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RESEARCH ARTICLE

Emotional face recognition, empathic trait (BEES), and cortical contribution in response to positive and negative cues. The effect of rTMS on dorsal medial prefrontal cortex

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Abstract The present study investigated the relationship between three different measures related to the affective empathy: facial expression detection in response to different emotional patterns (positive vs. negative), personal response to empathic scale [Balanced Emotional Empathy Scale (BEES)], and dorsal medial prefrontal cortex (dMPFC) contribution to mediate the facial detection task. Nineteen subjects took part in the study and they were required to recognize facial expression of emotions, after having empathized with these emotional cues. Repeated Transcranial Magnetic Stimulation (rTMS) method was used in the present research in order to produce a temporary virtual disruption of dMPFC activity. dMPFC disruption induced a worse performance, especially in response to negative expressions (i.e. anger and fear). High-BEES subjects paid a higher cost after frontal brain perturbation: they showed to be unable to correctly detect facial expressions more than low-BEES. Moreover, a "negative valence effect" was observed only for high-BEES, and it was probably related with their higher impairment to recognize negative more than positive expressions. dMPFC was found to support emotional facial expression recognition in an empathic condition, with a specific increased responsiveness for negative-valenced faces. The contribution of this research was discussed to explain the mechanisms underlying affective empathy based on rTMS application.

Keywords Empathy · rTMS · dMPFC · Facial expression · Emotion · Trait empathy

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Introduction

Regardless of the particular terminology used by different authors, there is broad agreement that empathy involves three primary elements: a cognitive capacity to adopt the perspective of the other person, some monitoring and self-regulatory mechanisms that keep track of the origins of self and other emotions, and an affective response to another person, that often entails sharing that person's emotional state (Batson et al. 1997; Decety and Jackson 2004; Harmon-Jones and Winkielman 2007; Hooker et al. 2008; Ickes 1997; Preston and de Waal 2001). Specifically, shared representations and emotions constitute the basic macro components of empathy, which are mediated by specific neural systems (Decety and Jackson 2004; Farrow and Woodruff 2007). Such systems give rise to "resonance mechanism", which represents one important aspect of empathy (Seitz et al. 2008). Other components, including the ability to monitor and regulate self and other emotional processes, are also necessary parts of a functional model of empathy (Chauhan et al. 2008; Lee et al. 2008). These aspects may be experienced independently from one another, and may constitute different levels of complexity, ranging from empathic mimicry to sympathy. In addition, occasionally, these components occur without awareness (Hoffman 1981), as in the affective sharing aspect. In fact, like many emotion-related processes, some components of empathy occur automatically. Contrarily, other components, such as cognitive perspective-taking and some aspects of emotion regulation, require intentional processing.

With respect to the emotional components, most authors agree that "emotional resonance" includes at least three different aspects: knowing what another person is feeling by monitoring external cue of emotions; feeling what another person is feeling; having the intention to respond compassionately to another person's distress. We generally know what emotional states other experienced by reading their facial expressions (Balconi and Pozzoli 2007, 2009), since emotional cue detection may guarantee an adequate empathic response to that emotional situation. Thus, the perceptual ability to attending in social relevant stimuli, including facial expression of emotions, is central to empathic response (Enticott et al. 2008). Some previous studies examined whether emotional empathy was linked to sensitivity to facial expressions. It was showed empathy can be modulated by appraisal processes, that may be also partially implicit, related to the emotional significance each facial stimulus may have (Balconi and Lucchiari 2005). Within this appraisal processes, the intensity (in terms of high vs. low arousing stimuli), valence (positive vs negative), and salience (personal relevance to the subject) of emotions displayed by the facial cue have a great influence on the observer's empathic response (de Vignemont and Singer 2006). For example, a central distinction should be made between positive vs. negative empathic condition and, whereas empathy for negative emotions was amply explored, empathy for positive emotions was less studied. Thus this is a first aspect to be considered and explored, that was largely underestimated by previous research. Direct relationship between empathic behavior and emotional facial detection performance was considered in the present research, taking into account the positive vs. negative valence of faces.

