Emotional Contagion for Unseen Bodily Expressions: Evidence from Facial EMG

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Abstract

Emotional contagion refers to the tendency to automatically mimic and synchronize our facial expressions with those of another person. Recent EMG studies have shown that emotionally-congruent expressive reactions in the observer's face may be also elicited by the perception of bodily expressions, thus challenging the view that emotional contagion is simply due to motor imitation based on conscious visual recognition. Here we investigated whether emotional contagion may be triggered by bodily expressions that cannot be consciously perceived. Facial EMG was recorded in response to the presentation of backwardly masked happy and fearful bodily expressions. The subjects reacted with emotionally-congruent facial expressions (i.e., greater zygomaticus major activity for happy expressions, and greater corrugator supercilli activity for fearful expressions), despite the fact that they were unable to consciously detect the triggering body stimuli. The present findings suggest that expressive facial reactions may unfold as an automatic response driven by the activation of emotion-specific affect programs that are independent from conscious visual recognition.

1. Introduction

Human and non-human primates are intensely social species and are especially sensitive to the gestural signals made by other conspecifics. It has been recently proposed that social cognition – the panel of abilities that allow us to understand thoughts and feelings of others – stems from a more basic mechanism referred to as "emotional contagion" [1-4]. Emotional contagion is the tendency to automatically mimic and synchronize our facial expressions and postures with those of another person and, consequently, to converge emotionally [5]. Previous research has shown that presentation of facial expressions can generate subtle changes in an observer's muscle activity, which are seldom visible by a naked eye, but may nevertheless be reliably detected by electromyography (EMG) [6-8]. Specifically, viewing happy faces elicits increased zygomaticus major activity (the facial muscle responsible for elevating the cheeks and pulling the corners of the mouth back and upwards into a smile), whereas negative expressions (e.g. angry or fearful faces) evoke increased corrugator supercilii activity (which results into a movement of the brows down into a frown).

Yet many different interpretations of emotional contagion have been put forth and the nature of the interaction between perception and expressive reaction to emotional signals is debated. For instance, the spontaneous imitation of emotional expressions – the hallmark of emotional contagion – has been considered by some authors a specific instance of motor contagion [9, 10]. This view is based on the discovery of the "mirror neurons" system, and argues that the observer understands a perceived action because this (*conscious*) perception activates the same cortical network of motor representations also active when he himself performs that action. An alternative explanation for the synchrony between the emotions observed and that displayed by the observer, is to consider emotional contagion as a primitive mechanisms different from, but interacting with, the mirror-neurons system [11-14]. In this case, the perception

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of some basic emotional expressions would trigger in the viewer the same expressions not on a motor imitation basis, but on activation of emotion-specific programs corresponding to the emotion seen.

Relevant evidence comes from recent studies that recorded facial EMG not only in response to the presentation of facial expressions, but also in response to auditory stimuli and bodily expressions of emotions [15, 16]. These studies have shown that emotional facial reactions are triggered by all these stimuli and not selectively by the view of facial expressions, thus suggesting that emotional contagion is not strictly an instance of mimicry of the stimulus, but rather results from processing its emotional valence.

If emotional contagion is generated by emotion-specific programs, a straightforward prediction would be that these programs elicit facial reactions automatically. In a strong sense, this means not only that emotional reactions in the observer are spontaneous, but also that they may be present even when the subject does not consciously perceive the triggering stimulus. At present, evidence of spontaneous emotional reactions to non-consciously perceived expressions is based only on one EMG study that recorded facial reactions to backwardly masked, and thus undetected, facial expressions [17]. A parallel line of research has convincingly shown that bodily expressions of emotions may be processed even in the absence of conscious visual awareness in both healthy subjects and neurological patients [18-20]. Nevertheless, the possible influence of unseen bodily expressions on spontaneous facial reactions is still unknown. In order to investigate whether emotional contagion may be triggered by unseen bodily expressions, here we recorded facial EMG during the presentation backwardly masked happy and fearful bodily expressions.

2. Methods

2.1. Participants

Eight healthy volunteers with normal or corrected-to-normal vision participated in this study (M = 23.26. years, SD = 3.53, age-range = 19-28). Written informed consent was obtained in accordance with the Declaration of Helsinki.

