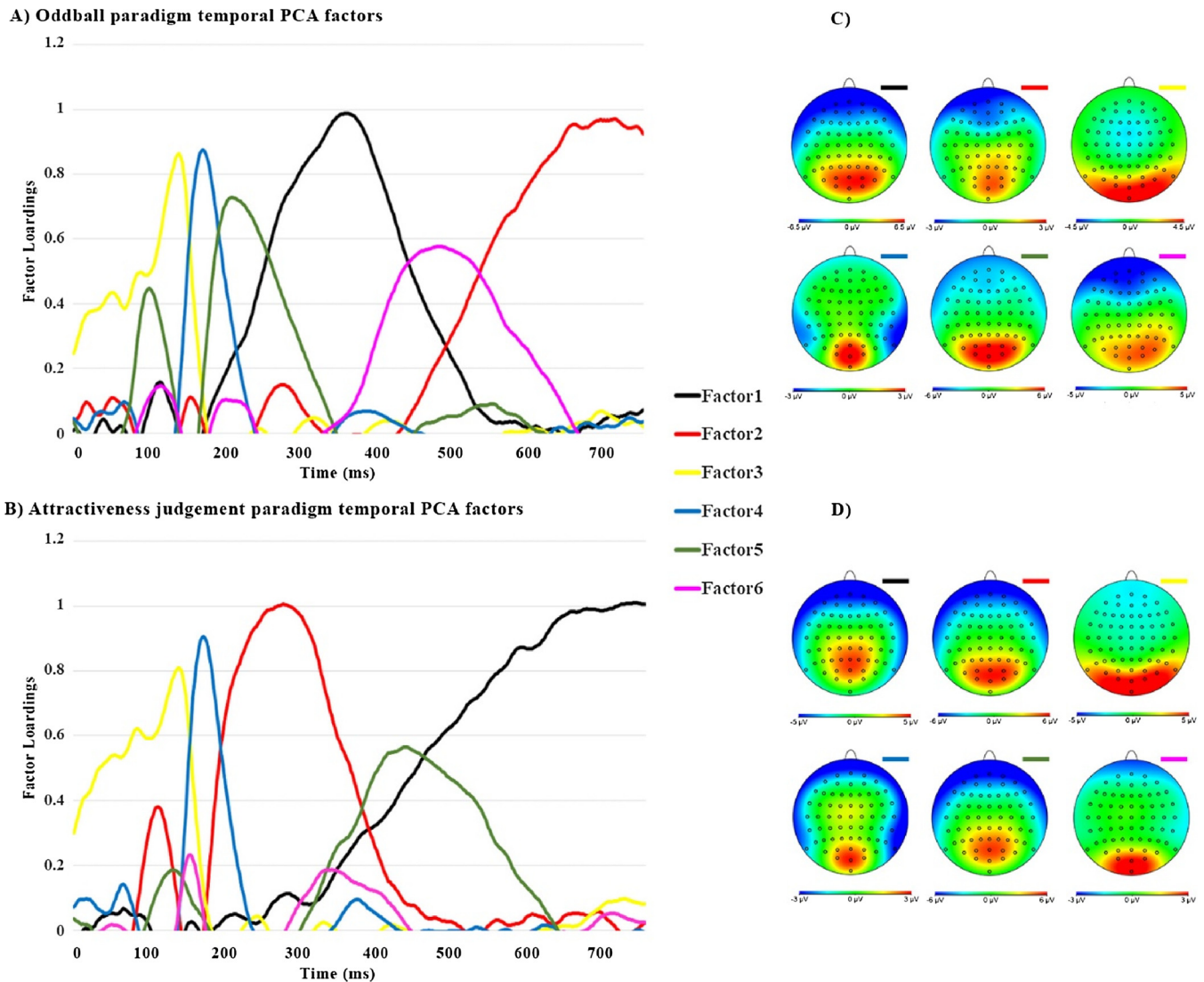


Fig. 3. A) extracted temporal principal components analysis factors for the oddball task. B) extracted temporal principal components analysis factors for attractiveness judgement task. C) voltage maps of PCA factors for oddball paradigm. D) voltage maps of PCA factors for attractiveness judgement paradigm.

P1. TF6 was likely associated to the descending slope to N190 peak as the factor loadings peaked between 145 and 160 ms post-stimulus and the largest negative factor scores were observed at occipital and parieto-occipital regions (Oz, O1, O2, PO7 and PO8). TF4 factor loadings peaked between 160 and 185 ms post-stimulus with its highest negative factor scores at parietal electrodes (P7, P8, P9 and P10). TF2 may be associated with P250 component as the largest positive factor loadings were observed between 190 and 340 ms post-stimulus with highest factor scores at parieto-occipital and occipital regions (Oz, O1, O2, POz, PO3, PO4, PO7 and PO8). TF5 showed maximal factor loadings from 380 to 500 ms after the onset of stimulus with the highest negative factor scores obtained at frontal electrodes (Fpz, Fp1, Fp2, AF7 and AF8). Finally, TF1 maximal factor loadings were observed between 500 ms and the end of the analyzed epoch (750 ms), while the maximal negative factor scores were recorded at frontal electrodes (Fpz, Fp1, Fp2, AFz, AF7 and AF8; see Supplementary Material for the graphs of all temporal factors from attractiveness judgement task).

Additionally, low-resolution brain electromagnetic tomography (LORETA) algorithms module implemented in BrainVision Analyzer 2.1 was used to identify the cortical sources displaying the highest activation for each TF time window (Pascual-Marqui, Michel, & Lehmann, 1994). LORETA algorithms (Pascual-Marqui, 1999; Pascual-Marqui et al., 1994) use the voltage values of all 64 active electrodes in a given

time window for the average across conditions, and participants, to yield images of current density with precise localization, albeit with low spatial resolution (i.e., neighboring neuronal sources will be highly correlated). In other words, it identifies the smoothest 3D current density distribution at the cortical surface that could generate the scalp recorded voltage distribution for that time window. The LORETA computations were made using a realistic 3-shell spherical head model (Fuchs, Kastner, Wagner, Hawes, & Ebersole, 2002) based on the Montreal Neurological Institute (MNI152) template (Mazziotta et al., 2001) with the three-dimensional solution space restricted to cortical gray matter and hippocampal volume partitioned in 2394 voxels (i.e. 7 mm spatial resolution). Current source distribution maps for each TF were generated as functional images representing the brain regions showing maximal activation for each TF (Fig. 4) while the coordinates of the voxel with higher estimated activity for each TF are presented in Table 2.

### 2.5. Analyses

For the behavioral data, a mixed-design repeated-measures analysis of variance (ANOVA) tested the effects of Participant Sex (male and female), Angle (anterior and posterior), and Body Pose (standing and contrapposto) on perceived attractiveness ratings and reaction time

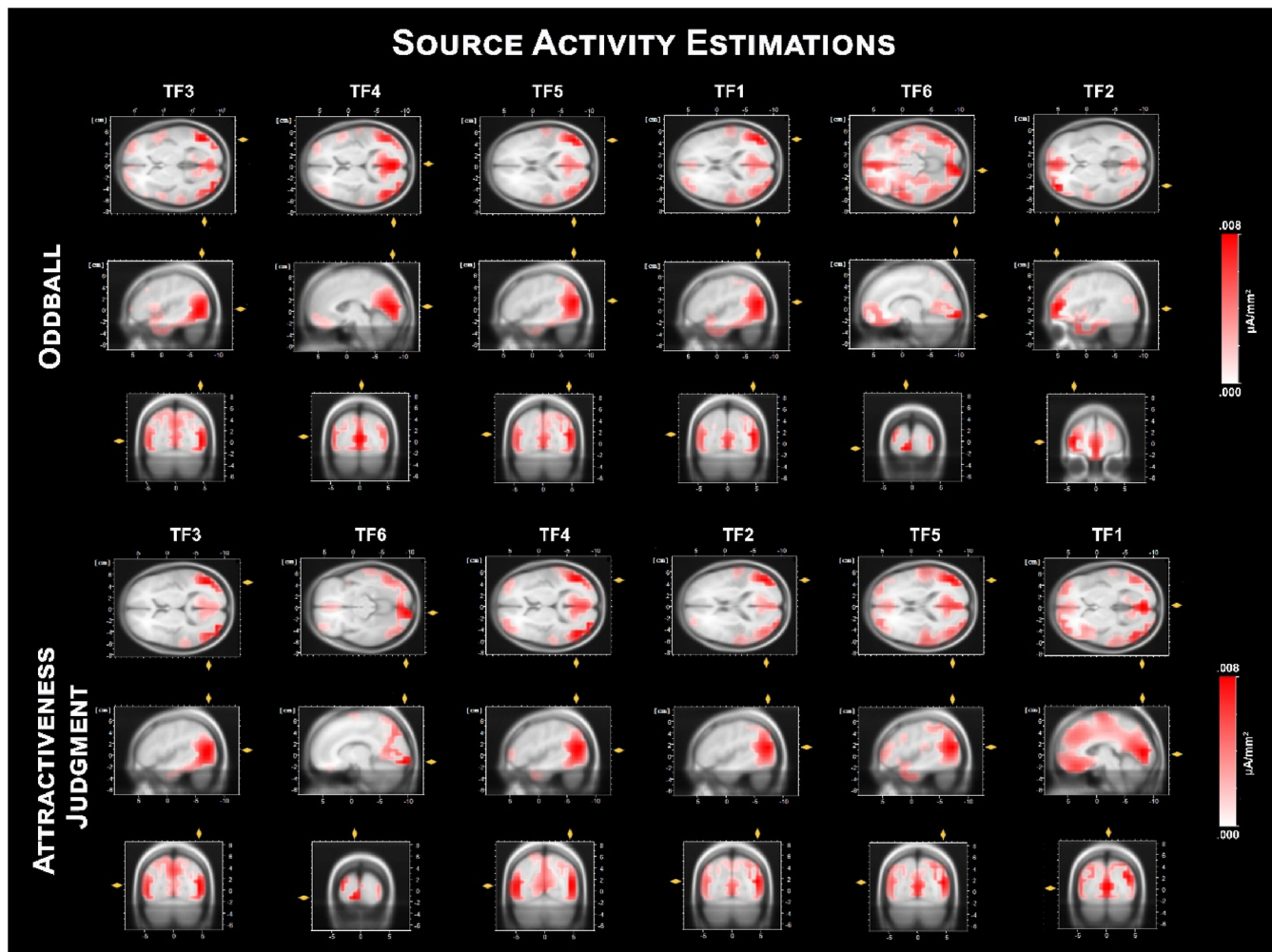


Fig. 4. Source activity estimation maps for each task and temporal factor showing the brain regions with maximal activation for each temporal factor.

from the attractiveness judgement task.

To analyze the ERP data for both the oddball and attractiveness judgement tasks, factor scores for the electrodes showing absolute maximal factor scores for each TF were averaged across three laterality levels (midline, left and right hemispheres) before being entered in the analysis. For TF4 in the oddball and attractiveness judgement tasks only two laterality levels were identified (left and right hemispheres). A mixed-design repeated-measures ANOVA tested the effects of Participant Sex (male and female), Body Pose (contrapposto and standing), Angle (anterior and posterior), and Laterality (midline, left

and right hemispheres) on factor scores (i.e. amplitude value).

For all the ANOVAs carried out, Greenhouse-Geisser correction was applied whenever there was violation of the sphericity assumption, and the Bonferroni test was applied whenever necessary, with significance cut-off at  $p \leq 0.05$ . Moreover, only the results for the significant temporal factors main effects and interactions were reported in the Results section.