Research into the relationship between emotional face detection and empathic trait differences has also been conducted. Empathic personality measures were considered valid criteria with which to evaluate the presence of structural differences in emotional empathic responsiveness. Subjects could be generally divided into high or low empathic groups, and researchers showed a direct relationship between subjects' recognition skills and different degrees of empathy (Besel 2007; de Wied et al. 2006). More directly, the ability to recognize emotional faces was found to be related to personal empathy. Recent research examined whether people with higher dispositional empathy are better at recognizing facial expressions of emotion at faster presentation speeds. This research found significant connections between expression recognition and the cognitive and emotional empathy (Hess and Blairy 2001). In addition, it was found individuals with greater autonomic tendency to reciprocate facial expressions score higher on an empathy questionnaire (Lee et al. 2008; Krause et al. 2012; Sonnby-Borgström 2002), suggesting that personality aspects of emotional empathy are coupled to autonomic processes (Balconi et al. 2011). Nevertheless, no previous study compared systematically the effect induced by different types of facial stimuli, such as positive-valenced and negative-valenced stimuli, with trait empathy. Thus, a second main point to be elucidated regards the relationship between trait empathy and facial cue recognition along a positive-negative continuum.

A third relevant topic is related to the role that specific cortical areas have to support emotional detection in an empathic context. Individual neuroimaging studies of emotion detection with relevance to empathy have revealed a very wide range of areas activated in response to emotional cues, specifically the medial prefrontal cortex in general emotional processing (Krause et al. 2012; Seitz et al. 2006; Shamay-Tsoory 2007), the superior frontal gyrus in emotional perspective taking (Seitz et al. 2008) and anterior cingulate cortex (ACC) in tasks requiring specific emotional appraisal processes (Bush et al. 2000). Specifically Krause et al. (2012) found that deep rTMS (Transcranial Magnetic Stimulation) on the dMPFC disrupted subjects' affective ToM performance for those with high self-reported empathy, but improved affective ToM performance for those with low self-reported empathy. A significant impairment of angry and fearful face recognition was observed when prefrontal activity was modulated by adopting a TMS paradigm (Balconi and Bortolotti 2012; Balconi et al. 2011; Harmer et al. 2001). Thus the role of dorsal prefrontal area in response to aversive situations with which we empathize appears to be relevant.

To summarize, the present study investigated the relationship between facial expression detection in response to different emotional patterns and personal response to empathic scale [Balanced Emotional Empathy Scale (BEES)], as well as the neural prefrontal contribution to support the facial detection task for empathic behavior. Specifically, we think that the ability to recognize facial expression of emotion may be modulated by the dMPFC, since this cortical area could act as a regulator and "mediator" of emotional behavior, from one hand, and it could have a monitoring function related to the facial emotional response, from the other hand. In the present research rTMS method was used to produce a temporary perturbation of specific cortical sites, that is dorsolateral portion of prefrontal cortex, presumably the more superficial dorsal portion of medial frontal gyrus (Seitz et al. 2008). We used rTMS trains at frequency known to transiently reduce the excitability of a cortical area during the execution of a detection task. In this way we intended firstly to examine the role dMPFC has in emotion detection in response to different emotional patterns (in terms of degree of arousal and valence).

Secondly, we suppose the emotional significance of faces may affect the empathic behavior. Specifically, the intensity (degree of experienced involvement in response to high/low arousing stimuli) and valence (positive vs. negative) of facial expressions could modulate the effect induced by TMS stimulation, with an increased inability to respond to the aversive facial cues.

Finally, we tested whether low-BEES subjects are less responsive to social empathic situation than high-BEES subjects, based on the assumption that people who are low in BEES are weak empathizers (de Wied et al. 2006). In parallel, we considered the modulation effect of dMPFC activity in relationship with subjects' differences as indexed by BEES: prefrontal perturbation may induce a more significant effect in high-BEES subjects, since the reduced ability on face recognition may be more important for people who are more responsive to these emotional markers, as they normally do.

Method

Participants

Nineteen undergraduate students (enrolled at the Faculty of Psychology at the Catholic University of Milan) took part in the study (10 women, age range 20–30, $M = 23.13$, $SD = 2.11$). All subjects were all right-handed and had normal or corrected-to-normal visual acuity. Exclusion criteria were history of psychopathology for the subjects or immediate family. Specifically they did not show specific deficits related to anxiety or depression (Beck Depression Inventory and STAI). All subjects gave informed written consent for participating in the study. The experimental protocol was approved by the Ethics Committee of Catholic University.

