cortex 70 (2015) 101–114

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

Gender differences in the neural network of facial mimicry of smiles – An rTMS study

Sebastian Korb [a,*,1], *Jennifer Malsert* [b,c,1], *Vincent Rochas* [d,e], *Tonia A. Rihs* [d,e], *Sebastian W. Rieger* [b,d], *Samir Schwab* [c], *Paula M. Niedenthal* [f] and *Didier Grandjean* [b,c]

[a] *Neuroscience Area, SISSA, Trieste, Italy*
[b] *Swiss Center for Affective Sciences, Geneva, Switzerland*
[c] *Neuroscience of Emotion and Affective Dynamics Laboratory, Department of Psychology and Educational Sciences, University of Geneva, Switzerland*
[d] *Department of Fundamental Neuroscience, University of Geneva, Switzerland*
[e] *Functional Brain Mapping Laboratory, Department of Fundamental Neuroscience, University of Geneva, Switzerland*
[f] *Department of Psychology, University of Wisconsin, Madison, USA*

ARTICLE INFO

Article history:
Received 7 October 2014
Reviewed 26 February 2015
Revised 7 April 2015
Accepted 24 June 2015
Published online 6 July 2015

Keywords:
Facial mimicry
Gender differences
TMS
Somatosensory cortex
Motor cortex

ABSTRACT

Under theories of embodied emotion, exposure to a facial expression triggers facial mimicry. Facial feedback is then used to recognize and judge the perceived expression. However, the neural bases of facial mimicry and of the use of facial feedback remain poorly understood. Furthermore, gender differences in facial mimicry and emotion recognition suggest that different neural substrates might accompany the production of facial mimicry, and the processing of facial feedback, in men and women. Here, repetitive transcranial magnetic stimulation (rTMS) was applied to the right primary motor cortex (M1), the right primary somatosensory cortex (S1), or, in a control condition, the vertex (VTX). Facial mimicry of smiles and emotion judgments were recorded in response to video clips depicting changes from neutral or angry to happy facial expressions. While in females rTMS over M1 and S1 compared to VTX led to reduced mimicry and, in the case of M1, delayed detection of smiles, there was no effect of TMS condition for males. We conclude that in female participants M1 and S1 play a role in the mimicry and in the use of facial feedback for accurate processing of smiles.

* *Corresponding author*. Neuroscience Area, SISSA, Via Bonomea 265, 34136 Trieste, Italy.
E-mail address: skorb@sissa.it (S. Korb).
[1] These authors contributed equally to this work.
http://dx.doi.org/10.1016/j.cortex.2015.06.025

1. Introduction

The human face is one of the most expressive channels of emotional and social communication. Accurate interpretation of clues to affective states and behavioral intentions displayed on the face are crucial abilities for smooth social interaction and successful goal pursuit in society. Indeed, impaired emotion recognition and reduced empathy are major factors leading to difficulties in social communication that characterize, for example, people with autism spectrum disorder (ASD). Tangible differences in the display and perception of emotional expressions also exist between healthy male and female individuals. It is therefore of scientific and societal interest to understand the processes and neural correlates that support emotion recognition. The present study investigated gender differences in the role of motor and somatosensory cortices in facial mimicry and emotion perception.

An influential theoretical account, which builds upon a long and prominent tradition in biology, philosophy, and psychology (Darwin, 1872; James, 1950; Lipps, 1903), suggests that emotional information is processed through somatovisceral and motoric re-experiencing (Barsalou, 2008; Iacoboni, 2009; Niedenthal, 2007). A component of this *embodied emotion theory* is the *facial feedback hypothesis*, according to which information from one's own facial expressions feeds back into the brain and triggers or colors emotional responses, and influences emotional judgments (Adelmann & Zajonc, 1989; Buck, 1980; Hatfield, Cacioppo, & Rapson, 1993; McIntosh, 1996; Strack, Martin, & Stepper, 1988). Support for this hypothesis comes from research showing that voluntarily producing emotional facial expressions results in specific physiological activity patterns (Ekman, Levenson, & Friesen, 1983) and shapes corresponding subjective feelings. Actively facilitating or inhibiting smiling, by holding a pen either between the teeth or the lips, influences the appraisal of humorous stimuli (Soussignan, 2002; Strack et al., 1988). Similarly, recent clinical trials suggest that individuals suffering from depression may benefit from procedures leading to the paralysis of the Corrugator muscles (involved in frowning and sadness), possibly by impeding this specific facial feedback that may contribute to the build-up of negative emotions (Finzi & Rosenthal, 2014; Wollmer et al., 2012).