**Table 2**  
Areas of activation in the oddball and attractiveness judgement tasks.

Task	Temporal Factor (time range in ms)	Anatomical region	Brodmann area	MNI Coordinates		
				x	y	z
Oddball	3 (110–150)	Right Middle Occipital Gyrus	19	46	-74	1
	4 (150–190)	Cuneus	17	4	-81	8
	5 (190–250)	Right Middle Temporal Gyrus	39	46	-74	15
	1 (250–430)	Right Middle Temporal Gyrus	39	46	-74	15
	6 (420–530)	Left Inferior Occipital Gyrus	17	-10	-95	-13
	2 (550–750)	Left Inferior Frontal Gyrus	10	-38	52	1
Attractiveness judgement	3 (120–145)	Right Middle Temporal Gyrus	39	46	-74	8
	6 (145–160)	Left Inferior Occipital Gyrus	17	-10	-95	-13
	4 (160–185)	Right Middle Temporal Gyrus	37	46	-67	8
	2 (190–340)	Right Middle Temporal Gyrus	39	46	-74	15
	5 (380–500)	Right Middle Temporal Gyrus	39	46	-74	15
	1 (500–750)	Lingual Gyrus	18	4	-81	1

### 3. Results

#### 3.1. Behavioral results

A 2 (Participant Sex) x 2 (Angle: anterior and posterior) x 2 (Body Pose: standing and contrapposto) repeated measures ANOVA was performed, with Participant Sex as a between-subjects factor and Angle and Body Pose as within-subjects factors for ratings of attractiveness. The main effect for Body Pose was significant,  $F(1,46) = 41.74$ ,  $p < 0.001$ ,  $\eta^2 = 0.47$ . Contrapposto pose ( $M = 4.65$ ,  $SEM = 0.15$ ) was rated more attractive than standing pose ( $M = 3.49$ ,  $SEM = 0.16$ ,  $p < 0.001$ ).

To investigate reaction time, a 2 (Participant Sex) x 2 (Angle: anterior and posterior) x 2 (Body Pose: standing and contrapposto) repeated measures ANOVA was performed, with Participant Sex as a between-subjects factor, and Angle and Body Pose as within-subjects factors. No significant difference was found either for main effects or the interactions for the reaction time (all  $ps > 0.325$ ).

#### 3.2. EEG results

##### 3.2.1. Oddball task

A 2 (Participant Sex) x 2 (Angle: anterior and posterior) x 2 (Body Pose: standing and contrapposto) x 3 (Laterality: midline, left and right hemispheres) repeated measures ANOVA was performed, with Participant Sex as a between-subjects factor, and Angle, Body Pose, and Laterality as within-subjects factors.

Results showed a significant Body Pose effect,  $F(1,46) = 24.87$ ,  $p < 0.001$ ,  $\eta^2 = 0.35$ , as well as a significant Body Pose x Participant Sex interaction for TF3,  $F(1,46) = 4.35$ ,  $p = 0.043$ ,  $\eta^2 = 0.08$ , meaning that women had higher factor scores for contrapposto pose ( $M = 1.52$ ,  $SEM = 0.19$ ) than standing pose ( $M = 1.00$ ,  $SEM = 0.18$ ,  $p < 0.001$ ; see Fig. 5 for TF3 ERPs and voltage maps).

For TF4, the effect of Body Pose,  $F(1,46) = 15.36$ ,  $p < 0.001$ ,  $\eta^2 = 0.25$ , as well as Body Pose x Angle interaction were significant,  $F(1,46) = 5.75$ ,  $p = 0.021$ ,  $\eta^2 = 0.11$ . In the anterior view, contrapposto pose ( $M = -1.08$ ,  $SEM = 0.13$ ), had higher negativity than standing pose ( $M = -0.77$ ,  $SEM = 0.13$ ,  $p < 0.001$ ). Also, for the standing pose, anterior view ( $M = -0.89$ ,  $SEM = 0.13$ ) had higher negativity than posterior view ( $M = -0.77$ ,  $SEM = 0.13$ ,  $p = 0.038$ ; see Fig. 6 for TF4 ERPs and voltage maps).

TF5 showed a significant Body Pose x Participant Sex interaction,  $F(1,46) = 4.91$ ,  $p = 0.032$ ,  $\eta^2 = 0.04$ ; male participants had higher factor scores for standing pose ( $M = 1.53$ ,  $SEM = 0.16$ ) than the contrapposto pose ( $M = 1.37$ ,  $SEM = 0.15$ ,  $p = 0.020$ ; see Fig. 7 for TF5 ERPs and voltage maps).

For TF6, the main effects for Angle,  $F(1,46) = 13.34$ ,  $p = 0.001$ ,  $\eta^2 = 0.22$ , and Body Pose were significant,  $F(1,46) = 8.03$ ,  $p = 0.007$ ,  $\eta^2 = 0.14$ . In addition, the Angle x Body Pose interaction was significant,  $F(1,46) = 8.07$ ,  $p = 0.007$ ,  $\eta^2 = 0.14$ ; the standing pose, anterior view ( $M = -1.19$ ,  $SEM = 0.10$ ) had higher negativity than the posterior view ( $M = -0.73$ ,  $SEM = 0.11$ ,  $p < 0.001$ ). Also, for the posterior view, contrapposto pose ( $M = -1.11$ ,  $SEM = 0.11$ ) had higher negativity than standing pose ( $M = -0.73$ ,  $SEM = 0.11$ ,  $p = 0.001$ ; see Fig. 8 for TF6 ERPs and voltage maps).

For TF2, the main effects for Angle,  $F(1,46) = 22.69$ ,  $p < 0.001$ ,  $\eta^2 = 0.33$  and Body Pose were significant,  $F(1,46) = 6.02$ ,  $p = 0.018$ ,  $\eta^2 = 0.11$ . The Angle x Body Pose,  $F(1,46) = 12.03$ ,  $p = 0.001$ ,  $\eta^2 = 0.20$ , as well as the Angle x Body Pose x Laterality interactions were significant,  $F(2,92) = 3.34$ ,  $p = 0.040$ ,  $\eta^2 = 0.06$ . For the posterior view, contrapposto pose (midline:  $M = -0.88$ ,  $SEM = 0.13$ ; right hemisphere:  $M = -0.68$ ,  $SEM = 0.14$ ; left hemisphere:  $M = -1.02$ ,  $SEM = 0.12$ ) had higher negativity than standing pose on the midline, right and left laterality levels (midline:  $M = -0.41$ ,  $SEM = 0.09$ ,  $p = 0.002$ ; right hemisphere:  $M = -0.32$ ,  $SEM = 0.11$ ,  $p = 0.039$ ; left hemisphere:  $M = -0.41$ ,  $SEM = 0.10$ ,  $p < 0.001$ ). Furthermore, for

the standing pose, anterior view (midline:  $M = -0.83$ ,  $SEM = 0.10$ ; right hemisphere:  $M = -0.76$ ,  $SEM = 0.12$ ; left hemisphere:  $M = -0.99$ ,  $SEM = 0.12$ ) had higher negativity than posterior view on the midline, right and left laterality levels (midline:  $M = -0.41$ ,  $SEM = 0.09$ ,  $p < 0.001$ ; right hemisphere:  $M = -0.32$ ,  $SEM = 0.11$ ,  $p < 0.001$ ; left hemisphere:  $M = -0.41$ ,  $SEM = 0.10$ ,  $p < 0.001$ ; see Fig. 9 for TF2 ERPs and voltage maps).

##### 3.2.2. Attractiveness judgment task

A 2 (Participant Sex) x 2 (Angle: anterior and posterior) x 2 (Body Pose: standing and contrapposto) x 3 (Laterality: midline, left and right hemispheres) repeated measures ANOVA was performed, with Participant Sex as a between-subjects factor, and Angle, Body Pose, and Laterality as within-subjects factors.

Results showed a significant main effect for Body Pose at TF3,  $F(1,46) = 58.21$ ,  $p < 0.001$ ,  $\eta^2 = 0.55$ ; contrapposto pose ( $M = 1.45$ ,  $SEM = 0.13$ ) had higher factor score than standing pose ( $M = 1.04$ ,  $SEM = 0.12$ ; see Fig. 10 for TF3 ERPs and voltage maps).

For TF6, results showed a significant Participant Sex x Angle x Body Pose interaction,  $F(1,46) = 5.83$ ,  $p = 0.020$ ,  $\eta^2 = 0.11$ ; for female participants posterior view ( $M = -1.03$ ,  $SEM = 0.26$ ) had higher negativity than anterior view ( $M = -0.72$ ,  $SEM = 0.22$ ,  $p = 0.030$ ) for the standing pose, while for male participants posterior view ( $M = -0.89$ ,  $SEM = 0.28$ ) had higher negativity than anterior view ( $M = -0.53$ ,  $SEM = 0.32$ ,  $p = 0.042$ ) for the contrapposto pose (see Fig. 11 for TF6 ERPs and voltage maps).

Results showed a significant main effect for Body Pose at TF4,  $F(1,46) = 21.61$ ,  $p < 0.001$ ,  $\eta^2 = 0.32$ ; contrapposto pose ( $M = -0.99$ ,  $SEM = 0.14$ ) had higher negativity than standing pose ( $M = -0.71$ ,  $SEM = 0.14$ ; see Fig. 12 for TF4 ERPs and voltage maps).

For TF2, the main effect for Body Pose was significant,  $F(1,46) = 4.31$ ,  $p = 0.043$ ,  $\eta^2 = 0.08$ . The Angle x Body Pose interaction was also significant,  $F(1,46) = 7.24$ ,  $p = 0.010$ ,  $\eta^2 = 0.13$ ; for the standing pose, anterior view ( $M = 1.32$ ,  $SEM = 0.10$ ) had higher factor score than posterior view ( $M = 1.16$ ,  $SEM = 0.10$ ,  $p = 0.003$ ). In addition, for the posterior view, contrapposto pose ( $M = 1.35$ ,  $SEM = 0.12$ ) had higher factor score than standing pose ( $M = 1.16$ ,  $SEM = 0.10$ ,  $p = 0.004$ ). A significant Participant Sex x Angle x Laterality interaction was also returned,  $F(2,92) = 3.13$ ,  $p = 0.048$ ,  $\eta^2 = 0.06$ ; for female participants, anterior view (midline:  $M = 1.43$ ,  $SEM = 0.14$ ; left hemisphere:  $M = 1.42$ ,  $SEM = 0.14$ ) had higher factor score than posterior view on the midline and left hemisphere (midline:  $M = 1.26$ ,  $SEM = 0.15$ ,  $p = 0.005$ ; left hemisphere:  $M = 1.28$ ,  $SEM = 0.15$ ,  $p = 0.039$ ; see Fig. 13 for TF5 ERPs and voltage maps).

For TF5, the main effect for Body Pose was significant,  $F(1,46) = 4.64$ ,  $p = 0.036$ ,  $\eta^2 = 0.09$ ; contrapposto pose ( $M = -1.23$ ,  $SEM = 0.15$ ) had higher negativity than standing pose ( $M = -1.00$ ,  $SEM = 0.14$ ; see Fig. 14 for TF5 ERPs and voltage maps).

For TF1, results showed a significant main effect for Angle,  $F(1,46) = 10.84$ ,  $p = 0.002$ ,  $\eta^2 = 0.19$ . The Angle x Laterality interaction was also significant for TF1,  $F(2,92) = 4.09$ ,  $p = 0.020$ ,  $\eta^2 = 0.08$ ; anterior view (right hemisphere:  $M = -1.23$ ,  $SEM = 0.17$ ; left hemisphere:  $M = -1.20$ ,  $SEM = 0.18$ ) had higher negativity than posterior view on the right and left hemispheres (right hemisphere:  $M = -0.89$ ,  $SEM = 0.14$ ,  $p < 0.001$ ; left hemisphere:  $M = -0.99$ ,  $SEM = 0.14$ ,  $p = 0.016$ ; see Fig. 15 for TF1 ERPs and voltage maps).