Stimuli and stimulus evaluation

Stimulus materials were taken from the set of pictures of Ekman and Friesen (1976). They represented black and white pictures of a male actor (five different exemplars), presenting respectively a happy, angry, fearful, or neutral face. Subjects were asked to analyze the stimuli viewed after the experimental section to evaluate the emotional significance ("*What type of emotion you can see here*?"), the emotional involvement, and the valence attributed to each face,. The emotional categories were correctly recognized (the percentage value of correct categorization was respectively for happy 97%, anger 96%, fear 95%, and neutral 93% faces). In case of neutral stimuli the response was "no emotion". Moreover, no differences were found between the four categories [$\chi^2(3, N = 19) = 2.07$ $p = .33$]. Secondly, the subjects were asked to express their degree of emotional involvement and valence for each stimulus (on a five-points Likert scale). They evaluated as more emotionally involving the negative emotion of fear ($M = 4.98$; $SD = .18$), followed by anger ($M = 4.77$; $SD = .20$) and happiness ($M = 4.55$; $SD = .13$). Neutral face was evaluated as not arousing ($M = 1.09$; $SD = .38$). The statistical significance of the differences between the emotional and neutral stimuli was tested by a repeated measures univariate analysis of variance (ANOVA) [$F(3, 18) = 9.67, p \leq 001, \eta^2 = .31$]. Post hoc analysis (contrast analysis) showed different responses between emotional and neutral stimuli (all comparison $p \leq .001$). Finally, valence attribution differed across-emotions [$F(3, 18) = 7.04$, $p \leq .001$, $\eta^2 = .27$]. Post hoc analysis showed anger and fear were rated as more negative than happiness, whereas happiness was considered the most positive one. Neutral stimulus was considered not significant about valence.

Procedure

Subjects were seated comfortably in a moderately lighted room with the monitor screen positioned approximately 70 cm in front of their eyes. Pictures were presented in a randomised order in the center of a computer monitor, with a horizontal angle of 9° and a vertical angle of 11.8° (Stim2 software). During the experimental phase subjects were instructed to make a two-alternatives forced-choice response (emotion; no emotion), by pressing a left/right button to indicate their judgment. The task performed during the rTMS application (see also the following Apparatus). Accuracy and speed were stressed. Moreover, subjects were required to empathize with the situation by entering into the other person's situation ("Try to enter into another's feelings by observing the facial stimulus represented"). In order to allow a clear sympathizing with the reproduced scene, the picture actor was similar in age to the experimental subjects (Brown et al. 2006). After the experimental phase, each subject was asked to evaluate his/her degree of experienced empathy with the facial stimuli ("How much did you enter into the actor's feelings and situations?"). Specifically, subjects rated their degree of empathy on a seven-point Likert scale. Response rating differences were assessed using a separate repeated measure ANOVA (independent factor: stimulus type, 4). The condition main effect was significant [$F(3, 18) = 8.09$, $p \leq .001$, $\eta^2 = .28$]. The subjective empathic response was considered consistent and high for each emotional type (specifically anger, fear, and happiness), whereas neutral face did not produce emotional response.

BEES measure on empathy

Trait empathy was assessed by a questionnaire for empathy, BEES (Mehrabian 1996), which tests the vicarious experience of another's emotional experience (Mehrabian and Epstein 1972). The BEES questionnaire consists of 30 items, all ranging from −4 (very strong disagreement) to +4 (very strong agreement). Higher scores represent higher levels of emotional empathy. Two different groups were created using a median division on BEES scores: high BEES ($M = 65.78$, $SD = 5.12$), and low-BEES ($M = 10.21$, $SD = 6.01$). For the overall sample, $M = 40.13$, $SD = 8.11$ and range $= -10/85$. Inter-item Cronbach's alpha was calculated for BEES measure (total 0.87).

Apparatus

We used a transcranial magnetic stimulator (Magstim Rapid^2) with a 70 mm figure-of-eight coil (maximum output 1.2 T). The center of the coil, that produced the maximum electric field, was positioned perpendicularly to the cortical site to be stimulated. Participants wore an electrocup and the FCz electrode position, was located and marked using the International 10–20 system (Jasper 1958). The scalp coordinates for the TMS stimulation were one-third the distance from nasion to in inion, and the control site was one-third the distance from inion to nasion, both on the midline (Fig. 1a). The accurate localization of rTMS pulse was confirmed for subjects using Brainsight frameless stereotaxy system (Brainsight Magstim). This scan procedure suggested that TMS was applied over dorsal medial prefrontal area, presumably the dorsal part of the medial frontal gyrus (Harmer et al. 2001). TMS pulses were set at an intensity of 120 % of the motor threshold, defined as the TMS intensity that caused a visible twitch at the muscle of the right hand in 80 % of the delivered pulse (two series of ten pulses) over left MI.

