When you smile, the world smiles at you: ERP evidence for self-expression effects on face processing

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Complete List of Authors:	Sel, Alejandra; Royal Holloway University London, Department of Psychology Calvo Merino, Beatriz; City University London, Department of Psychology Tuettenberg, Simone; City University London, Department of Psychology Forster, Bettina; City University London, Department of Psychology
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Title:

When you smile, the world smiles at you: ERP evidence for self-expression effects on face processing

Abbreviate title:

Effects of self-expression

Alejandra Sel[1,2]*, Beatriz Calvo-Merino[2,3], Simone Tuettenberg[2], Bettina Forster[2]

[1] Lab of Action & Body, Department of Psychology, Royal Holloway University London, Egham, Surrey, TW20 0EX, London, U.K.

[2] Department of Psychology, City University London. Northampton Square, EC1V 0HB, London, U.K.

[3] Department of Psychology, Complutense University of Madrid. Campus de Somosaguas 28223. Madrid, Spain.

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Corresponding Author:
Dr. Alejandra Sel.
Department of Psychology,
Royal Holloway University London.
Egham, Surrey
TW20 0EX, London, U.K
E-mail: alex.sel@rhul.ac.uk

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Abstract

Current models of emotion simulation propose that intentionally posing a facial expression can lead to changes in one's subjective feelings, which in turn influences the processing of visual input. However, the underlying neural mechanism whereby one's facial emotion modulates the visual cortical responses to other's facial expressions remains unknown. To understand how one's facial expression affects visual processing we measured participants' visual evoked potentials (VEPs) during a facial emotion judgment task of positive and neutral faces. To control for the effects of facial muscles (facial feedback) on VEPs, we asked participants either to smile (adopting an expression of happiness) or to pose with a neutral face, in two separate blocks. Results showed that the expression posed modulates face-specific early visual processing components (N170/vertex positive potential-VPP) to watching other facial expressions. Specifically, when making a happy expression, neutral faces are processed similarly to happy faces. When making a neutral expression, however, responses to neutral and happy face are significantly different. This effect was source localized within multisensory associative areas, angular gyrus, associative visual cortex, and somatosensory cortex. We provide novel evidence that one's own emotional expression acts as a top-down influence modulating low-level neural encoding during facial perception.

Keywords: face processing, emotional embodiment, facial feedback, VEPs, N170.

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Introduction

Current models of emotion simulation propose that initial visual processing of facial expressions is followed by a mimicry response of the observed emotion, which is evident in facial electromyography (EMG) (Niedenthal, 2007; Halberstadt et al., 2009). Importantly, the relationship between facial mimicry and the processing of observed emotional facial expression is reciprocal. That is, the facial mimicry triggers afferent feedback from the receptors involved in the facial movements evoking an emotional state that can then influence the observer's perception of emotional expressions in others (Strack et al., 1988; Lee et al. 2006; Kuhn et al., 2011). Whereas the effects of one's own facial and bodily postures on the perception and evaluation of emotional and neutral information at the behavioural level has been well documented (Strack et al., 1988; Niedenthal, 2007; Critchley and Nagai, 2012), it remains unclear how intentionally adopting a particular facial expression may influence visual cortical activity during the processing of observed facial expressions.

Evidence for the impact of bodily states on the processing of external information comes from recent investigations on the interplay between mind and body in social interactions. The key premise of these studies is that facial and bodily states act as a context for emotions, shaping affective processes in a manner similar to the effects of the external context (Bouton, 2001; Niedenthal, 2007; Critchley and Nagai, 2012). Within this frame, clinical studies have shown that the fixed sad facial expression adopted by depressed individuals can negatively bias their stimulus processing and encoding into memory (Critchley and Nagai, 2012). Together, these observations highlight the role of face and bodily states in shaping emotional brain processes and responses. Interestingly, direct evidence for the effect of deliberately posed facial emotions on the neural processing of facial expressions comes from a series of fMRI studies showing that intentionally adopting a particular emotional facial expression is associated with increased activity within the emotional brain network (Lee et al., 2006, 2008;

Kuhn et al., 2011). These studies demonstrate that the engagement of specific facial muscles is associated to enhanced sensitivity of brain areas that support emotional processing, which in turn intensifies the experience of the observed emotion and leads to changes in the visual judgements of these emotions. However, whether the neural processing of the visual stimuli is likewise modulated remains unknown.