### 4. Discussion

While previous research has considered the neural correlates of human body form perception (Downing et al., 2001; Peelen & Downing, 2005, 2007; Schwarzlose et al., 2005; Taylor et al., 2007; Thierry et al., 2006) and perception of attractive body sizes (Holliday et al., 2011; Pazhoohi et al., 2020; Platek & Singh, 2010; Spicer & Platek, 2010), to the best of our knowledge there are no previous studies of body posture's impact on brain electrical activity of an observer which is either

# ODDBALL TASK TEMPORAL FACTOR 3

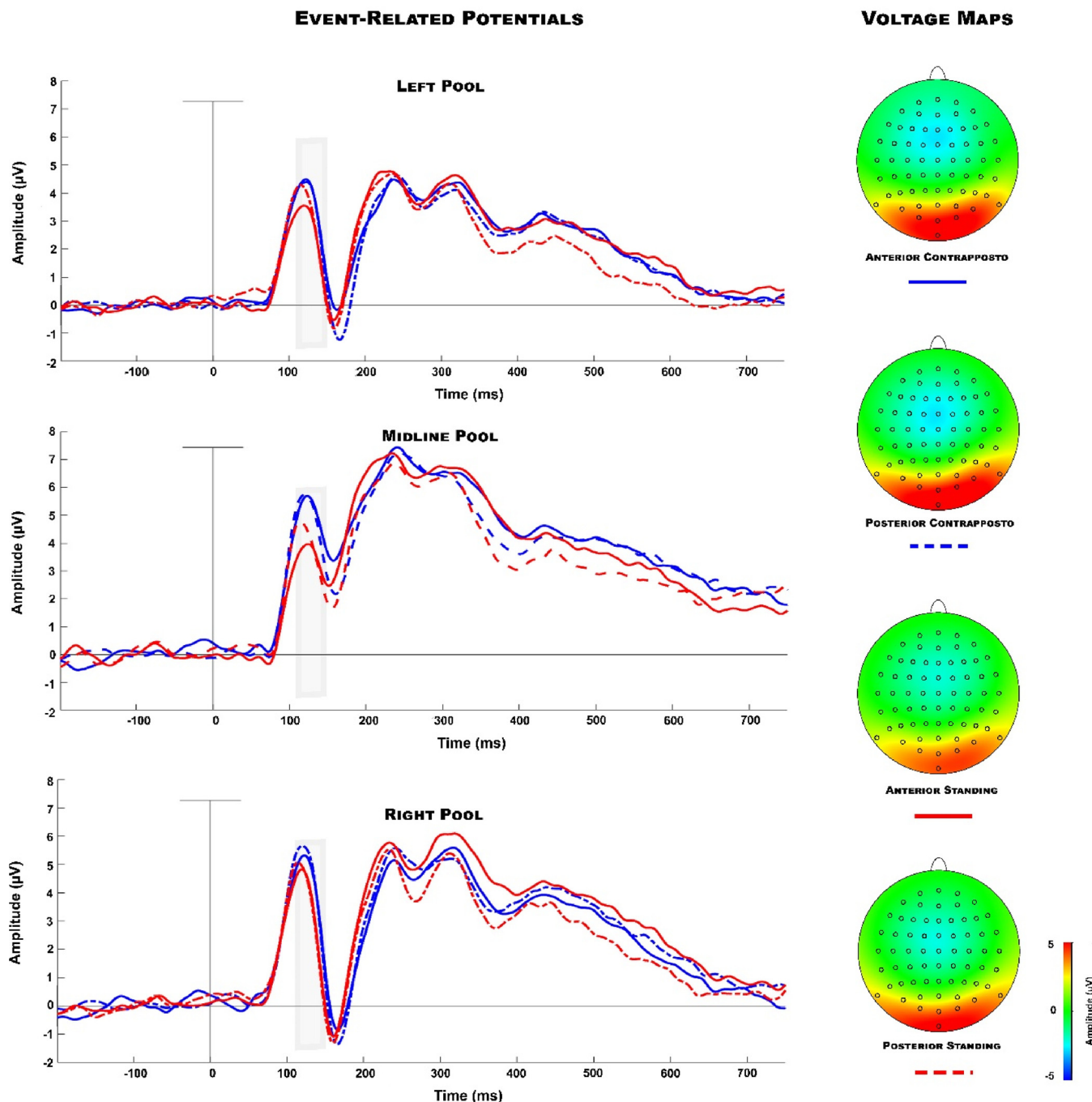


Fig. 5. Event-related potentials and voltage maps for temporal factor 3 of oddball task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

judging the attractiveness of an image or simply encountering an image while doing some other task.

Behavioral results of the current study showed that both men and women rated contrapposto stimuli more attractive than standing ones, regardless of the angle of view of the stimuli (anterior or posterior). This is in accordance with the behavioral results of a recent eye-tracking study in which contrapposto was considered more attractive than standing by both men and women (Pazhoohi et al., 2019).

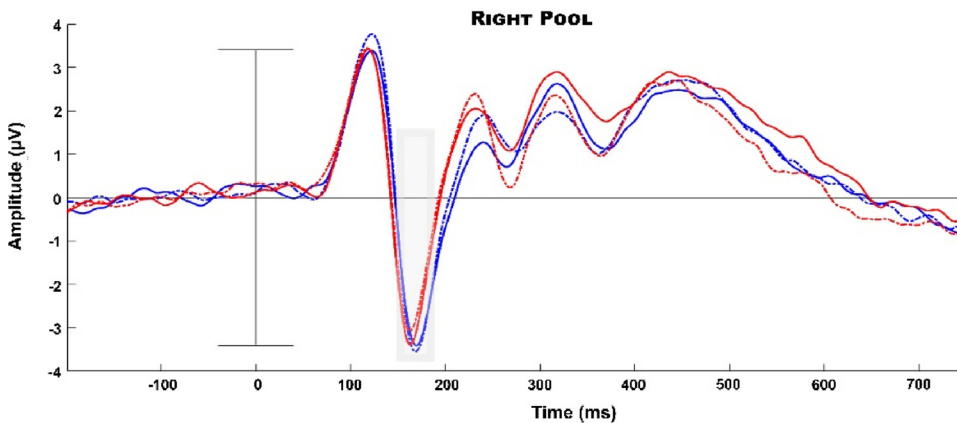
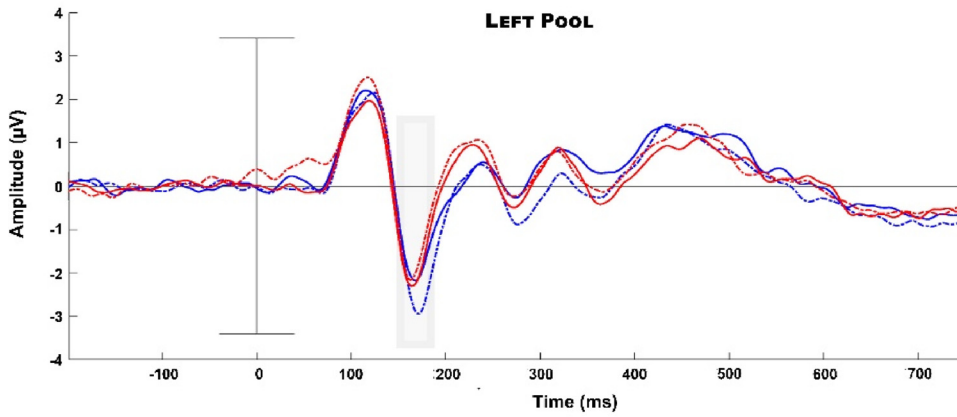
### 4.1. Oddball task

The electrophysiological results for oddball task showed an effect for P1 (TF3) component. For women, contrapposto had higher factor scores (amplitude) than standing pose. Del Zotto and Pegna (2017) reported a higher P1 amplitude for male participants for the WHR 0.7 compared with the other ratios (0.6, 0.8, and 0.9). Based on the results of Del Zotto and Pegna (2017) and current study, an early temporal component sensitive to variation in women body form or body posture creating supernormal body forms could be suggested. In the current

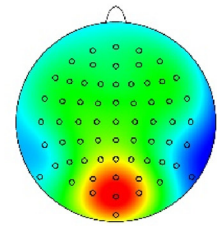


# ODDBALL TASK TEMPORAL FACTOR 4

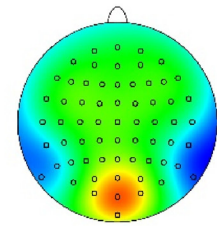
## EVENT-RELATED POTENTIALS



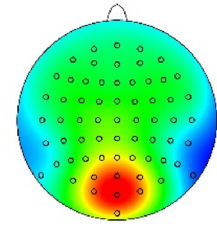
## VOLTAGE MAPS



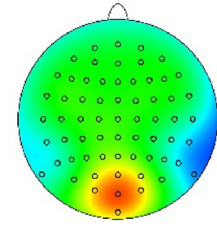
ANTERIOR CONTRAPPOSTO



POSTERIOR CONTRAPPOSTO



ANTERIOR STANDING



POSTERIOR STANDING

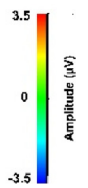


Fig. 6. Event-related potentials and voltage maps for temporal factor 4 of oddball task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

study, the P100 (TF3) parieto-occipital component peaked within the range from 110 to 150 ms post-stimulus and using LORETA maximal cortical activation was identified at the right middle occipital gyrus in Brodmann area 19 (secondary visual cortex). Brodmann area 19 is a part of the extrastriate visual cortex in which the EBA is situated (Brodmann, 2006). This shows the role of regions associated with the perception of the human body, such as the EBA (Downing et al., 2001) in distinguishing human body posture in an early temporal component. Similarly, it is shown that right and left EBA in right and left middle temporal gyri are activated more robustly to contorted body postures compared with ordinary postures (Cross, Mackie, Wolford, & Hamilton,

2010).

Component N190 (TF4) showed an effect for body pose for the anterior view, with a contrapposto pose having higher amplitude than a standing pose. The N190 (TF4) component in the current study had the maximal amplitude at parieto-temporal electrodes and peaked between 150 and 190 ms after the onset of the stimulus. This is in accordance with the reported N190 body-selective response in previous studies (Del Zotto & Pegna, 2017; Pourtois, Peelen, Spinelli, Seeck, & Vuilleumier, 2007; Pazhoohi et al., 2020; Thierry et al., 2006). Interestingly, Del Zotto and Pegna (2017) showed a higher N190 amplitude in response to the perception of the lowest WHR ratio (0.6), which is a supernormally