Two control conditions were included into the experimental design in order to control the simple stimulation effect (sham condition: absence of TMS stimulation) and the location effect (control site condition: Pz stimulation). The first effect was checked for the acoustic noise induce by TMS procedure. For the latter, it is important to demonstrate not just that TMS effect is specific to a particular cognitive task, or a particular type of trial within a cognitive task, but it is also necessary to show that the effect of the TMS is specific to a specific region of cortex. The sequence of the three conditions (FCz; control site; sham stimulation) was counterbalanced across-subjects to prevent the order effect and to reduce possible carryover effect, in line with the normal standard of TMS stimulation for an on-line paradigm (Miniussi et al. 2008). A 30-min time interval was provided between one condition and the others. A 5-s rTMS stimulation (1 Hz, five pulses) was time locked to the stimulus. A trial started with the rTMS stimulation (5,000 ms before the stimulus presentation,

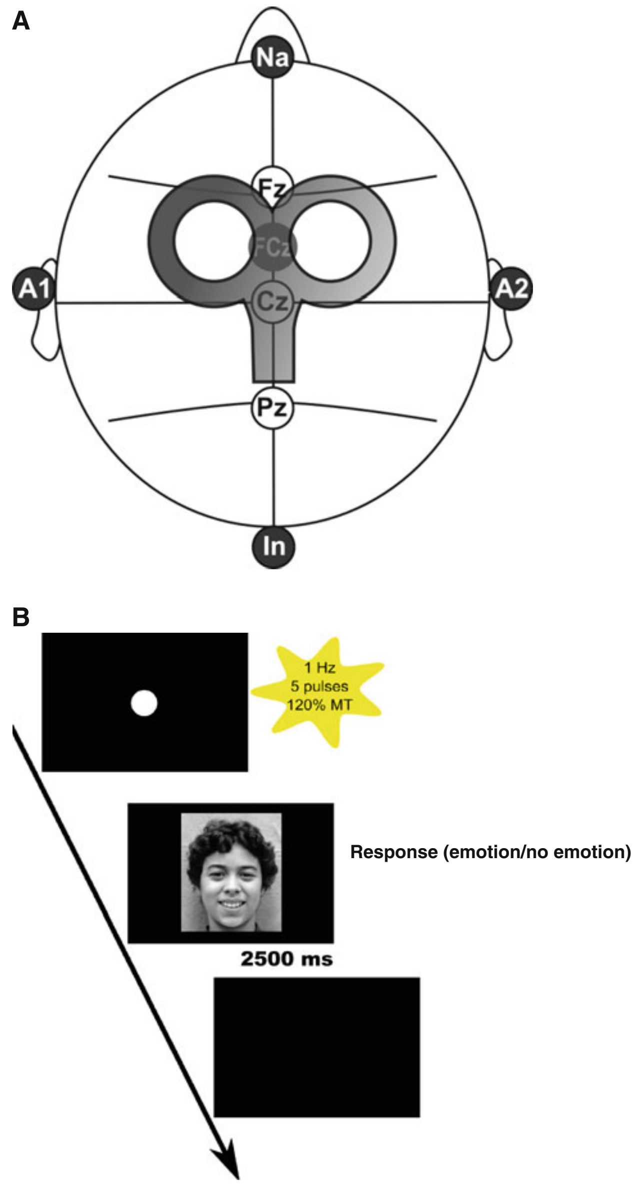


Fig. 1 **a** Coil position on the scalp and **b** experimental procedure for rTMS stimulation in emotional detection task

simultaneously the presentation of a fixation point), the facial stimulus (2,500 ms), and a blank (500 ms), according to the recommendation for repetitive stimulation (Rossi et al. 2009). Subjects could response starting from the onset of the stimulus (Fig. 1b).

Each emotional expression (anger, fear, happiness, neutral, five different faces) was shown 20 times in random order in all stimulation conditions (FCz, Pz, sham) for a total of 240 trials. A different block for each stimulation condition was randomly run. Each block was divided into two sub-blocks separated by a brief pause. A training phase preceded the experimental phase, in order to allow the subjects to familiarize with the overall procedure.

