



## Original Research Article

## Gender differences in the neural underpinning of perceiving and appreciating the beauty of the body

Valentina Cazzato<sup>a,b,\*</sup>, Sonia Mele<sup>a,b</sup>, Cosimo Urgesi<sup>a,b,\*</sup><sup>a</sup> Dipartimento di Scienze Umane, Università degli Studi di Udine, Udine, Italy<sup>b</sup> Istituto di Ricovero e Cura a Carattere Scientifico Eugenio Medea, San Vito al Tagliamento, Pordenone, Italy

## HIGHLIGHTS

- rTMS was used to investigate the neural bases of body esthetic perception.
- rTMS over EBA altered the esthetic judgments of opposite-gender bodies.
- Women showed stronger right EBA dominance than men in body esthetic judgments.
- Left- and right-EBA rTMS did not affect perception of body weight.

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## ABSTRACT

Although previous studies have suggested a certain degree of right hemisphere dominance for the response of extrastriate body area (EBA) during body perception, recent evidence suggests that this functional lateralization may differ between men and women. It is unknown, however, whether and how gender differences in body perception affect appreciating the beauty of the body of conspecifics. Here, we applied five 10-Hz repetitive transcranial magnetic stimulation (rTMS) pulses over left and right EBA and over the vertex to investigate the contribution of visual body representations in the two hemispheres on esthetic body perception. Female and male healthy volunteers were requested to judge how much they liked opposite- and same-gender virtual model bodies or to judge their weight, thus allowing us to compare the effects of right- and left-EBA rTMS on esthetic (liking) and perceptual (weight) judgments of human bodies. The analysis of the esthetic judgments provided by women revealed that right-EBA rTMS increased the liking judgments of opposite- but not same-gender models, as compared to both vertex and left EBA stimulation. Conversely, in men the liking judgments of opposite-gender models decreased after virtual disruption of both right and left EBA as compared to vertex stimulation. Crucially, no significant effect was found for the perceptual task, showing that left- and right-EBA rTMS did not affect weight perception. Our results provide evidence of gender difference in the hemispheric asymmetry of EBA in the esthetic processing of human bodies, with women showing stronger right hemisphere dominance in comparison with men.

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\* Corresponding authors at: Corresponding authors at: Valentina Cazzato or Cosimo Urgesi, Department of Human Sciences, University of Udine, Via Margreth, 3, I-33100 Udine, Italy. Tel.: +39 0432 249889.

E-mail addresses: [valentina.cazzato@uniud.it](mailto:valentina.cazzato@uniud.it) (V. Cazzato), [cosimo.urgesi@uniud.it](mailto:cosimo.urgesi@uniud.it) (C. Urgesi).

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## 1. Introduction

Repetitive transcranial magnetic stimulation (rTMS) and neuroimaging studies have established that a specialized brain network involving the occipital and temporal cortices subserves perception of bodies in humans [35,38,54,55]. In particular, extrastriate body area (EBA) located at the posterior inferior temporal sulcus/middle temporal gyrus [22] and the fusiform body area located at the ventro-medial temporal cortex [38] display a highly selective activity for visual presentations of human bodies. These areas respond selectively to photorealistic depictions of whole human bodies or body parts, still images of human bodies or body parts extending to 'stick figures' and silhouettes, in preference to human faces, images of object parts and scenes [20,21,38,53].

Interestingly, recent findings have shown that visual body representations are crucially involved during esthetical appreciation of body stimuli [23]. For example, Di Dio et al. [18] found stronger neural activity in the lateral occipital cortex for images of whole-body statues obeying the 'Golden section', a principle of spatial proportion traditionally felt to be beautiful, than for statues not following this principle. Cross et al. [16] reported a greater activation of EBA during observation of the dance moves that participants rated as both more pleasing and more difficult to reproduce. Crucially, only one study used rTMS to interfere with EBA during esthetic preference judgements of static postures of dance moves [6]. The results of this study showed that rTMS interference with either left or right EBA had a detrimental effect on the consistency of participants' esthetic judgments across multiple sessions, thus blunting esthetic judgments about body postures. The authors interpreted these results within the framework of a 'dual-route' model of visual body perception [54], which suggests that EBA may be involved in the local processing of the details of human body parts, while other regions, including the fronto-parietal cortex and FBA may be involved in configural body processing. In this view, the results of Calvo-Merino et al. [6] may suggest that disruption of the local processing system, housed in EBA, blunts esthetic sensitivity, while interference with the global processing system (i.e., premotor and parietal areas) tends to heighten esthetic sensitivity. Importantly, Calvo-Merino et al. [6] did not find any hemispheric lateralization effect, thus proposing that both left and right EBA contributed in a similar manner to esthetic body processing. However possible gender difference effects were not explored in that study and, thus, it could not be established whether different lateralization patterns of EBA involvement in esthetic body perception occur in male and female observers.