To investigate specifically the impact of one's emotional expressions on the visual processing of observed faces we measured visual-evoked potentials (VEPs) during a facial emotion judgement task while we manipulated facial mimicry and its associated facial feedback. Previous investigations in facial mimicry suggest that happiness engages more facial muscles and leads to a greater facial feedback than any other emotion (Ekman, 2004; Oberman et al., 2007). Accordingly, in two separate blocks participants were asked either to smile (i.e. to adopt an expression of happiness) or to adopt a neutral face. This allowed us to directly measured and contrast the neural effects of adopting an expression of happiness on VEPs elicited by viewing happy or neutral faces. In addition, to further explore whether the effects on perception of facial expressions of adopting a happy face were associated with changes in sensorimotor and other multimodal areas, we examined the neural generators of the VEPs, by using standardized low-resolution brain electromagnetic tomography (s-LORETA).

We hypothesise that the facial muscular changes during expression of happiness lead to changes in the sensorimotor representations of this emotion, along with other multimodal emotional brain areas (Ekman, 2004; Kuhn et al., 2011). We further predict that when participants adopt a happy face, then the activation of sensorimotor representations of happiness in multimodal areas will act as a top-down influence on visual facial processing, compared to when participants adopt a neutral facial expression. Moreover, in line with previous evidence (Lee et al., 2008; Kuhn et al., 2011) we expect that adopting an expression of happiness will have a distinctive impact on the neural processing of observed happy and neutral faces. In the literature on face processing, the N170/vertex positive potential-VPP complex has been suggested as an index of the structural encoding of visual facial features (Bentin et al., 1996; Conty et al., 2012). The N170 is source localized in the superior temporal cortex, where neurons show selectivity for different facial expressions (Williams et al., 2006). Moreover, electrophysiological evidence shows a selective modulation of the N170/VPP, and other early visual components, to different emotional facial expressions relative to neutral faces (Ashley et al., 2004; Williams et al., 2006), as well as emotional priming effects on early VEPs (Werheid et al., 2005; Li et al., 2008; Lu et al., 2011). We therefore hypothesise that adopting a happy face will lead to changes in early VEPs as compared to putting on a neutral expression. Finally, if one's expression of happiness impacts on VEPs of visual faces, we should expect this effect to be source localized within somatosensory areas, together with neural centres that play a central role in the processing of embodied emotions (Pitcher et al., 2008; Sel et al., 2014), and also those multimodal associative areas where visual and sensorimotor information is integrated.

Material and Methods

Participants

25 right-handed participants with normal or corrected-to-normal vision took part in the experiment. (One participant was excluded from the analysis because of excessive artifacts in the EEG signal, resulting in a final total of 24 participants (8 males), aged 24–39 years, mean = 28.75. Participants gave informed consent, with approval by the Ethics Committee, School of Social Sciences, City University London.

Stimuli and procedure

A set of 90 pictures depicting happy and neutral emotions was selected from the Karolinska Directed Emotional Faces set (Lundqvist et al., 1998). Faces were grayscaled and enclosed in a rectangular frame (140 X 157 inches), excluding most of the hair and nonfacial contours.

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Eight volunteers, none of whom participated in the subsequent study, judged the strength of emotion expressed in the faces on a visual analog scale (VAS-100 = "extremely happy"; 0 = "not happy at all"). Based on these judgments, we selected 20 happy faces (mean ± SD, 76.53 ± 6.95) and 20 neutral faces-faces that had been rated closest to the "not happy at all" judgment (mean ± SD, 10.76 ± 4.74) (half male).

As shown in figure 1, trials started with the presentation of a fixation cross (500 ms), followed by a neutral or happy face (500 ms), and by a VAS (100 = "extremely happy"; 0 = "not happy at all") (duration until response). The overall experiment consisted of 320 randomized trials, presented in two blocks (160 trials per block/task, including 80 neutral and 80 happy faces). In the 'self happy' block , participants were instructed to assume a happy expression leading to an activation of their facial muscles involved in smiling. To ensure that the participants held the smile expression constant across the block they were asked to bite on a pen horizontally with the teeth so that the pen was pointing perpendicularly away from the participants' face. It was emphasized that they should not allow the pen to touch their lips (Strack et al., 1988; Ito et al., 2006; Blaesi and Wilson, 2010). In the 'self neutral' block, participants were asked to maintain a neutral expression and to relax their facial muscles during the length of the block, thus preventing them from contracting their facial muscles. In order to ensure compliance with the task, the experimenter monitored participants' facial expression throughout the experiment via a camera placed in the EEG cabin. In the self happy and self neutral blocks, participants were instructed to closely observe the faces presented on the screen, and to rate these faces using the VAS scale. Thus, we created situations where participants observed and rated the perceived intensity of happy and neutral faces while adopting either a happy (self happy block) or a neutral (self neutral block) facial expression themselves. Block order was randomized across participants and participants were given a break between blocks. Participants were seated in a dimly lit, sound-attenuated and electrically shielded chamber in front of a monitor, at a distance of 80 cm. Visual stimuli were presented centrally on a black background using E-prime software (Psychology Software Tools).