Table 1 Mean error rates (ER) and response times (RTs) for each emotional type and stimulation condition (FCz, Pz, and sham)

	ER		RTs		ER		RTs	
	High-BEES				Low-BEES			
	M	SD	M	SD	M	SD	M	SD
FCz								
Anger	0.17	1.22	1.45	1.50	0.12	1.20	1.20	1.40
Fear	0.20	1.28	1.68	1.29	0.13	1.24	1.13	1.24
Happiness	0.11	1.33	1.15	1.32	0.08	1.34	1.01	1.23
Neutral	0.08	1.40	1.01	1.78	0.08	1.61	1.02	1.12
Pz								
Anger	0.04	1.28	0.93	1.10	0.09	1.28	1.09	1.10
Fear	0.07	1.34	0.90	1.22	0.10	1.30	1.01	1.27
Happiness	0.07	1.60	0.98	1.30	0.07	1.48	1.01	1.40
Neutral	0.06	1.31	0.89	1.12	0.08	1.35	1.10	1.02
Sham effect								
Anger	0.05	1.15	0.76	1.10	0.08	1.11	0.99	1.16
Fear	0.05	1.30	0.83	1.21	0.08	1.10	1.01	1.66
Happiness	0.07	1.29	0.80	1.48	0.07	1.40	0.97	1.70
Neutral	0.06	1.30	0.90	1.13	0.11	1.38	1.01	1.28

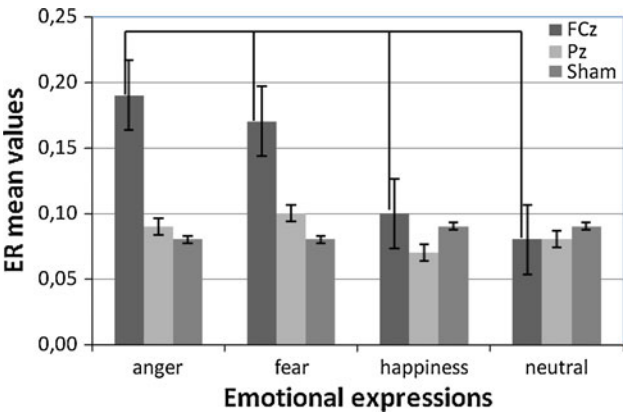


Fig. 2 ER mean values in case of rTMS stimulation on FCz, Pz, and sham as a function of emotional types

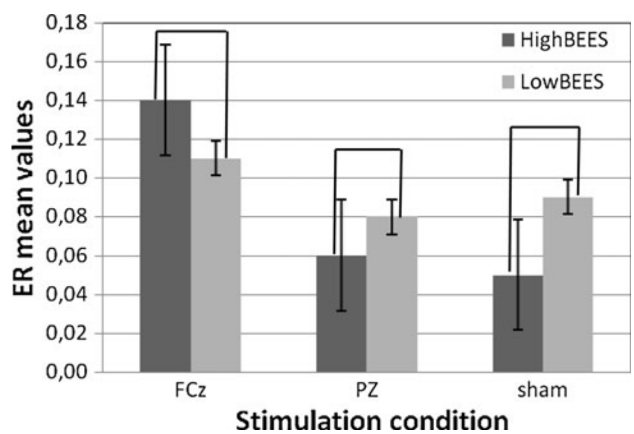


Fig. 3 ER mean values in case of rTMS stimulation on FCz, Pz, and sham as a function of high- and low-BEES

Data analysis

Mixed design repeated measure ANOVAs with two independent within-subjects factors (emotional Type: 4 levels, and stimulation Condition: 3 levels) and one between-subjects factor (BEES rating: 2 levels) were applied to the dependent behavioral measures of error rate and RTs. For all of the ANOVA tests, degrees of freedom were corrected by Greenhouse-Geisser epsilon where appropriate. Reaction times (RTs) were recorded from stimulus onset, and error rates (ERs) were calculated as the total of incorrect detection out of total trial. They both were computed separately for each stimulus type, experimental condition and BEES-groups.