# ODDBALL TASK TEMPORAL FACTOR 5

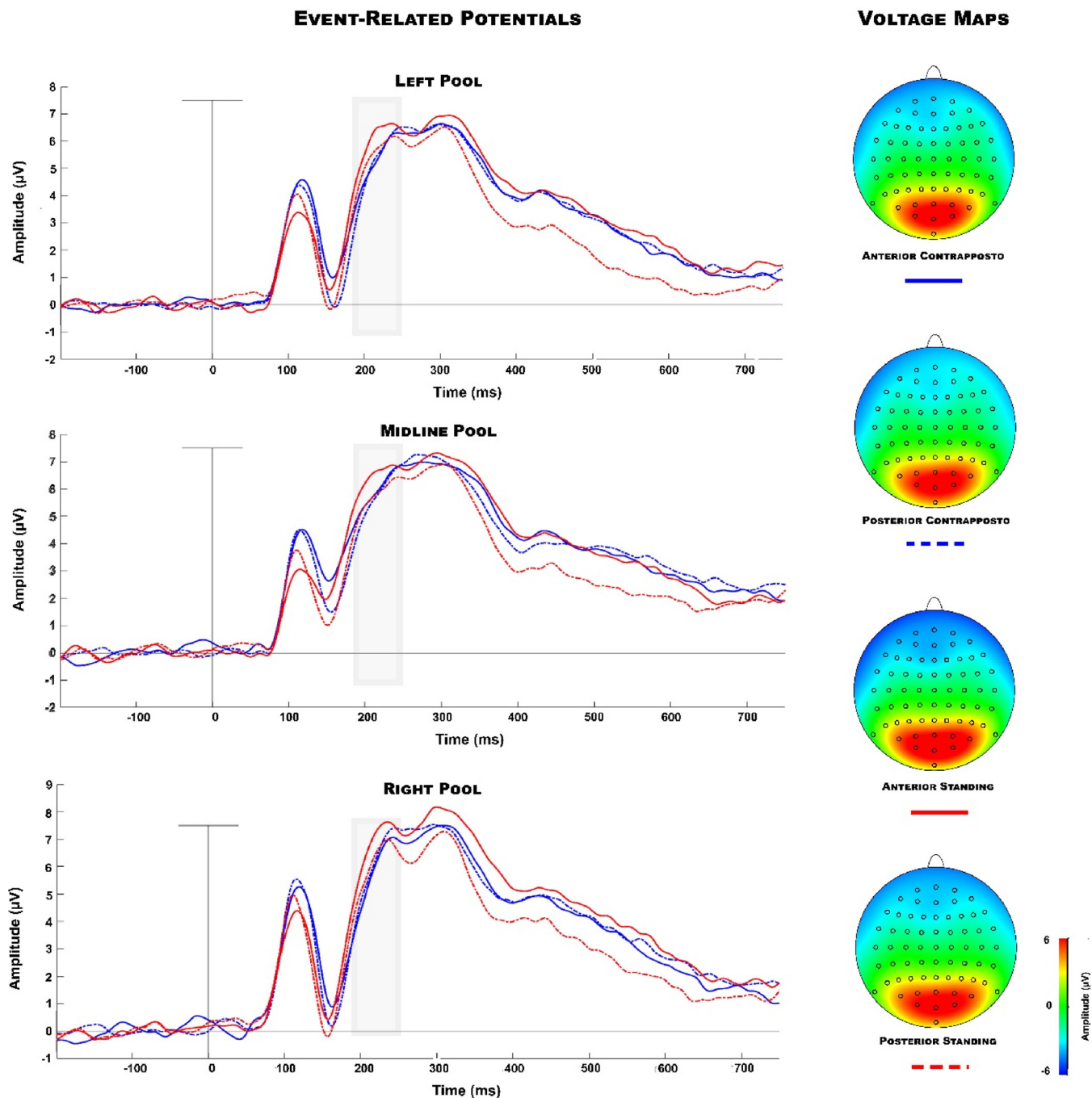


Fig. 7. Event-related potentials and voltage maps for temporal factor 5 of oddball task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

low ratio, compared to other ratios (0.7, 0.8 and 0.9). This indicates that N190 is modulated by female attractive body posture and/or form. Furthermore, LORETA estimations suggest that N190 (TF4) in the current study may originate in the Cuneus (BA 17) which is situated within the primary visual cortex (V1). It is reported that the Cuneus exhibits higher neural activation to body stimuli than face stimuli (Kret, Pichon, Grèzes, & de Gelder, 2011), and the current results highlight that its activity may be modulated by the perception of different human body postures.

Additionally, results for TF5 showed higher factor scores for a

standing pose than a contrapposto pose, but only for male participants. This component peaked between 190 and 250 ms after the onset of the stimulus, being maximal at occipital and parieto-occipital electrodes. Maximal activation was also identified at Brodmann area 39 (right middle temporal gyrus) by LORETA source estimations. Middle temporal gyrus is shown to be involved in perception of facial attractiveness while this region is not necessarily within face processing areas (Vartanian et al., 2013). Brodmann area 39 includes the angular gyrus (Triarhou, 2007), which is known to be a connecting hub associated with numerous tasks and processes (Seghier, 2013). Therefore, the

## ODDBALL TASK TEMPORAL FACTOR 6

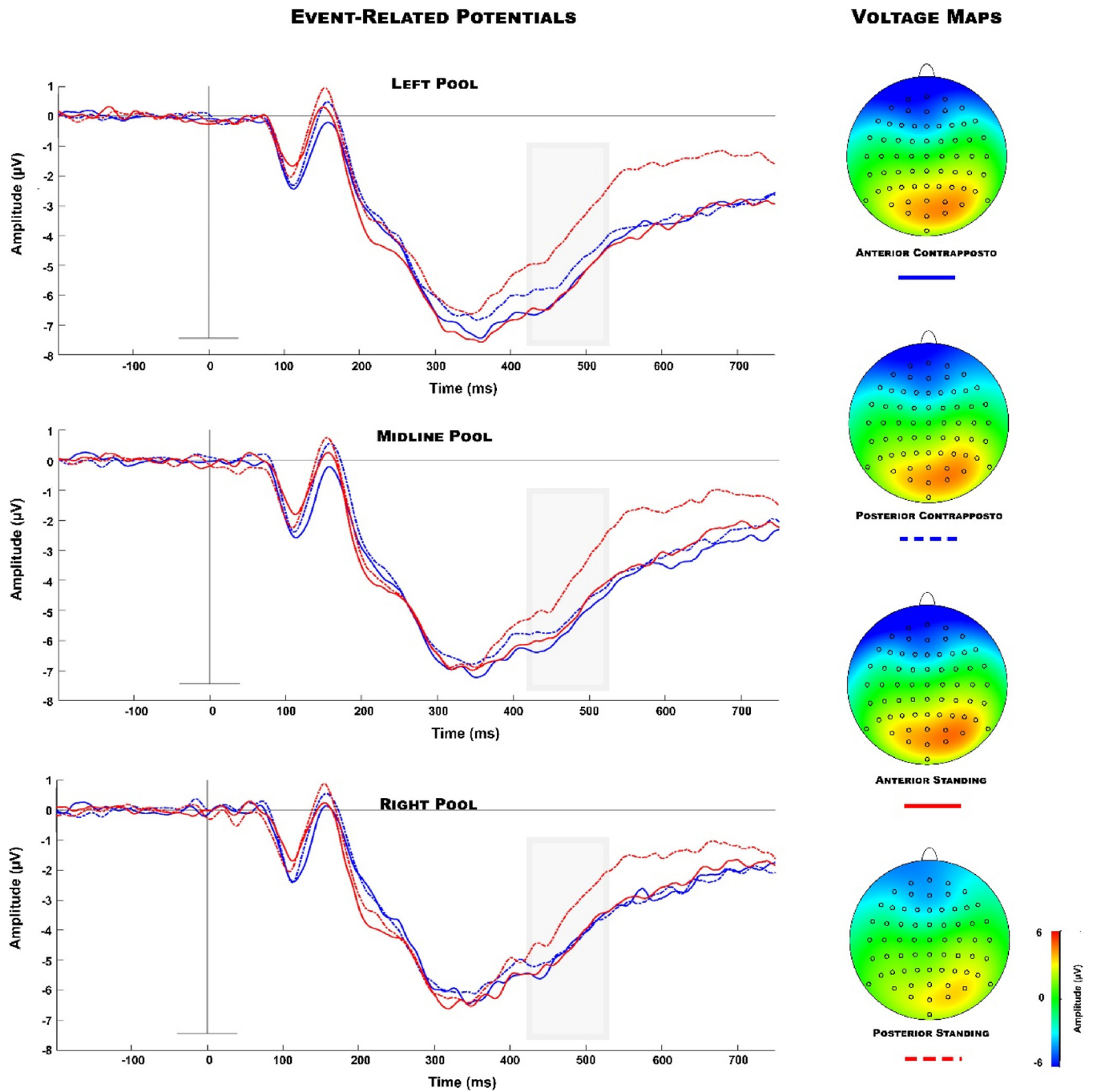


Fig. 8. Event-related potentials and voltage maps for temporal factor 6 of oddball task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

activation of middle temporal and angular gyri in the processing of human body posture extends the involvement of these brain regions to the perception and evaluation of facial attractiveness to that of body postures.

Component TF6 peaked between 420 and 530 ms with the largest amplitude at frontal electrodes, and showed higher negative factor scores (amplitude) for contrapposto pose than standing pose in the posterior view. In addition, the anterior view had higher negativity than the posterior view. LORETA showed that component TF6 maximal activation was corresponding to Brodmann area 17 (left inferior

occipital gyrus) or primary visual cortex (V1) in the occipital lobe. The inferior occipital gyrus comprises the occipital face area, which is considered a region for face recognition and early face processing (Pitcher, Walsh, Yovel, & Duchaine, 2007). While right inferior occipital gyrus is reported as the location for early face perception (Jacques et al., 2019; Pitcher et al., 2007; Pitcher, Charles, Devlin, Walsh, & Duchaine, 2009; Uono et al., 2017), left as well as right inferior occipital gyri are also known to play role in body form discrimination (Moro et al., 2008). Our result suggests a late peak in neural activity from left inferior occipital gyrus regarding body posture and body side

## ODDBALL TASK TEMPORAL FACTOR 2

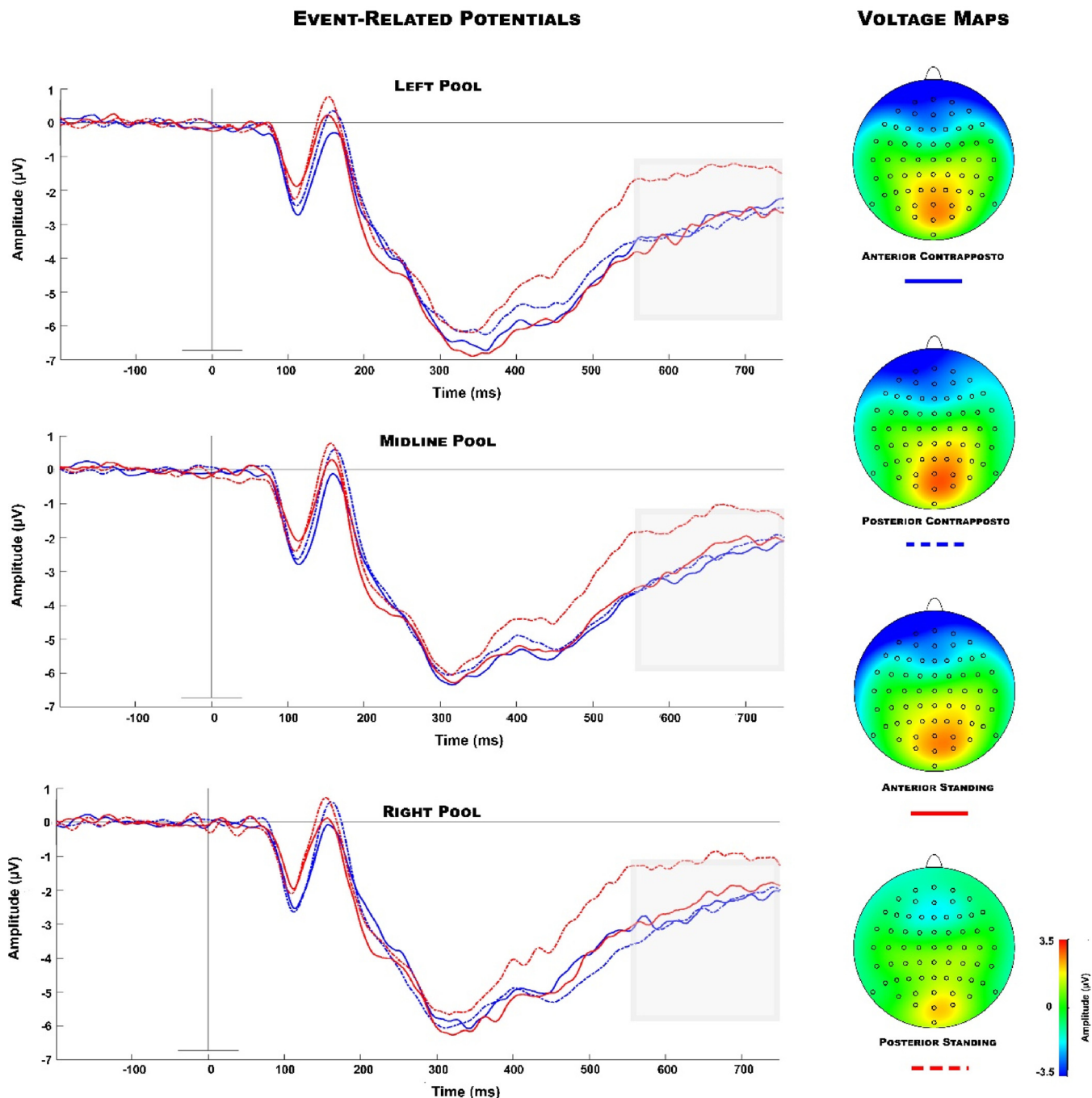


Fig. 9. Event-related potentials and voltage maps for temporal factor 2 of oddball task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

in the oddball task as well as an early neural activity peak in the attractiveness judgement task (see below), supporting previous evidence in body form perception (de Gelder et al., 2010; Moro et al., 2008).