Another component of embodied emotion theory is the observation that people spontaneously engage in motor mimicry. The perception of a smile, for example, causes the observer to smile in return. The observer's own smile is hypothesized to facilitate the recognition of the observed expression through afferent feedback to the brain. Indeed, mimicry of happy faces increases the accuracy of judgments of smile authenticity (Korb, With, Niedenthal, Kaiser, & Grandjean, 2014; but see Hess & Blairy, 2001), and the blocking of facial mimicry reduces the speed and the accuracy of recognizing emotional facial expressions. For example, blocking facial mimicry slows the recognition of positive and negative facial expressions (Stel & van Knippenberg, 2008), impairs the distinction between true and false smiles (Maringer, Krumhuber, Fischer, & Niedenthal, 2011; Rychlowska et al., 2014), delays the perception of the offset of happy and sad facial expressions (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001), and interferes with the recognition of happiness (Oberman, Winkielman, & Ramachandran, 2007). Furthermore, paralysis of the Corrugator muscle through injections of botulinum toxin decreases responses to angry faces in emotion centers of the brain such as the amygdala, and reduces the functional coupling between the amygdala and brain stem regions implicated in autonomic emotional responses (Hennenlotter et al., 2009).

The hypothesis that facial mimicry occurs both spontaneously and unconsciously is supported by findings that mimicry can occur in the absence of conscious perception of the stimulus face (Dimberg, Thunberg, & Elmehed, 2000; Mathersul, McDonald, & Rushby, 2013), and that it is difficult to suppress voluntarily (Dimberg, Thunberg, & Grunedal, 2002; Korb, Grandjean, & Scherer, 2010). Facial mimicry may be crucial for the development of empathy, which requires the detection and the representation of another person's emotional state. Indeed, facial mimicry is increased in individuals high in self-reported trait empathy (Dimberg, Andréasson, & Thunberg, 2011; Sonnby-Borgstrom, 2002). However, emotion recognition can also occur without facial mimicry, for example in individuals with facial paralysis (Rives Bogart & Matsumoto, 2010), and the simulation of motor and somatosensory events linked to facial expressions can occur in the brain only, that is, in the absence of an overt peripheral response.

Which systems of the brain are responsible for the spontaneous production of facial mimicry, and which ones utilize the resulting facial feedback, or provide a visceral and somatic simulation, during the processing of facial expressions? To answer these questions we turn to the neuroscientific literature, where current models of social cognition are built upon the notion that motor, somatosensory, and emotional brain regions simulate other people's actions, sensations, and emotions, and by doing so contribute to the their perception and interpretation (Iacoboni, 2009; Keysers, Kaas, & Gazzola, 2010). Studies using neuroscientific or neuropsychological methods largely suggest that perceiving another person performing a motor action, displaying a facial expression, or being touched on their body, results in increased neural activity in the perceiver's motor, emotional, and somatosensory areas.

The mirror neuron system (MNS) provides a putative neural basis for facial mimicry. It includes the inferior frontal gyrus (IFG), the posterior parietal cortex, but also primary and secondary somatosensory cortices (S1 and S2), and the insula (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gazzola & Keysers, 2009; Molenberghs, Cunnington, & Mattingley, 2012; Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010; Rizzolatti & Craighero, 2004; Rizzolatti, Fogassi, & Gallese, 2001). Brain imaging studies have found substantial overlap in the brain activity accompanying the production and observation of facial expressions (Van der Gaag, Minderaa, & Keysers, 2007). However, only few studies have specifically investigated the neural correlates of spontaneous facial mimicry. Schilbach, Eickhoff, Mojzisch, and Vogeley (2008) reported increased brain activity, likely accompanying facial mimicry, in the face area of the left primary motor cortex (M1) and in the bilateral posterior cingulate gyrus.