Results

Error rate

ANOVA showed significant effect for Condition [$F(2, 18) = 6.13$, $p \leq .001$, $\eta^2 = .25$], Type x Condition [$F(6, 18) = 8.50$, $p \leq .001$, $\eta^2 = .30$), and BEES x Condition [$F(2, 18) = 8.10$, $p \leq .001$, $\eta^2 = .29$]. Specifically, as reported by post-hoc comparisons (contrast analysis), ER increased in response to FCz stimulation than control site (Pz) stimulation and no stimulation (all comparisons $p \leq .001$) (Table 1). Secondly, as shown by significant interaction effect, when FCz area was stimulated higher ER scores were obtained in response to anger and fear than

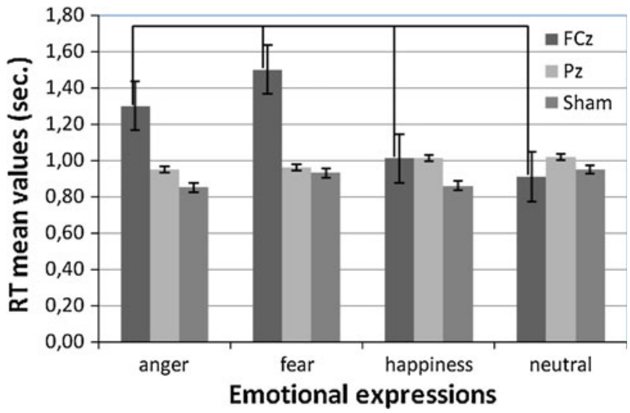


Fig. 4 RT mean values in case of rTMS stimulation on FCz, Pz, and sham as a function of emotional types

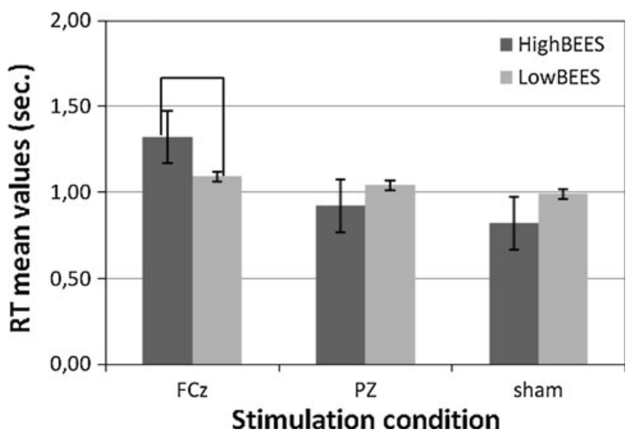


Fig. 5 RT mean values in case of rTMS stimulation on FCz, Pz, and sham as a function of high- and low-BEES

happiness and neutral facial stimuli (all comparisons $p \leq .001$) (Fig. 2). Finally, high-BEES were more impaired in face recognition in case of FCz stimulation than low-BEES (Fig. 3). Contrarily, high-BEES were more accurate in case of Pz and sham effect than low-BEES (all comparisons $p \leq .001$).