Finally, for the oddball task, results showed an effect for NSW (TF2), peaking from 550 ms post-stimulus to the end of the recording epoch (750 ms). This component had the highest neural activity at frontal electrodes and maximally activated source at left inferior frontal gyrus (BA10). Contrapposto pose had higher negative amplitude than standing pose in the posterior view. Also, anterior view had higher negative amplitude than posterior view for the standing pose. Inferior

frontal gyrus is known to play role in facial attractiveness judgement (Bzdok et al., 2011; Kranz & Ishai, 2006; Winston, O’Doherty, Kilner, Perrett, & Dolan, 2007). However, Cross et al. (2010) reported activation in right inferior frontal gyrus in body posture processing. The results of the current study therefore extend the role of left inferior frontal gyrus to the perception of attractive body postures.

### 4.2. Attractiveness judgement task

The electrophysiological results for active judgement of

# ATTRACTIVENESS JUDGEMENT TASK TEMPORAL FACTOR 3

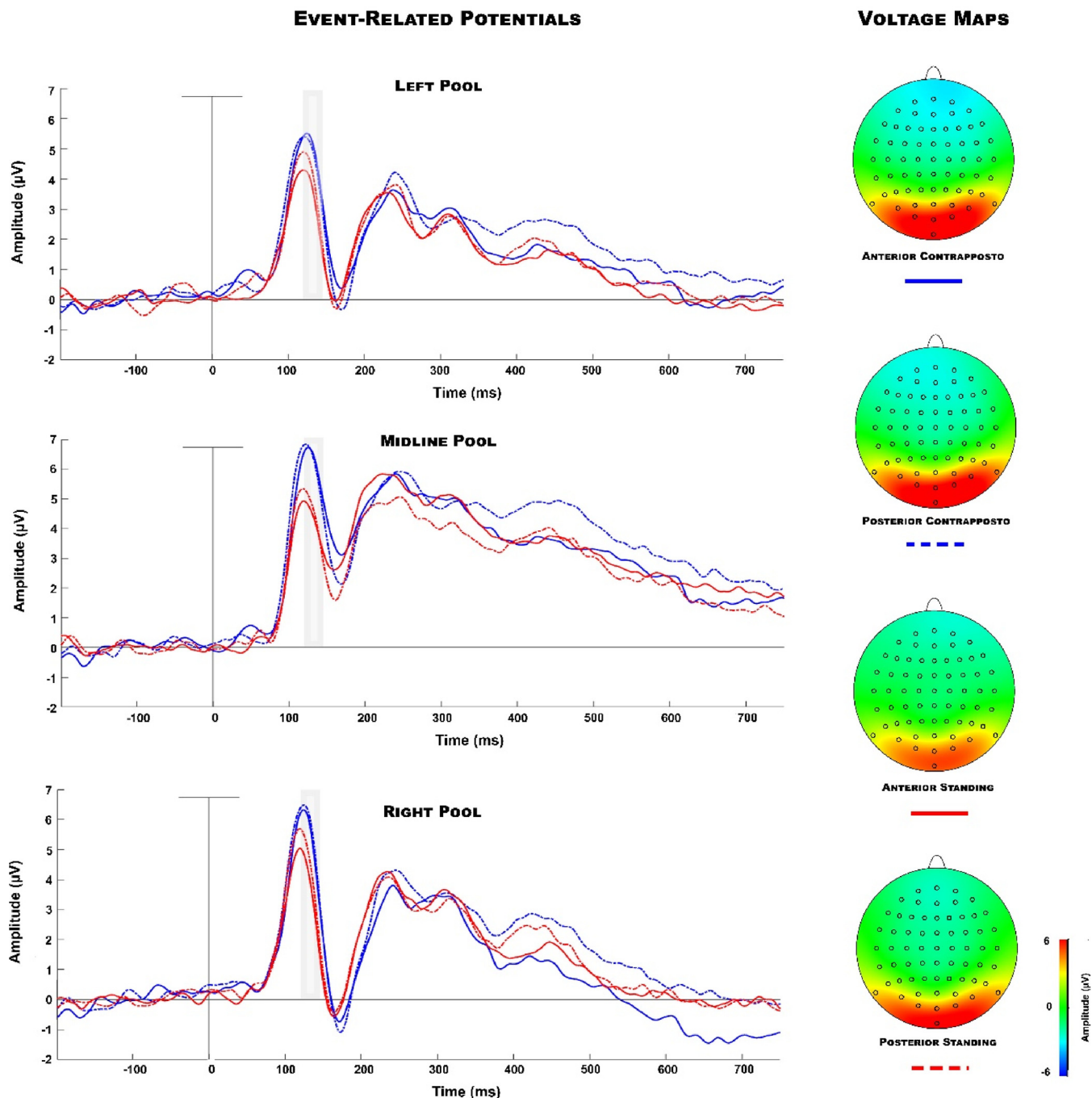


Fig. 10. Event-related potentials and voltage maps for temporal factor 3 of attractiveness judgement task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

attractiveness of contrapposto and standing postures showed an effect for the TF3 (P1) component, with maximal factor scores from 120 to 145 ms post-stimulus peaking at occipital, parietal, and parieto-occipital electrodes. This supports the results from the oddball task that showed an early temporal component sensitive to body posture. Results for TF3 showed that the contrapposto pose had higher factor scores (amplitude) than the standing pose, and further suggest that the maximally activated cortical sources were in the right middle temporal gyrus (BA39), a region previously shown to be activated during perception of contorted body postures (Cross et al., 2010). This area

encompasses the angular gyrus, which is shown to be active in facial attractiveness judgment tasks (Shen et al., 2016; Zhang, Tang, & Zhou, 2014). Thus, our results extend the activation of this brain region regarding the physical attractiveness judgments to body posture.

The present study's results also showed an effect for N190 (TF6) component, peaking between 145 and 160 ms post-stimulus with the largest current source activation estimated at the left inferior occipital gyrus (BA17). For female participants, a posterior view had higher negativity than an anterior view in the standing pose, while for male participants a posterior view had higher negativity than an anterior

# ATTRACTIVENESS JUDGEMENT TASK TEMPORAL FACTOR 6

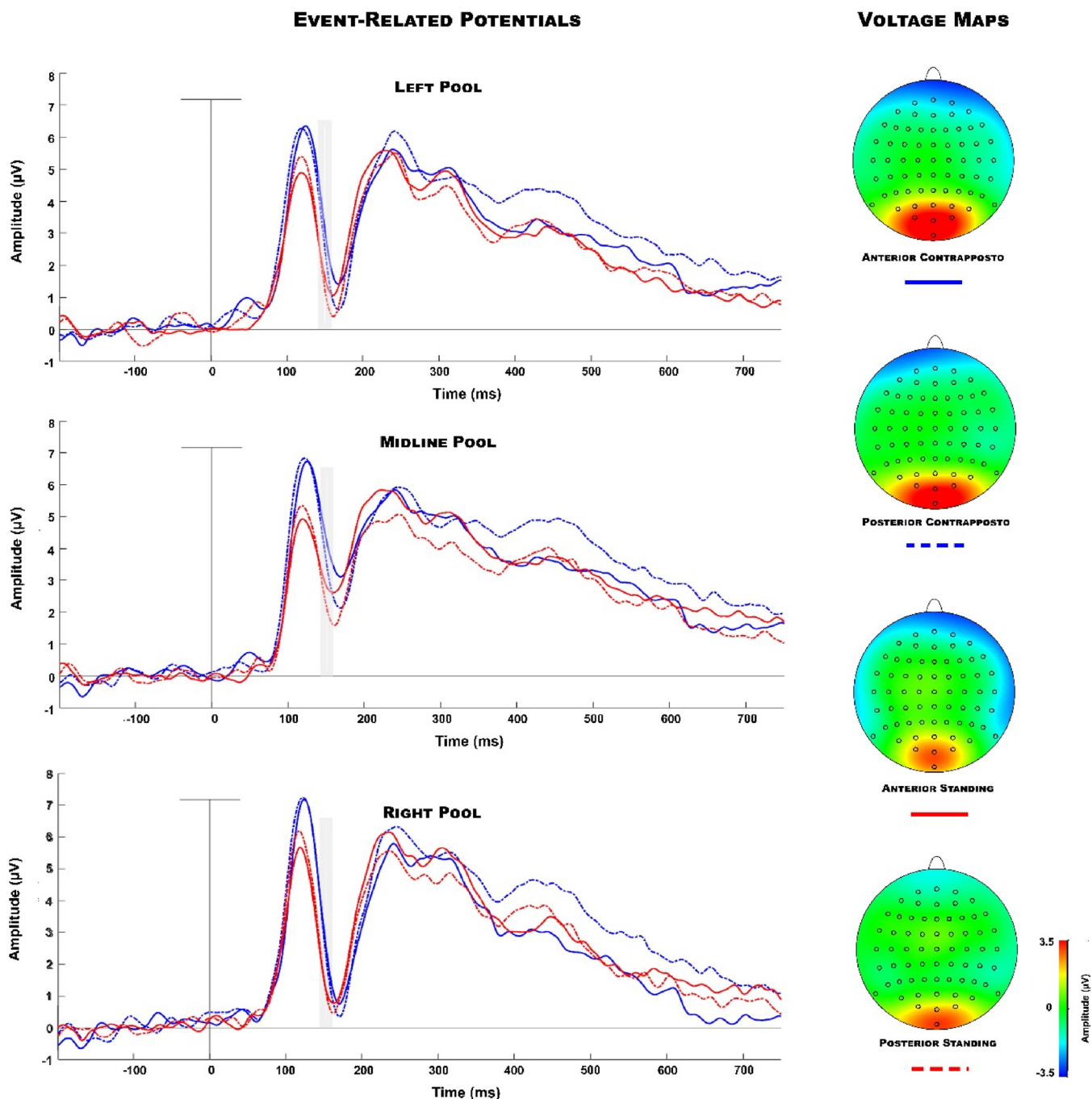


Fig. 11. Event-related potentials and voltage maps for temporal factor 6 of attractiveness judgement task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