Behavioral performance

Behavioral performance was measured using a Visual Analogical Scale (VAS) ranging from 100 for “extremely happy” to zero for “not happy at all”. For each trial, participants were asked to judge the perceived intensity of the happiness in the observed face by marking the VAS with the mouse cursor. Responses were averaged across happy and neutral faces and these measures were subjected to a two-way repeated-measures ANOVA, with factors ‘other’s emotion’ (other-happy, other-neutral) and ‘own emotion’(self-happy, self-neutral).

EEG recording and data analysis

EEG was recorded with active electrodes from 60 scalp electrodes, mounted equidistantly on an elastic electrode cap (M10 montage; EasyCap). All electrodes were referenced to the right mastoid and rereferenced to the average reference off-line. Vertical and bipolar horizontal electrooculograms were recorded for purposes of artifact correction. Continuous EEG was recorded using a BrainAmp amplifier (BrainProducts; 500 Hz sampling rate). Off-line EEG analysis was performed using Vision Analyzer software (BrainProducts). The data was digitally low-pass-filtered at 40 Hz, and ocular correction was performed (Gratton et al., 1983). The EEG signal was epoched into segments of 600 ms length, starting 100ms before the stimuli onset. Segments were then baseline corrected to the first 100ms, and artifact rejection was computed, eliminating epochs with amplitudes exceeding ± 100 µV. Single-subject ERPs for ‘other emotion’ (other-happy, other-neutral) and ‘self emotion’ (self-happy, self-neutral) were calculated and used to compute ERP grand-averages across subjects.

To analyse the self-face manipulation effect on early and mid-latency emotional face processing activity, mean voltages of the VEPs, time-locked to the observed face onset, were computed at occipital, temporal and frontal regions of interest (ROIs; corresponding to O1/z/2 -occipital-, TP9/10, P9/10 –temporal-, and F1/z/2 –frontal- electrodes of the 10/20 system), where electrophysiological markers of early and mid-latency emotional face processing are typically observed (Williams et al., 2004, 2006; Conty et al., 2012). ROIs were defined on the basis of the difference potential maps between the other-neutral and the other-happy trials in the self-neutral condition. Mean ERP responses were computed by averaging across electrodes within the ROIs. Repeated-measures ANOVA, with factors other emotion (other-happy, other-neutral), self emotion (self-happy, self-neutral) and region (occipital, temporal, frontal) was conducted on mean amplitudes for the time window (TW) of the P120/N120 (120-150ms), N170/VPP (160-200 ms), P230/N200 (240-320ms) and N250/P300 (320-440ms) according to previous literature (Williams et al., 2006; Conty et al., 2012), and also according to visual inspection of the topographical maps. Where appropriate, Greenhouse–Geisser adjustments to the degrees of freedom were applied, and *p* values were corrected for multiple comparisons, using Bonferroni correction.

Electrophysiological source analysis

Standardized Low Resolution Brain Electromagnetic Tomography (s-LORETA) was used to estimate the brain generators associated with modulations of visual-evoked activity. s-LORETA provides an approximate three-dimensional discrete solution to the inverse EEG problem. It estimates the most active brain areas using a 5mm resolution brain volume template of the Montreal Neurological Institute (MNI). MNI coordinates were translated to Talairach coordinates by Talairach Daemon (Pascual-Marqui, 2002). Compared to dipole-based methods, s-LORETA has the advantage of estimating activity sources without any *a priori* assumptions about the number of sources, or their location. Source estimations were performed on single-subject data to determine the likely regions differentially activated when observing happy *versus* neutral 'other faces' within the TW where the self-face manipulation affected visual processing of the other's facial expressions (160-200ms).