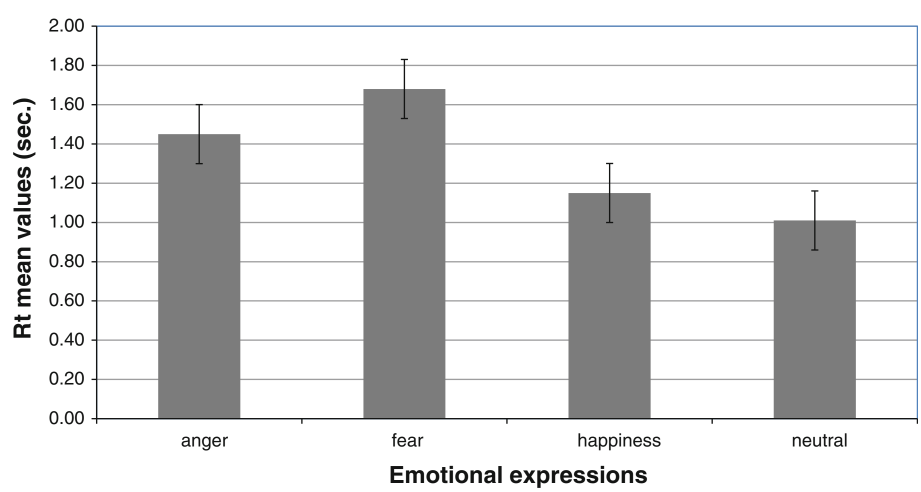
RTs

As shown in Table 1, RTs differences were revealed in response to Condition [$F(2, 17) = 9.14$, $p \leq .001$, $\eta^2 = .33$], Type x Condition [$F(6, 17) = 6.30$, $p \leq .001$, $\eta^2 = .26$], BEES x Condition, and BEES x Condition x Type. FCz stimulation produced higher RTs than control site stimulation and sham stimulation. In addition, anger and fear increased their RTs in comparison with happiness and neutral faces when FCz was stimulated (all comparisons $p \leq .001$) (Fig. 4). Moreover, high-BEES showed increased RTs when FCz was stimulated in comparison with low-BEES (Fig. 5). In addition, high-BEES had reduced RTs in case of Pz and sham effect than low-BEES. Finally, contrast analyses revealed longer RT in high-BEES in case of negative faces (anger and fear respectively) when FCz was stimulated (all comparisons $p \leq .001$) (Fig. 6).

Discussion

The present research pointed out three main significant results. Firstly, dorsomedial prefrontal area was found to support facial cue detection task in case of an empathic response, that is it was observed an impaired performance in case of TMS stimulation (inhibition) of prefrontal area. Secondly, this effect was reported in greater measure for specific emotional patterns, that is when negatively valenced stimuli (mainly angry and fearful faces) were presented to the subjects. Finally, trait empathy seems to affect the degree of subjective responsiveness to facial cues, that is high-BEES subjects were more accurate to respond to emotional faces when dMPFC activity was not perturbed,

Fig. 6 RT mean values in case of rTMS stimulation on FCz for high-BEES as a function of emotional types



whereas an increased impairment was observed for these subjects in case of dMPFC perturbation, especially for stimuli rated as more negative and arousing. The direct link between these three measures (brain response, face detection and trait empathy) was explored in the following discussion.

dMPFC contribution in face detection task

Taking into account the present results, the effect of dMPFC activity on the ability to detect emotional facial expression was suggested. With respect of recognition of facial cues, we observed an increase of difficulty to detect emotional expressions when this cortical area was perturbed. This result was confirmed by the simultaneous increasing of RTs and error rate when FCz cortical site was temporarily modulated by rTMS stimulation. This cortical modulation produced an effective incidence on the emotional cue detection: behavioral performance was worse in FCz condition, reflecting the increased cognitive difficulty to check for emotional content of faces in case of dMPFC inhibition. In that condition, the ability to monitor and detect facial cue could be partially compromised, since this area seems to be related to facial expression monitoring, as shown also in previous experiments (Krause et al. 2012; Seitz et al. 2008).

Nevertheless, this effect was observed not indistinctly, but it was noted mainly in response to certain emotional categories, such as anger and fear, that is emotions rated as more negative and with more involving power by the subjects (Balconi and Carrera 2011; Balconi and Pozzoli 2009). Whereas all the emotional types revealed a significant impairment in case of dMPFC deactivation, negative, aversive faces showed a more consistent decreased performance in comparison with other emotional categories (i.e. positive emotions). Specifically a significant effect was found for negative and potentially aversive stimuli, which were more frequently undetected when prefrontal area was inhibited. Thus, a specific sensitivity of dMPFC to these emotional patterns may be suggested. The results may be directly compared with previous research by Seitz et al. (2008) which underlined the significant effect induced by empathic responsiveness in viewing facial displays of emotions, with an increased medial frontal gyrus activity. However, this study only compared happiness and sadness expressions, fact that does not allow to directly discuss the effect of aversive, potentially high arousing stimuli (i.e. fear and anger emotions) in comparison to the positive or low-arousing stimuli. On the contrary, the present research could demonstrate the impact of threatening and negative facial expressions which may be more "salient" for the subject's safeguard, with a more specific contribution by the dMPFC.