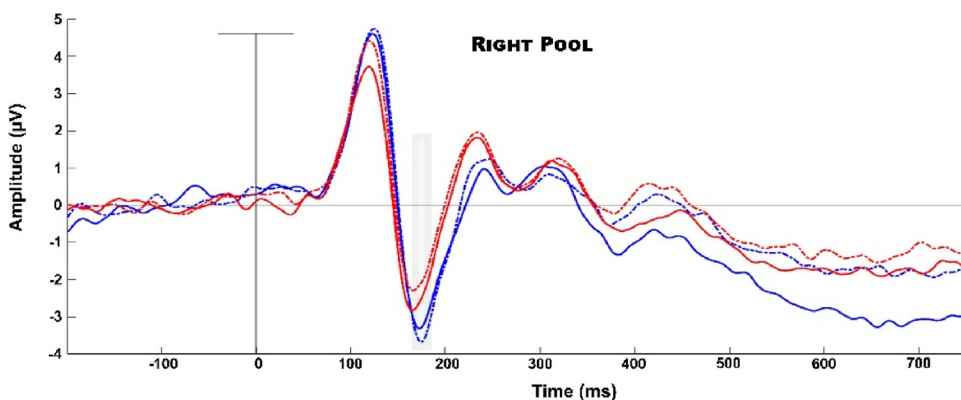
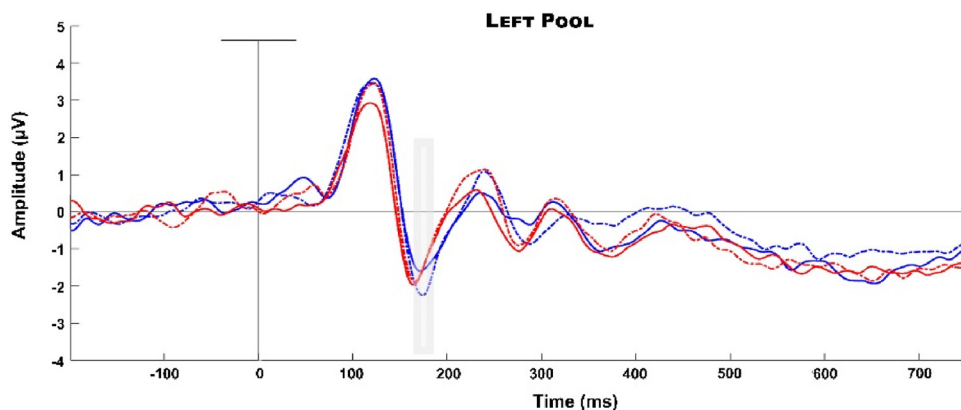
view for the contrapposto pose. Similarly, Del Zotto and Pegna (2017) reported higher N190 in response to a posterior view compared to anterior view of female stimuli in the standing pose. As previously mentioned regarding our results in the oddball task, the left inferior occipital gyrus is a region that plays a role in body form discrimination (de Gelder et al., 2010; Moro et al., 2008). Our results show that this region also responds differently to anterior and posterior views of body morphs at the early stages of stimulus presentation in the attractiveness judgement task. Furthermore, our result is in accordance with the previous research indicating that the N190 component is sensitive to

images of the human body (Thierry et al., 2006).

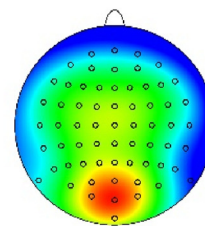
For the TF4 component which peaked between 160 and 185 ms post-stimulus at frontal and parietal electrodes, the current results show higher negative amplitude for the contrapposto pose than the standing pose. The highest neural activity was identified in the right middle temporal gyrus (BA37) which encompasses the fusiform gyrus. These different neural activation results for body posture at TF4 are in accordance with previous research indicating neural responses to visual depiction of human body in the EBA and FBA (extrastriate visual cortex) in the visual cortex (Downing et al., 2001; Peelen & Downing,

# ATTRACTIVENESS JUDGEMENT TASK TEMPORAL FACTOR 4

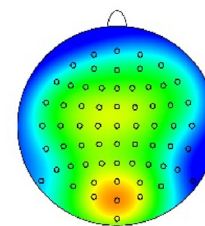
## EVENT-RELATED POTENTIALS



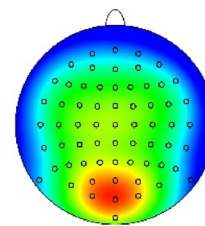
## VOLTAGE MAPS



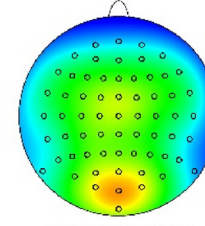
ANTERIOR CONTRAPPOSTO



POSTERIOR CONTRAPPOSTO



ANTERIOR STANDING



POSTERIOR STANDING

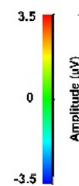


Fig. 12. Event-related potentials and voltage maps for temporal factor 4 of attractiveness judgement task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

2005, 2007; Schwarzlose et al., 2005; Taylor et al., 2007). Recently, Bernard et al. (2019) have reported similar results, as they found higher negativity in a similar time-window for human stimuli displaying contrapposto pose compared to standing one. Although they aimed to investigate the neural correlates of body objectification and grouped their stimuli in two categories of 'suggestive' and 'nonsuggestive' body postures, their stimuli can be recast as contrapposto and standing poses. Unlike the Bernard et al. (2019) study that used stimuli with a hand placed on the hip as an indicator of sexual suggestiveness, we used stimuli without hands and the head to exclude the potential perceptual effect of face and limbs on brain activity. As has been previously shown,

face and body might have overlapping effects during EEG recordings (Thierry et al., 2006) and under evaluative conditions, faces and bodies activate the brain differently (Muñoz & Martín-Loeches, 2015). Therefore, we conclude that human brain responds to contrapposto pose differently than standing pose irrespective of hands and face presence.

Results for the attractiveness judgement task also showed an effect for TF2, with the peaking amplitude between 190 and 340 ms post-stimulus at parieto-occipital and occipital regions. Maximal cortical activation for this temporal factor was also identified in middle temporal gyrus and Brodmann area 39 which encompasses angular gyrus. For the standing pose, an anterior view had higher amplitude than a

## ATTRACTIVENESS JUDGEMENT TASK TEMPORAL FACTOR 2

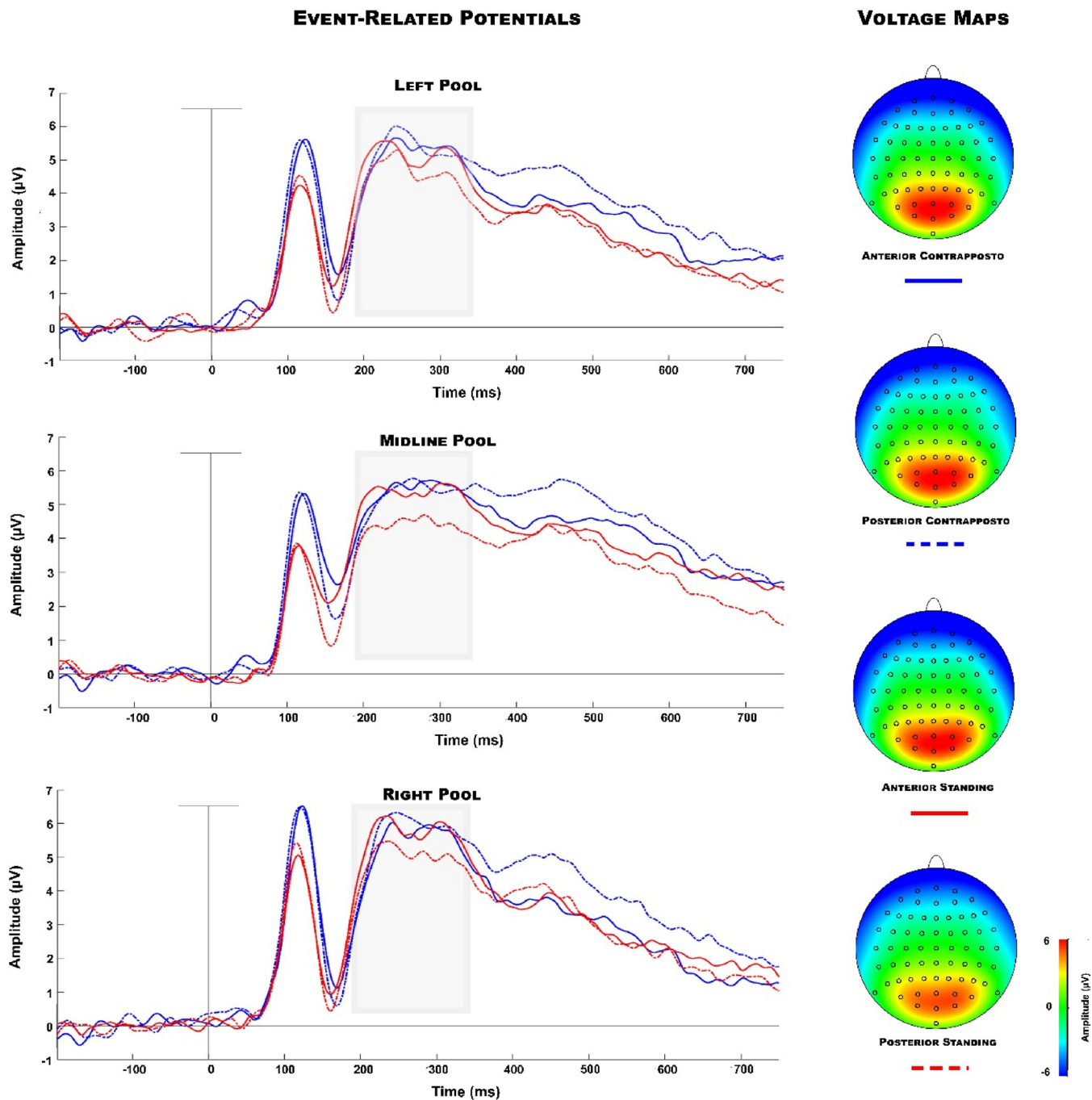


Fig. 13. Event-related potentials and voltage maps for temporal factor 2 of attractiveness judgement task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

posterior view. Also, for the posterior view, the contrapposto pose had a higher amplitude than the standing pose. The TF5 had maximal factor loadings from 380 to 500, and maximal factor scores at frontal electrodes; with a higher negative amplitude for the contrapposto pose than the standing pose, and its source of neural activation identified in middle temporal gyrus (angular gyrus/BA39). Therefore, the current paper indicates the role of middle temporal gyrus and angular gyrus in the perception of body posture and the judgement of its attractiveness, both in early and late components as well as for passive perception of posture (oddball) and active attractiveness judgement. And as

previously noted, the activation of middle temporal gyrus and angular area in the processing of human body posture can suggest specific processes related to the perception of attractiveness in faces and body figures (Shen et al., 2016; Vartanian et al., 2013; Zhang et al., 2014).

