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Facial gender and hemispheric asymmetries: A hf-tRNS study

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Dear Editor,

A right-hemispheric superiority for the representation of the female face has been previously shown [1–3], and it has been attributed to the 'cradling bias', namely the leftward bias observed during infant cradling by an adult, found in female but not in male individuals [4]. Due to the fact that infants are cradled on the left side by the mother, their right hemisphere would be preferentially exposed to the mother's face, and the right-hemisphere of the mother would be directly exposed to the baby's face [5]: this bias has been interpreted as the basis of the hemispheric imbalance for processing female faces [1,2].

In a face gender categorization task, we applied high frequency transcranial random noise stimulation (hf-tRNS) unilaterally over the temporo-parietal cortex, starting from the evidence of decreased adaptation after-effects for female faces when cathodal – but not anodal – trancranial direct current stimulation (tDCS) was applied over the right temporo-parietal cortex [6]. We expected to find a different modulation in the categorization of female faces according to the stimulation of the left or the right hemisphere.

Materials and methods

Participants

Forty healthy volunteers took part in the study (age: 24.53 ± 0.33): twenty participants were randomly assigned to the left stimulation group (13 females), and 20 participants to the right stimulation group (13 females). Two participants were excluded because they were left-handed (right stimulation group), as measured by the Edinburgh Handedness Inventory [7], and the handedness score of the remaining participants was 69.18 (±3.58). All participants were free from psychiatric or neurological disorders and gave written consent before beginning the experiments. The whole procedure was carried out in accordance with the principles of the Declaration of Helsinki and had been approved by the Local Ethical Committee.

tRNS and general procedure

hf-tRNS was delivered by a battery-driven, constant current stimulator (DC-Stimulator, NeuroConn GmbH, Germany) through a pair of surface saline-soaked sponge electrodes kept firm by elastic bands. The active electrode (4 × 4 cm) was placed over P7/P8 site of the 10–20 EEG system, in the left/right stimulation group respectively. The reference electrode (5 × 7 cm) was placed over the shoulder contralateral to the stimulated hemisphere. tRNS with intensity 2 mA and with 0 mA offset was applied for 15 minutes at random frequencies ranging from 100 to 640 Hz (high frequency), with a ramping period of 30 sec both at the beginning and at the end of the stimulation.

Participants took part in 2 different sessions (tRNS and sham), separated by at least 24 hours. During the sham, the cephalic electrode was placed over the right hemisphere for participants who received hf-tRNS over the left hemisphere, and *vice versa*, and the current was turned off after 30 sec. The order of sessions was counterbalanced across subjects. The task started 5 minutes after the beginning of the stimulation and it was carried out online.

Stimuli and procedure

The photographs of 10 female and 10 male faces in frontal view were converted into gray scale images and covered by an oval-shaped white mask in order to hide hair. A portion of face measuring 150 × 205 pixels was led visible (3.43° × 5.46° of visual angle, at a distance of 56 cm; for more details see Ref. [2]).

In each session, 320 trials were presented (160 female faces). In a trial, a black fixation cross was presented for 1000 ms, and it was followed by a face presented in the center of the screen for 150 ms. Then the screen became blank until participants gave the response, and then the next trial started. Participants were asked to categorize each stimulus as female or male, as accurately and rapidly as possible, by pressing 2 different keys with the right hand (association between key and response was balanced among participants).

Results

Data analysis was based on the Inverse Efficiency Score (IES), consisting in the response times for the correct responses divided by the proportion of correct responses in each condition [8]. Five participants were excluded from the analysis because their IES exceeded more than 2 standard deviations in at least one condition (2 female in the left stimulation group, 2 female and 1 male in the right stimulation group).