Trait empathy and dMPFC virtual impairment

Moreover, also the subjective responsiveness to empathy, as marked by BEES measure, showed to be able to affect the detection performance in an emotional condition. In fact, firstly a clear better competence in emotional cue detection task was found for high-BEES subjects. They were generally more able to recognize facial patterns than low-BEES, as evidenced by the increased correctness and reduced RTs when the dMPFC area was preserved (Pz and sham conditions). This fact may imply the presence of specific competences to attribute an emotional value to facial mimic by high trait empathy subjects. With regard to empathy, previous research pointed out the contribution of emotional appraisal as functional mechanism able to activate a mirroring function of the emotional behavior displayed by other people, where sharing similar emotional (and autonomic) responses allows a direct form of understanding other people by a simulation process (Preston and de Waal 2001; Seitz et al. 2008). More specifically, contexts evaluated as emotionally involving and significant may ingenerate a consonant shared response by a higher empathic observer, who firstly recognizes and secondly "mimics" the somatic markers related to the experienced emotions (Preston 2007).

Contrarily, virtual impairment induced by rTMS in dMPFC area may have produced a real deficit of the emotional appraisal processes, that was more consistent in higher-BEES. dMPFC was shown to be related to the recognition of emotional facial expressions (Krause et al. 2012) and it may be involved in assessing the salience of emotional and motivational information and in regulating of the emotional responses by the subjects (Dolan and Fullam 2007). Specifically, more empathic subjects may have paid in greater measure for the detection task, as a consequence of this cortical impairment, with a significant worse performance in cue recognition. It should be due to the main function prefrontal cortex has in appraisal processing when high empathic subjects are required to empathize with the emotional situation: whereas they are more prompt in responding to emotional cues thanks to dMPFC contribution, they are also more impaired when this cortical area is perturbed.

Taken together with the subjective trait measure of empathy, the present results suggest that the high empathy group was consistently more able to detect emotion from face than low empathy group. Moreover, the relationship between trait empathy and dMPFC perturbation, with lower performance in high-BEES, suggests that this brain area significantly contributes to the emotional detection, especially for subjects who show an increased ability to recognize emotions in empathic situations (high-BEES) by using facial expression as a valid cue to detect emotions.

Thus, in general the direct role of dMPFC in recognizing the emotional cue may explain the failure of the mechanisms that modulate the subjective empathic response during the emotional cue detection, and it could suggest the relevant impact the prefrontal cortex has on the emotive empathic responsiveness (Balconi and Caldiroli 2011; Balconi and Bortolotti 2012). It is supposable that prefrontal perturbation does not allow a functional detection of emotional significance of faces, with a potential and concomitant reduction of empathic responsiveness to facial expressions by high-BEES.

Nevertheless, this effect was not undifferentiated for all the stimulus types (in terms of valence and arousal). That is, high trait empathic subjects paid a higher cost in terms of increased RTs more for negative than positive facial patterns in case of prefrontal modulation, with a clear "negativity effect" (more decreased performance in response to negative faces). This result can be supposed taking into account the specific subject's sensitivity for aversive conditions: when more negative and arousing stimuli are elaborated, dMPFC would furnish a greater contribution as a specific cortical module, whereas, in case of deficit to this area, subjects may not be able to use alternative ways to elaborate relevant emotional information.

dMPFC and emotional empathy: some implications

To summarize the dMPFC has been described as an important structure related to the affective functions, autonomic and behavioral response in case of empathic conditions, since this area could be involved in empathic behavior and emotional processes. In the present research the dMPFC virtual "inhibition" may have acted to interrupt the monitoring activity related to empathic response, accompanied by a less efficient detection of the emotional value of facial patterns (inhibition of the appraisal processes). Prefrontal virtual perturbation may have induced a less empathic responsiveness toward the emotional faces, with significant effect on the attributional functions. The suggested interpretation of these results is supported by the fact that prefrontal area includes specific processing modules for emotional information processing, and it is able to integrate input from various sources, including motivation and representations from cognitive (such as ToM) and emotional (such as emotional expressions) networks. Thus, the role of dMPFC to empathy-related response was elucidated, with possible circular effect on both monitoring ability (cue detection) and empathy responsiveness (trait empathy).

Future research could test more directly the effect of dMPFC impairment on behavioral emotional responsiveness (such as facial feedback by analyzing EMG response) and autonomic response (such as visceral measures) in empathic situations by the subjects rated high or low in empathy. Secondly, in the present research an induced empathic response was required by the subjects. A direct comparison of the present results with those produced in a spontaneous condition (spontaneous empathic response) could be suggested, in order to test the similarity or dissimilarity of the two experimental conditions. Finally, the role of deeper structures underlying dMPFC, such as ACC, should be tested in future research, since it was shown to contribute to the regulation of facial appraisal and emotional empathy behavior.

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