Results

Behavioral performance

The two-way repeated-measures ANOVA with factors 'other emotion' (other-happy, other-neutral) and 'self emotion' (self-happy, self-neutral) showed a main effect of other emotion (F(1,23) = 298.71, $p < 0.01$) indicating that observed's happy faces were rated as more happy (M = 79.85 , SD = 8.94) than neutral faces (M = 29.98, SD = 11.47). There were no significant main effects of self emotion or interaction other emotion X self emotion in the behavioural results.

Emotional modulation of VEP amplitudes

We performed a repeated-measures ANOVA of VEP amplitude, with factors 'other emotion' (other-happy, other-neutral), 'self emotion' (self-happy, self-neutral) and region (occipital, temporal, frontal). Analysis of the N170/VPP time window revealed a significant main effect of other emotion, with enhanced VEP amplitude when participants were observing happy faces relative to neutral faces (F(1,23) = 21.95, p < 0.01). Results also showed a significant interaction other emotion X self emotion (F(1,23) = 6.88, p = 0.01). Follow-up *t* tests showed a significant difference between other-happy and other-neutral, in the self-neutral condition (t(23)= 5.023, p < .001). However other-happy did not differ from other-neutral in the self-happy condition (t(23)= 1.93, p = .26). A further contrast of the self-face manipulation effect (by subtracting the amplitudes of other-happy from the other-neutral, in the self-happy and self-neutral conditions separately) demonstrated a selective effect of the self-face manipulation on happy and neutral other faces, with a significant modulation of the N170/VPP component to other-neutral faces in the self-happy condition relative to the self-neutral condition (t(23) = 2.32, p = 0.04) (Figure 2). Analysis of the P230/N200 TW revealed

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a main effect of the factor self emotion (F(1,23) = 5.20, p = 0.03) showing enhanced amplitudes for VEPs associated to both other-happy and neutral faces in the self-happy condition as opposed to the self-neutral condition. Furthermore, in the TW of the N250/P300 component, we observed a main effect of the factor 'other emotion' (F(1,23) = 8.85, p < 0.01), and a significant interaction other emotion X region (F(2,46) = 5.25, p = 0.01. Follow-up *t* tests performed on individual ROIs revealed a main effect of other emotion at occipital sites (t(23) = 2.91, p = 0.02), reflecting an enhancement of VEPs to other happy *versus* other neutral faces. There were no significant main effects, nor any interactions, with other emotion for the P120/N120 time window. Overall, these results show that the self-face expression manipulation modulates the visual processing of facial emotions within the N170/VPP TW, as shown by the significant differences between the observation of other-happy and other-neutral in the self-neutral condition, but not in the self-happy condition. The pattern of interaction shown in Figure 2A suggests that the similar pattern of activation for other-happy and other-neutral in the self happy condition is due to an enhancement of the other-neutral activity, making this process similar to the ones of other-happy faces. In essences this shows that adopting a happy face modulates the processing of non-happy (neutral) facial expression.

Source localization analysis

Cortical source estimation was performed on the N170/VPP TW (160-200ms), where self-face manipulation significantly modulated mean amplitude difference in VEPs. This identified a set of regions whose peak of activity was maximal for other-happy *versus* other-neutral conditions (Figure 2D). When participants adopted happy expressions, maximum differential activity between other-happy and other-neutral faces was source localized in the angular gyrus (Brodmann area –BA 39), secondary somatosensory cortices (SCx- BA 40), and in the associative visual cortex (BA 19) within the right hemisphere. By contrast, when participants adopted neutral expressions, a cluster of sources was found in the inferior temporal gyrus (ITG- BA 20) and the face fusiform area (FFA- BA 36/37) in the right hemisphere.