Recent evidence suggests that the gender of the observer may influence the lateralization of EBA response to human body images. Aleong and Paus [1] showed that healthy women exhibited greater response to human bodies in the right vs. left EBA and greater right-EBA response compared with men. The right and left hemispheres may have complimentary roles in visual body representation and their relative involvement may be different in women and men. A behavioral study of Mohr et al. [36] showed that unilateral presentation of self-body images in the left visual hemi-field, which projects first to the right hemisphere, resulted into an overestimation bias in women, but not in men. These findings suggest a role

of right hemisphere body representation in the development and maintenance of body image distortions in women and may shed light on the neural mechanisms of eating disorders (EDs), seen that higher prevalence of this psychiatric disorder is in women than in men. Accordingly, recent findings suggest that structural and functional alteration in the EBA in EDs patients might explain the body size misjudgement in this clinical population [47,48].

To our knowledge, no studies have so far investigated the causative role of visual brain regions in the esthetic appreciation of the body of same- vs. opposite-gender individuals. Crucially, it is unknown whether the differences in the functional lateralization of body perception in men and women may extend into appreciating the beauty of the body of conspecifics. Thus, we sought to investigate: (a) the active contribution of right (rEBA) and left EBA (lEBA) on esthetic vs. perceptual judgments of human bodies; (b) the potential differences between men and women in the hemispheric asymmetry of EBA during perceiving and appreciating the beauty of the body. To answer these questions, we applied brief trains of rTMS (10 Hz, 500 ms) over lEBA and rEBA to investigate their relative role in perceptual and esthetic body processing. Stimulation of the vertex served as control condition.

Previous neuroaesthetic works have used either a 'subjectivist' or 'objectivist' approach to the study of aesthetics experience (for a discussion, see [5,10]). In the former, researchers are interested into the specific attributes that make objects or persons to be beautiful, thus treating beauty as attribute of stimuli; in this context they explore which brain activations differentiate the processing of beautiful and non-beautiful stimuli independently of whether the observer is engaged or not in esthetic evaluation [3,12,18]. Importantly, objectivist approaches assume the generalizability of the features that drive esthetic appreciation across different individuals, eventually claiming the functional significance of beautiful features (e.g., symmetry and sexual dimorphism) for natural or sexual selection [11]. On the other hand subjectivist approaches stress the role of individual taste and preference, largely determined by previous experience and cultural environment, ultimately treating esthetic attribute as a property of the observer (i.e., 'beauty is in the brain of the beholder') rather than a stimulus property. Studies using this approach make rather few predictions about which specific stimuli are liked more by a group of individuals, but they link neural activations to the esthetic preferences expressed by each individual. More recently, other studies have focused on subjective evaluation of stimuli with the further attempt to identify the stimuli that share some specific perceptual features and are liked more by a group of individuals. For example, Calvo-Merino et al. [5] scanned participants during passive observation of dance moves and then asked the same participants to judge each move on a series of esthetic attributes, including simple-complex, dull-interesting, tense-relaxed, weak-powerful, and like-dislike dimensions. Comparing brain activations in response to moves that were liked more vs. those that were liked less at the group level revealed specific activation in the occipital cortices and in right premotor cortex; furthermore, the moves that were liked more were also those that had more whole body displacement in space. No specific brain activation pattern emerged considering the other esthetic dimensions, suggesting that 'liking-disliking' is

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