2.2. Stimuli and Procedure

Sixteen grayscale whole-body photographs (eight women, age-range = 22-36 years), 8 with a fearful and 8 with a happy bodily expression, were presented against a dark background (Figure 1). To focus specifically on whole-body expressions, in all images the faces were blanked out (see ref. [2, 21] for details on stimulus preparation and validation). Image size was 9.4 cm wide and 21.2 cm high sustaining a visual angle of ~8.59° X ~20.14° from a viewing distance of ~60 cm from the screen of a 21-inch CRT monitor. Stimuli were centered on the screen. Mean luminance of the happy bodies was 11.05 cd/m^2 and of the fearful bodies 10.85 cd/m^2. Mean luminance of the dark background was 24 cd/m^2. There was no significant difference in overall luminance between happy and fearful body sets ($U \leq 32$, $p \geq 0.64$ in Mann-Whitney U tests). A scrambled body with the same rectangular shape, size, luminance, and spatial frequency of the target body stimuli was used as mask. This mask was constructed by randomly swapping small parts (9 X 9 pixels) of pictures showing neutral expressions of the same 16 actors used as target emotional bodies.

Figure 1: Examples of target stimuli. Happy (left panel) and fearful (right panel) bodily expressions

A stimulus onset asynchrony (SOA) of 20 ms was used to mask the target emotional bodies. Thus, a target bodily expression was projected for 20 ms with its offset temporally and spatially coincident with the onset of the mask that remained on the screen for 230 ms. This SOA is sufficient to prevent conscious perception of the target stimulus, as assessed in a pilot study that used objective forced-choice criteria based on signal detection analysis [22-24]. Indeed, signal detection analysis allow to measure an index of perceptual sensitivity, *d'*, independently of response criteria. This pilot study reported that at 20 ms SOA the subjects were not able to discriminate whether a blank or a body stimulus preceded the mask, as indicated by the fact that mean *d'* value was not significantly different from 0 in this condition (mean $d' = 0.1$; $t(7) = 0.99$, $p = 0.35$).

Each trial started with a central cross (lasting from 1 to 2s) that was followed by the presentation of the target/mask pairs. A blank screen lasting from 1750 to 2750 ms followed stimulus presentation. Overall, 256 trials were administered to each subject (128 with a fearful and 128 with a happy target expression). Fearful and happy bodily expressions were randomly intermingled.

2.3. EMG Recordings and Data Reduction

Facial EMG was measured by bipolar attached electrodes placed over the corrugator supercilii and the zygomaticus major on the left side of the face, according to the guidelines given by Fridlund and Cacioppo [25] (Figure 2). During recording, EMG signals were band pass filtered (10-1000 Hz) at a sampling rate of 1024 Hz. Subsequently, EMG signals were filtered offline (High pass = 20 Hz), full-wave rectified and integrated (time constant = 20 ms).

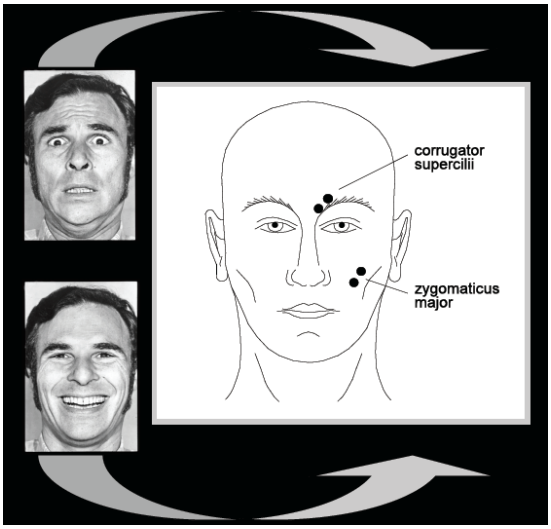

Figure 2: Electrodes positioning over the corrgator spercilii and zygomaticus major of the left hemiface

Acquired signals were segmented into epochs of 500 ms pre-stimulus baseline and of 2000 ms stating with stimulus onset, separately, and expressed in µV. Mean rectified EMG activity for each stimulus was calculated by subtracting the mean activity during the pre-stimulus period (500 ms) to the average response during the 2000 ms following stimulus onset. Subsequently, these data points were depicted as a percentage of mean pre-stimulus baseline amplitude.

3. Results

At debriefing, subjects were exposed to the unmasked fearful and happy bodily expressions previously presented during the EMG experiment under masking condition. They were asked to report whether they had seen the stimuli during the main experiment. None of the subjects reported having seen the target stimuli.