Specificity of self-happy expression on VEPs

To determine whether the effects of self-happy expression on visual processing of facial emotions might be due to a mere contraction of one's facial muscles, rather than to the specific effects of smiling, we performed a control EEG study to examine the extent to which the contraction of one's facial muscles impacts on the neural activity underlying facial emotion processing. If the enhancement of the N170/VPP to other-neutral faces can be explained in terms of the general effects of one's facial muscle contraction, then adopting a posture involving contraction of facial muscles should modify the early cortical processing of facial emotions. In two blocks, participants (N=17; 3 males; aged 22–40 years; mean=27.35) performed the facial emotion judgment task, as described in the main study (see material and methods) while they were required to purse their lips in order to hold a pen with their lips only, which is assumed to cause contraction of the facial muscles which is incompatible with smiling (Strack et al, 1988) (the 'self-control' block), or to maintain a neutral facial expression (the 'self-neutral' block). A 2 (other emotion –other-happy, other-neutral) X 2 (facial muscle contraction –self-control, self-neutral) X 3 (ROI –occipital, temporal, frontal region) repeated-measures ANOVA of VEP amplitude showed an effect of other emotion in the N170/VPP TW - 160-200ms- (other emotion, $F(1,16) = 10.29$, $p = 0.01$; other emotion X ROI, $F(2,32) = 11.35$, $p = 0.01$), localized in temporal ($t(16)=4.01$, $p=0.01$) and occipital ($t(16) = 3.45$, $p = 0.01$) regions. Additional analysis showed a main effect of facial muscle contraction in the N250/P300 TW -320-440 ms – ($F(1,16) = 6.82$, $p = 0.01$). Importantly, there were no significant main effects of other emotion or facial muscle contraction or their interaction in the TWs of the P120/N120 (110-140 ms) or the P230/N200 (240-320 ms).These results reveal that engagement of one's own facial muscles does not affect emotion

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processing of facial expressions. They only show a general, non-specific effect of one's contraction of facial muscles on later visual processing stages. Taken together, this control study confirms that the effects on visual processing of facial emotions within the N170/VPP TW are specific to one's own facial expression of happiness (as reported in the main experiment).

Discussion

This study investigated the effect of one's own facial expressions on the visual processing of other people's facial expressions, by means of cortical-evoked activity. In two separate blocks, we asked participants to adopt either a happy or a neutral facial expression during a judgement task of the emotion intensity of observed happy and neutral faces. This allowed us to directly control and contrasts the effect of one's own emotional expression on the neural mechanisms underlying visual processing of observed facial expressions. If visual face processing is independent of one's own emotional expression, then the visual-evoked potentials of observing other's happy and neutral faces should not be differentially affected by one's own facial expressions.

Our results show that one's own facial expression of happiness significantly modulated the N170/VPP component in response to other's neutral faces, indicating that they were processed in a similar manner to the observation of other's happy faces. This modulation does not happen while observing happy faces or when one is adopting a neutral facial expression. These results suggest that when adopting a happy facial expression, observed facial expressions such as non-happy (neutral) faces are processed similarly to the way in which a happy face is processed. Importantly, we found that the effect of this manipulation of the participant's own facial expression was source localized within the secondary SCx, the angular gyrus, and the associative visual cortex. Moreover, we observed an enhancement of the N170/VPP and the N250/P300 components associated with other-happy faces relative to other-neutral faces, which is in line with the results of previous studies (Williams et al., 2006). We also found a modulation of the P230/N200 amplitude to both other people's happy and neutral faces in the self-happy condition, as opposed to the self-neutral condition. Overall, our results contribute to simulationist models of emotions (Niedenthal, 2007; Hussey and Safford, 2009), showing the first functional manifestation of the impact of self facial expressions on the electrophysiological response underlying visual face processing.

The main finding was that adopting a happy expression, as opposed to a neutral expression, enhanced N170/VPP amplitude in response to another's neutral facial expression, suggesting a direct contribution of one's own facial expression to the neural correlates of visual face processing. Converging evidence suggests that the N170 component, and its fronto-central concomitant the VPP, are likely to index early stages of face perception where the structural visual features are encoded (Bentin et al., 1996; Williams et al., 2006). Furthermore, observing happy faces has been associated with an enhancement of the N170/VPP complex relative to neutral faces (Ashley et al., 2004; Williams et al., 2006). Here we show that expressing happiness leads to an enhancement of N170/VPP component of response to neutral faces, which previously has been only associated to emotional priming effects (Williams et al., 2004, 2006; Conty et al., 2012). These results are in line with former studies showing contextual effects of emotion on low level processing of visual information, in which prior visual emotional information biases the incoming neutral stimulus (Werheid et al., 2005; Li et al., 2008; Lu et al., 2011). Our findings provide novel evidence that not only external visual context but also one's own bodily context modulates visual processing of facial expressions.