Finally, in the attractiveness judgement task, TF1 revealed an effect for angle with the anterior angle showing higher negative amplitude than the posterior angle. This component peaked from 500 ms post-stimulus to the end of the analyzed epoch (750 ms), with the maximal negative factor scores being recorded at frontal electrodes. LORETA analysis showed that the cortical sources of maximal activation were



# ATTRACTIVENESS JUDGEMENT TASK TEMPORAL FACTOR 1

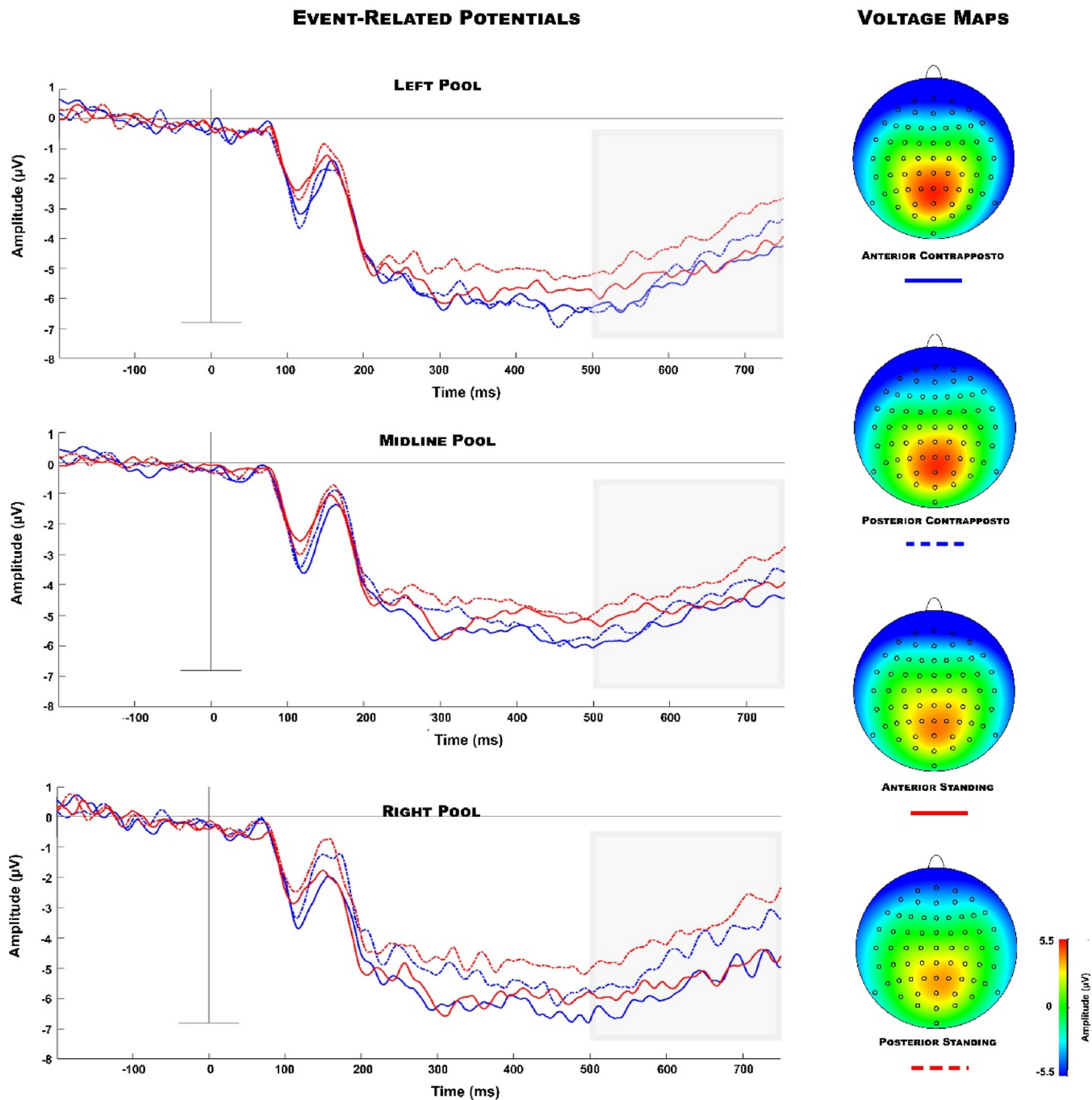


Fig. 14. Event-related potentials and voltage maps for temporal factor 1 of attractiveness judgement task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

identified at the lingual gyrus in Brodmann area 18 (secondary visual cortex). Lingual gyrus has been shown to be responsive to pictures of faces (McCarthy, Puce, Belger, & Allison, 1999), as well as bodies (Vocks et al., 2010). Previous research has highlighted the role of Lingual gyrus in bodily attractiveness perception (Martín-Loeches, Hernández-Tamames, Martín, & Urrutia, 2014; Pazhoohi et al., 2020; Platek & Singh, 2010).

It is noteworthy that there are several items that arise from this exploratory analysis that may warrant future research. First, the sample was slightly unbalanced in favor of the female group. Therefore, future

studies with equally large groups would help to enhance the exploration of potential gender differences in the processing of female body postures. Additionally, in order to extend results from the current study, future research should consider using more ecological stimuli (e.g. photos of real models).

## 5. Concluding remarks

Overall, the current study extends our understanding of the behavioral and neural correlates of human body posture perception. At the

# ATTRACTIVENESS JUDGEMENT TASK TEMPORAL FACTOR 5

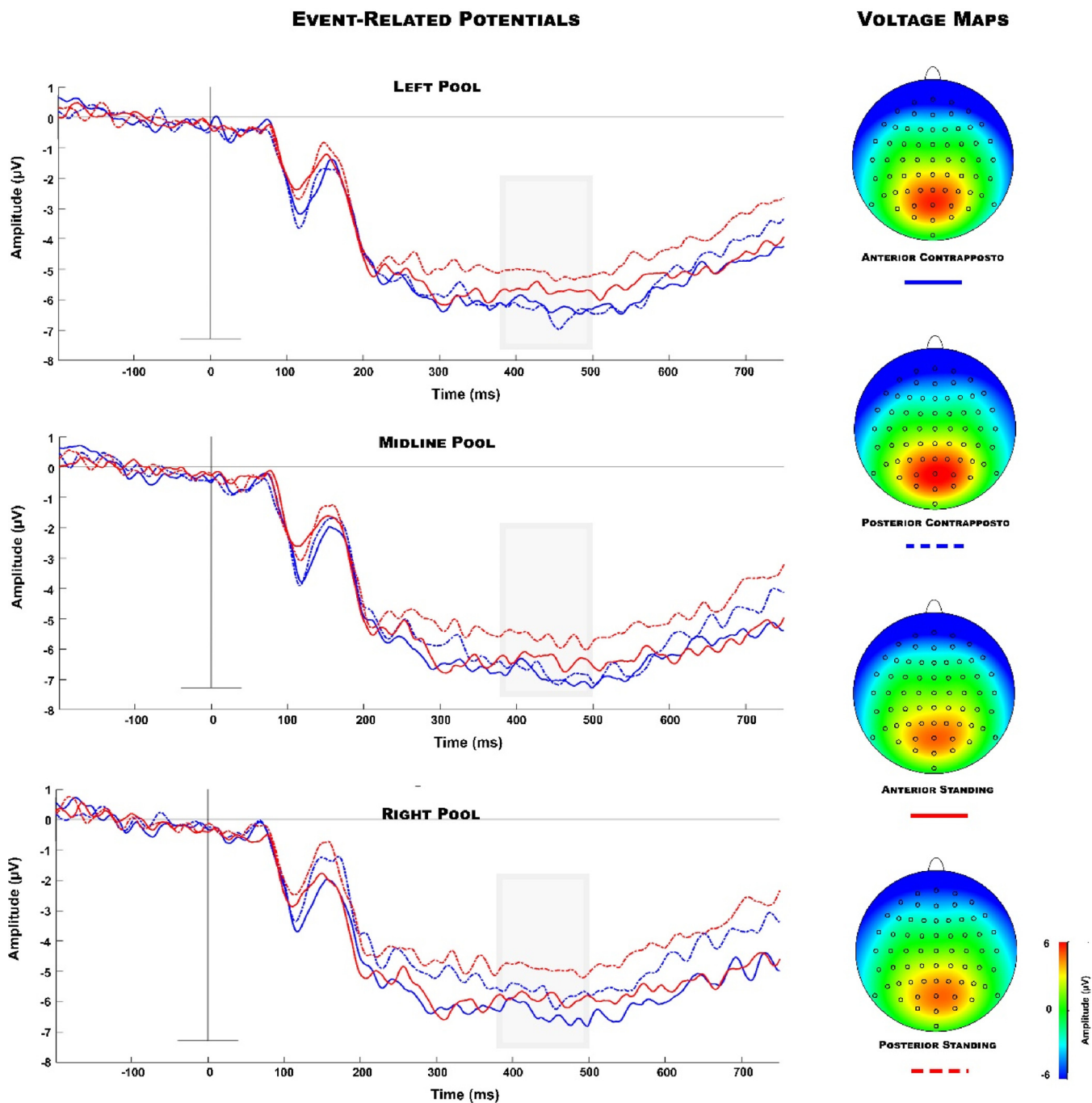


Fig. 15. Event-related potentials and voltage maps for temporal factor 5 of attractiveness judgement task showing left, midline and right pools for body poses (contrapposto and standing) and side (anterior and posterior).

behavioral level, our results show that contrapposto pose is considered more attractive by both men and women. We argue that female body depictions containing exaggerated WHRs that are lower than optimal, as is the case for the contrapposto posture, are supernormal stimuli and are therefore considered more attractive. Moreover, our results at the neural level show that the visual information relevant to body posture are processed differently by early components in the visual stream, indicating brain responsivity to variation in human body posture, namely contrapposto versus standing. This is in line with the results of previous studies regarding the perception of female body forms varying

in WHR (Del Zotto & Pegna, 2017; Pazhoohi et al., 2020). Furthermore, the EEG results show differences in the late components, indicating differences in attention and judgement of the characteristics defining the attractiveness of the stimuli varying in body pose. In addition to the visual cortex, the LORETA estimations of the current study identified the middle temporal gyrus along with angular area as regions maximally activated in association with the perception and judgment of the attractiveness of females' bodies with different body poses. Overall, we argue that the preference for lower WHRs is evolutionary hardwired into human brains and the appearance of an exaggerated low view-

dependent WHR in a static depiction of the human body, as is present in the contrapposto pose, activates brain regions associated with perception and judgments of attractiveness, thereby contributing to increased attention and attractiveness ratings when compared to a standing posture.

### Data availability

Data are available from Dr. Diego Pinal (diego.pinal.fdez@gmail.com) upon reasonable request.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.biopsycho.2020.107842>.