A 2 × 2 MANOVA was performed on EMG data with the factors of muscle region (corrugator vs. zygomaticus) and emotional expression (happy vs. fearful). There was a significant main effect of muscle region, with overall higher response in the corrugator (104 % ± 0.81), as compared to the zygomaticus (100.1 % ± 0.82), $F(1) = 11.38$, $p = 0.004$. This aspecific higher reactivity of the corrugator to stimulus presentation has been reported also by several prior studies and scribed to anticipatory activity and startle reflex that engage this muscle region more than the zygomaticus [16, 17]. No main effect of emotion was reported $F(1) = 0.5$, $p = 0.49$ ns. Importantly, however, there was a significant muscle region × emotional expression interaction ($F(1) = 27.3$, $p = 0.0001$. The zygomaticus major showed an enhanced response to masked happy (102.13 % ± 1.03 SE) than fearful bodily expressions (98.13% ± 0.77), $p = 0.038$ by Bonferroni corrected post-hoc comparison. The opposite effect was observed for the corrugator supercilii, that reacted more to masked fearful (106.63 % ± 0.86) than happy expressions (101.38 % ± 1.35), $p = 0.005$ (Figure 3).

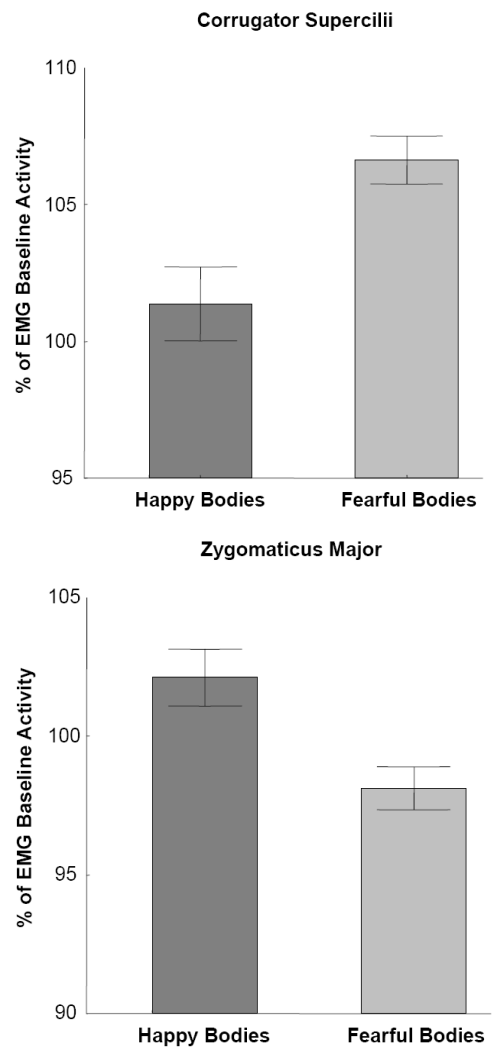

Figure 1: Mean percentage of facial EMG response compared to baseline activity for the corrugator supercillii and zygomaticus major separately.

4. Discussion

The goal of the present study was to investigate whether unseen and undetected bodily expressions may induce emotionally-congruent expressive reactions in the observer's face. We therefore used a backward masking procedure to prevent conscious visual perception of the body stimuli and we simultaneously recorded facial EMG to the zygomaticus major and corrugator supercilli, as pleasant stimuli typically elicit grater activity in the former, whereas unpleasant stimuli evoke more response in the latter muscle.

Our data show that despite the fact that the subjects were not able to consciously see the target stimuli, they nevertheless reacted with a facial response pattern consistent with the emotional valence of the masked body stimuli. In fact, the facial reactions were similar to that previously reported when the same body stimuli were presented in overt view and participants were fully aware of their exposure; namely, greater zygomaticus activity in response to happy as compared to fearful bodily expressions, and greater corrugator activity for fearfull with respect to happy expressions.

The present findings are consistent with prior data showing that emotional bodily expressions may be processed automatically when attention is engaged elsewhere and even when visual awareness is lacking [18-20]. Although the neural correlates of this effect were not directly investigated in the present study, a growing amount of research points to the amygdala, perhaps in concert with other subcortical structures like the superior colliculus, as a brain area sensitive to emotional stimuli, including bodily expressions, even under conditions of non-conscious perception [12, 26, 27].

Most importantly, our results are consistent with idea that emotional contagion is not a phenomenon strictly based on motor mimicry, and emotional perception is not dependent by motor simulation, as suggested by mirror neurons theorists. Rather, the present findings suggest that the initial facial reactions to emotional expressions is controlled by affect programs that can be triggered by the perception of emotional stimuli independently of conscious visual recognition and even when the emotion is communicated by non-facial expressions. An important next step in research would be to systematically investigate different stimulus categories (e.g., artifacts like guns etc., in addition to facial and bodily expressions) in various modalities (visual, auditory) and for a variety of emotions to reveal whether specificities exist in nonconscious processing of certain emotions communicated by different stimulus formats.

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