IES from the remaining 33 participants were used as the dependent variable in a repeated measures analysis of variance (ANOVA) with Sex of participant (Female, Male) and Side of stimulation (Left stimulation, Right stimulation) as between-subjects factors, and

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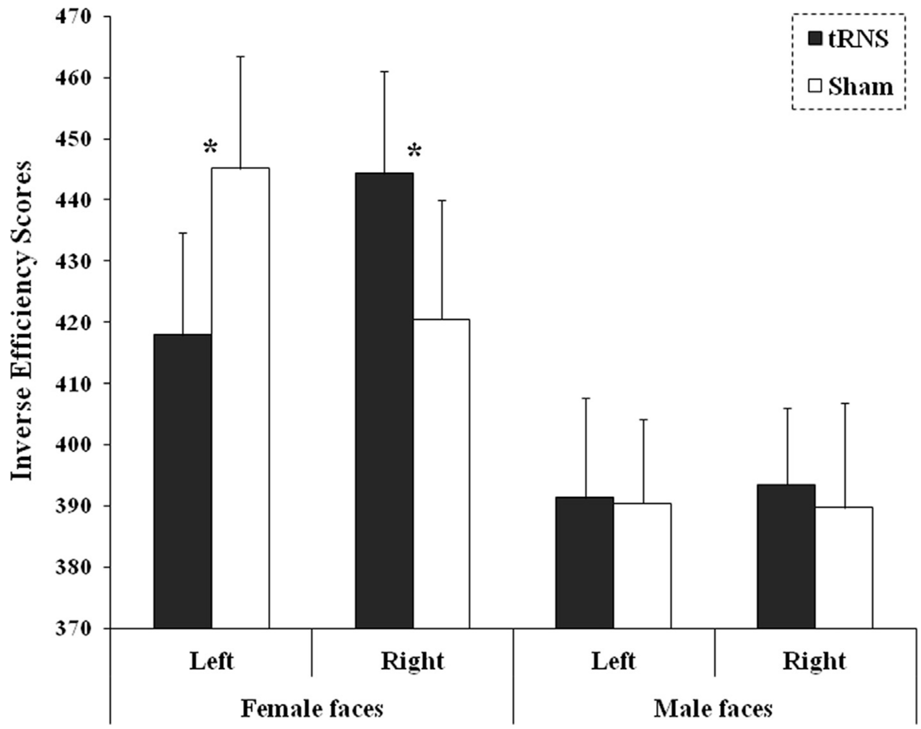

Fig. 1. Interaction among Sex of face (Female faces, Male faces), Side of stimulation (Left: P7; Right: P8) and Session (tRNS, Sham) on the Inverse Efficiency Scores (response times for the correct responses divided by the proportion of correct responses). Bars represent standard errors and asterisks show significant differences. Note that the difference between female and male faces is significant in all conditions (tRNS and Sham, for both Left stimulation and Right stimulation).

Sex of face (Female, Male) and Session (tRNS, Sham) as within-subjects factors.

The main effect of Sex of face was significant ($F_{1,29} = 20.95$, $p < 0.001$, $\eta^2_p = 0.42$): the performance was better for Male faces (391.28 ± 7.38) than for Female faces (432.00 ± 8.86). The interaction among Sex of face, Side of stimulation and Session was significant ($F_{1,29} = 5.94$, $p = 0.021$, $\eta^2_p = 0.17$; Fig. 1) and post-hoc comparisons - carried out by means of the Duncan test - confirmed that in each condition Male faces were better categorized than Female faces ($p < 0.02$ for all comparisons). Importantly, the categorization of Female faces was better during tRNS than during Sham, in the Left stimulation ($p = 0.019$), whereas it decreased with tRNS as compared to Sham in the Right stimulation ($p = 0.027$). The performance for Female faces did not differ between Left/Right tRNS ($p = 0.364$), nor between Left/Right sham ($p = 0.395$). No difference was observed for Male faces.

Discussion

The present results show the usefulness of hf-tRNS as a non-invasive tool to modulate gender recognition. In accordance with a differential involvement of the left and right hemispheres in processing facial gender, as suggested by previous findings [1–3,6], hf-tRNS applied over the left temporo-parietal site improves the ability to correctly categorize female faces, whereas hf-tRNS applied over the right temporo-parietal site leads to a significant decrement of this ability. The fact that the modulation found here is specific for female faces, but no significant difference was found for male faces, leads us to suggest that this type of asymmetry could be linked to the hemispheric processing advantage supporting the infant's cradling bias. This "female bias" has been also shown in nonhuman primates [9] and it has been associated with a normal socio-affective development [10]. We can conclude that a special circuit exists in the brain of both females and males for the processing of female faces. This circuit seems to be linked to an innate bias in maternal cradling, and it can be selectively altered by hf-tRNS applied over the temporo-parietal cortex.

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