### References

- Bernard, P., Hanoteau, F., Gervais, S., Servais, L., Bertolone, I., Deltenre, P., & Colin, C. (2019). Revealing clothing does not make the object: ERP evidences that cognitive objectification is driven by posture suggestiveness, not by revealing clothing. *Personality and Social Psychology Bulletin*, 45(1), 16–36.
- Bertoquini, V., & Pais-Ribeiro, J. (2006). Estudo de formas reduzidas do NEO-PI-R: Exame do NeoFFI, do Neo-FFI-R, e do Neo FFI-P para o contexto português. *Psicologia: Teoria, Investigação e Prática*, 11, 85–102.
- Brodmann, K. (2006). *Brodmann's: Localisation in the cerebral cortex*. Springer Science & Business Media.
- Bzdok, D., Langner, R., Caspers, S., Kurth, F., Habel, U., Zilles, K., ... Eickhoff, S. B. (2011). ALE meta-analysis on facial judgments of trustworthiness and attractiveness. *Brain Structure and Function*, 215(3–4), 209–223.
- Canavairo, M. C. (1999). Inventário de Sintomas Psicopatológicos: BSI. In M. R. Simões, M. Gonçalves, & L. S. Almeida (Vol. Eds.), *Testes e provas psicológicas em Portugal: Vol. II*, (pp. 87–109). Braga: SHO/APPORT.
- Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research*, 1(2), 245–276.
- Cloutier, J., Heatherton, T. F., Whalen, P. J., & Kelley, W. M. (2008). Are attractive people rewarding? Sex differences in the neural substrates of facial attractiveness. *Journal of Cognitive Neuroscience*, 20(6), 941–951.
- Costa, M., & Corazza, L. (2006). Aesthetic phenomena as supernormal stimuli: The case of eye, lip, and lower-face size and roundness in artistic portraits. *Perception*, 35, 229–246.
- Costa, P. T., & McCrae, R. R. (1995). Domains and facets: Hierarchical personality assessment using the revised NEO personality inventory. *Journal of Personality Assessment*, 64(1), 21–50.
- Cross, E. S., Mackie, E. C., Wolford, G., & Hamilton, A. F. D. C. (2010). Contorted and ordinary body postures in the human brain. *Experimental Brain Research*, 204(3), 397–407.
- Dael, N., Mortillaro, M., & Scherer, K. R. (2012). The body action and posture coding system (BAP): Development and reliability. *Journal of Nonverbal Behavior*, 36(2), 97–121.
- de Gelder, B., Van den Stock, J., Meeren, H. K., Sinke, C. B., Kret, M. E., & Tamiotto, M. (2010). Standing up for the body. Recent progress in uncovering the networks involved in the perception of bodies and bodily expressions. *Neuroscience & Biobehavioral Reviews*, 34(4), 513–527.
- Del Zotto, M., & Pegna, A. J. (2017). Electrophysiological evidence of perceived sexual attractiveness for human female bodies varying in waist-to-hip ratio. *Cognitive, Affective, & Behavioral Neuroscience*, 17(3), 577–591.
- Derenne, A., Breistein, R. M., & Cicha, R. J. (2008). Shifts in postdiscrimination gradients within a stimulus dimension based on female waist-to-hip ratios. *Psychological Record*, 58, 51–60. <https://doi.org/10.1901/jeab.2010.93-485>.
- Derogatis, L. R. (1993). *BSI: Brief symptom inventory* (3rd ed.). Minneapolis: National Computers Systems.
- Dien, J. (1998). Addressing misallocation of variance in principal components analysis of event-related potentials. *Brain Topography*, 11(1), 43–55.
- Dien, J., Beal, D. J., & Berg, P. (2005). Optimizing principal components analysis of event-related potentials: Matrix type, factor loading weighting, extraction, and rotations. *Clinical Neurophysiology*, 116(8), 1808–1825.
- Downing, P. E., Jiang, Y., Shuman, M., & Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science*, 293(5539), 2470–2473.
- Doyle, J. F. (2009). A woman's walk: Attractiveness in motion. *Journal of Social, Evolutionary, & Cultural Psychology*, 3, 81–92.
- Doyle, J. F., & Pazhoohi, F. (2012). Natural and augmented breasts: Is what is not natural most attractive? *Human Ethology Bulletin*, 27(4), 4–14.
- Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G\* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191.
- Fink, B., Klappauf, D., Brewer, G., & Shackelford, T. K. (2014). Female physical characteristics and intra-sexual competition in women. *Personality and Individual Differences*, 58, 138–141.
- Fuchs, M., Kastner, J., Wagner, M., Hawes, S., & Ebersole, J. S. (2002). A standardized boundary element method volume conductor model. *Clinical Neurophysiology*, 113(5), 702–712.
- Ghirlanda, S., & Enquist, M. (2003). A century of generalization. *Animal Behaviour*, 66, 15–36. <https://doi.org/10.1006/anbe.2003.2174>.
- Graffar, M. (1956). Une méthode de classification sociale d'échantillons de population. *Courrier*, 6(8), 455–459.
- Grammer, K., Fink, B., Oberzaucher, E., Atzmüller, M., Blantar, I., & Mitteroecker, P. (2004). The representation of self reported affect in body posture and body posture simulation. *Collegium Antropologicum*, 28(2), 159–173.
- Gratton, G., Coles, M. G., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography & Clinical Neurophysiology*, 55, 468–484.
- Hamann, S., Herman, R. A., Nolan, C. L., & Wallen, K. (2004). Men and women differ in amygdala response to visual sexual stimuli. *Nature Neuroscience*, 7(4), 411.
- Holliday, I. E., Longe, O. A., Thai, N. J., Hancock, P. J., & Tovée, M. J. (2011). BMI not WHR modulates BOLD fMRI responses in a sub-cortical reward network when participants judge the attractiveness of human female bodies. *PLoS One*, 6(11), e27255.
- Jacques, C., Jonas, J., Maillard, L., Colnat-Coulbois, S., Koessler, L., & Rossion, B. (2019). The inferior occipital gyrus is a major cortical source of the face-evoked N170: Evidence from simultaneous scalp and intracerebral human recordings. *Human Brain Mapping*, 40(5), 1403–1418.
- Kranz, F., & Ishai, A. (2006). Face perception is modulated by sexual preference. *Current Biology*, 16(1), 63–68.
- Kret, M. E., Pichon, S., Grèzes, J., & de Gelder, B. (2011). Similarities and differences in perceiving threat from dynamic faces and bodies. An fMRI study. *Neuroimage*, 54(2), 1755–1762.
- Kret, M., Stekelenburg, J., Roelofs, K., & De Gelder, B. (2013). Perception of face and body expressions using electromyography, pupillometry and gaze measures. *Frontiers in Psychology*, 4, 28.
- Martín-Loeches, M., Hernández-Tamames, J. A., Martín, A., & Urrutia, M. (2014). Beauty and ugliness in the bodies and faces of others: an fMRI study of person esthetic judgement. *Neuroscience*, 277, 486–497.
- Mazziotta, J., Toga, A., Evans, A., Fox, P., Lancaster, J., Zilles, K., ... Holmes, C. (2001). A probabilistic atlas and reference system for the human brain: International Consortium for Brain Mapping (ICBM). *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 356(1412), 1293–1322.
- McCarthy, G., Puce, A., Belger, A., & Allison, T. (1999). Electrophysiological studies of human face perception. II: Response properties of face-specific potentials generated in occipitotemporal cortex. *Cerebral Cortex*, 9(5), 431–444.
- Mehrabian, A. (1969). Significance of posture and position in the communication of attitude and status relationships. *Psychological Bulletin*, 71(5), 359.
- Moro, V., Urgesi, C., Pernigo, S., Lanteri, P., Pazzaglia, M., & Aglioti, S. M. (2008). The neural basis of body form and body action agnosia. *Neuron*, 60(2), 235–246.
- Morris, P. H., White, J., Morrison, E. R., & Fisher, K. (2013). High heels as supernormal stimuli: How wearing high heels affects judgements of female attractiveness. *Evolution and Human Behavior*, 34, 176–181.
- Muñoz, F., & Martín-Loeches, M. (2015). Electrophysiological brain dynamics during the esthetic judgment of human bodies and faces. *Brain Research*, 1594, 154–164.
- Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*, 9(1), 97–113.
- Pascual-Marqui, R. D. (1999). Review of methods for solving the EEG inverse problem. *International Journal of Bioelectromagnetism*, 1(1), 75–86.
- Pascual-Marqui, R. D., Michel, C. M., & Lehmann, D. (1994). Low resolution electromagnetic tomography: A new method for localizing electrical activity in the brain. *International Journal of Psychophysiology*, 18(1), 49–65.
- Pazhoohi, F., Doyle, J. F., Macedo, A. F., & Arantes, J. (2018). Arching the back (lumbar curvature) as a female sexual proceptivity signal: An eye-tracking study. *Evolutionary Psychological Science*, 4(2), 158–165.
- Pazhoohi, F., Macedo, F. A., Doyle, J. F., & Arantes, J. (2019). Waist to hip ratio as supernormal stimuli: Effect of contrapposto pose and viewing angle. *Archives of Sexual Behavior*, 1–11. <https://doi.org/10.1007/s10508-019-01486-z>.
- Pazhoohi, F., Arantes, J., Kingstone, A., & Pinal, D. (2020). Waist to hip ratio and breast

- size modulate the processing of female body silhouettes: an EEG study. *Evolution & Human Behavior*, 1–20. <https://doi.org/10.1016/j.evolhumbehav.2020.01.001>.
- Peelen, M. V., & Downing, P. E. (2005). Selectivity for the human body in the fusiform gyrus. *Journal of Neurophysiology*, 93(1), 603–608.
- Peelen, M. V., & Downing, P. E. (2007). The neural basis of visual body perception. *Nature Reviews Neuroscience*, 8(8), 636.
- Pinel, P., Piazza, M., Le Bihan, D., & Dehaene, S. (2004). Distributed and overlapping cerebral representations of number, size, and luminance during comparative judgments. *Neuron*, 41(6), 983–993.
- Pitcher, D., Walsh, V., Yovel, G., & Duchaine, B. (2007). TMS evidence for the involvement of the right occipital face area in early face processing. *Current Biology*, 17(18), 1568–1573.
- Pitcher, D., Charles, L., Devlin, J. T., Walsh, V., & Duchaine, B. (2009). Triple dissociation of faces, bodies, and objects in extrastriate cortex. *Current Biology*, 19(4), 319–324.
- Platek, S. M., & Singh, D. (2010). Optimal Waist-to-Hip Ratios in women activate neural reward centers in men. *PLoS One*, 5(2), e9042.
- Pourtois, G., Peelen, M. V., Spinelli, L., Seeck, M., & Vuilleumier, P. (2007). Direct intracranial recording of body-selective responses in human extrastriate visual cortex. *Neuropsychologia*, 45(11), 2621–2625.
- Rupp, H. A., & Wallen, K. (2008). Sex differences in response to visual sexual stimuli: A review. *Archives of Sexual Behavior*, 37(2), 206–218.
- Schwarzlose, R. F., Baker, C. I., & Kanwisher, N. (2005). Separate face and body selectivity on the fusiform gyrus. *Journal of Neuroscience*, 25(47), 11055–11059.
- Seghier, M. L. (2013). The angular gyrus: Multiple functions and multiple subdivisions. *The Neuroscientist*, 19(1), 43–61.
- Shen, H., Chau, D. K., Su, J., Zeng, L. L., Jiang, W., He, J., ... Hu, D. (2016). Brain responses to facial attractiveness induced by facial proportions: Evidence from an fMRI study. *Scientific Reports*, 6, 35905.
- Spicer, K. R., & Platek, S. M. (2010). Curvaceous female bodies activate neural reward centers in men. *Communicative & Integrative Biology*, 3(3), 282–283.
- Squires, N. K., Squires, K. C., & Hillyard, S. A. (1975). Two varieties of long-latency positive waves evoked by unpredictable auditory stimuli in man. *Electroencephalography and Clinical Neurophysiology*, 38(4), 387–401.
- Staddon, J. E. R. (1975). A note on the evolutionary significance of “supernormal” stimuli. *The American Naturalist*, 109, 541–545. <https://doi.org/10.1086/283025>.
- Taylor, J. C., Wiggett, A. J., & Downing, P. E. (2007). fMRI analysis of body and body part representations in the extrastriate and fusiform body areas. *Journal of Neurophysiology*, 98, 1626–1633.
- Thierry, G., Pegna, A. J., Dodds, C., Roberts, M., Basan, S., & Downing, P. (2006). An event-related potential component sensitive to images of the human body. *Neuroimage*, 32(2), 871–879.
- Tinbergen, N. (1948). Social releasers and the experimental method required for their study. *The Wilson Bulletin*, 60(1), 6–51.
- Triarhou, L. C. (2007). A proposed number system for the 107 cortical areas of Economo and Koskinas, and Brodmann area correlations. *Stereotactic and Functional Neurosurgery*, 85(5), 204–215.
- Uono, S., Sato, W., Kochiyama, T., Kubota, Y., Sawada, R., Yoshimura, S., & Toichi, M. (2017). Time course of gamma-band oscillation associated with face processing in the inferior occipital gyrus and fusiform gyrus: A combined fMRI and MEG study. *Human Brain Mapping*, 38(4), 2067–2079.
- Vartanian, O., Goel, V., Lam, E., Fisher, M., & Granic, J. (2013). Middle temporal gyrus encodes individual differences in perceived facial attractiveness. *Psychology of Aesthetics, Creativity, and the Arts*, 7(1), 38–47.
- Vocks, S., Busch, M., Grönemeyer, D., Schulte, D., Herpertz, S., & Suchan, B. (2010). Neural correlates of viewing photographs of one's own body and another woman's body in anorexia and bulimia nervosa: An fMRI study. *Journal of Psychiatry & Neuroscience: JPN*, 35(3), 163.
- Winston, J. S., O'Doherty, J., Kilner, J. M., Perrett, D. I., & Dolan, R. J. (2007). Brain systems for assessing facial attractiveness. *Neuropsychologia*, 45(1), 195–206.
- Zhang, Y., Tang, A. C., & Zhou, X. (2014). Synchronized network activity as the origin of a P 300 component in a facial attractiveness judgment task. *Psychophysiology*, 51(3), 285–289.