Our results support the notion that intentionally adopting a particular facial expression can modulate the subjective feelings corresponding to that emotion, which in turns influences perception of other's facial expressions (i.e. Khun et al., 2011). Neuroimaging investigations

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have demonstrated that intentional imitation of happy expressions heightens the engagement of brain areas that represent pleasant feelings states and reward (Lee et al., 2006), whereas the intentional expression of a different emotion, such as sadness, leads to an activation of multimodal brain areas associated with emotional conflict processing (Lee et al., 2008; Khun et al., 2011). However, despite the evidence that one's own emotional expression engages multimodal brain areas of emotion processing, direct empirical evidence about the effects of one's facial emotional expression on the visual sensory processing of observed facial expressions have not been provided until now. We here show for the first time that one's own happy expression acts as top-down influence on early stages of visual processing, modulating low-level neural activity when one observes neutral faces as compared to happy faces. Furthermore, one's own facial expression modulates specific stages of visual processes related to the encoding of other's facial expressions.

The neural sources of the maximum peak difference between the 'other-neutral' and 'other-happy' face, when participants assumed happy expressions, were localized in the right associative visual cortex and the right angular gyrus. These cortical areas are involved in the integration of visual information and multimodal information from visual, somatosensory and auditory primary areas, respectively. These results accord well with previous evidence of the engagement of these cortical areas in response to affective stimuli associated with strong somatovisceral responses (Phillips et al., 1998; Kesler-West et al., 2001). Moreover, the secondary SCx was a further neural focus in source localized activity associated with neutral *versus* happy other face in the self-happy condition. The secondary SCx is responsible for integration of sensorimotor signals from the body (Maldjian et al., 1999) and has a fundamental role in the processing of emotional faces (Pitcher et al., 2008; Sel et al., 2014). By contrast, when participants adopted neutral expressions, the maximum peak difference between happy and neutral other face was source localized in the ITG and the FFA in the right hemisphere. These cortical areas are associated with high level processing of visual information, with a principal role in the integration of visual elements into perceptual wholes (Haxby et al., 2000; Atkinson and Adolphs, 2011).

Taken together, our findings support the hypothesis that facial expression recognition cannot be performed as a disembodied cognitive process but rather that perception of facial expression relies on the activation of sensorimotor areas which have an active role on the processing of biologically significant stimuli (Pitcher et al., 2008; Sel et al., 2014). On the other hand, the lack of modulation of the N170/VPP component in response to happy faces as a result of one's own happy expression is perhaps less consistent with previous findings of facial mimicry (i.e. Lee et al., 2006). However, it should be noted that the two accounts are not mutually exclusive within the context of this study. Considering that, during facial mimicry, the intentional expression of a happy face facilitates the perception of positively valenced stimuli including smiling faces, one might expect a modulation of the N170/VPP complex to happy faces when participants adopted a happy face. Importantly, however, the current results show a modulation of the P230/N200 component, in the 'self-happy' condition, to both happy and neutral observed face, indicating a non-valence-specific effect of one's own happy face on visual processing. It may thus be possible that the lack of recorded effect of one's own facial expression on the visual processing of another's happy face in this experiment may have been hidden by a ceiling effect, that would only reveal the effects of other's neutral face because the amplitude of the N170/VPP is by nature greater in happy than neutral expressions. Potentially a more demanding paradigm, i.e. presentation of irrelevant information simultaneously to target stimuli, is required to resolve whether one's own expression of happiness affects the visual processing of happy or other emotional faces. Nonetheless, our findings endorse the proposal that emotional facial mimicry is not purely a motor behaviour but also modulates visual processing of facial expressions.

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Furthermore, our results demonstrate that changes in the state of somatosensory and motor multimodal areas lead to modulations of cortical activity in low-level visual areas. These observations are consistent with a Predictive Coding (PC) framework, an emerging unifying theory of cortical function. The key premise of PC is that perception relies on hierarchical generative representations of the sensory inputs, that arise from multisensory information, and that are constantly updated through the prediction and integration of unimodal sensory information (i.e. emotional faces) in multimodal areas (Friston and Kiebel, 2009; Clarck, 2013). Likewise, we could argue that the sensorimotor representations of happiness in multimodal areas, triggered by motor expression, might act as top-down influence on the visual perception of neutral faces, by updating predictions about the causes of the sensory signals, and thus induce positive biases in the VEPs. However, although it is tempting to speculate about the probabilistic nature of the one's own facial expression effects on visual face processing, further studies are required to confirm such hypotheses.

In conclusion, this study provides novel evidence for a fundamental role of one's own facial expressions in the visual processing of the observed facial expressions of other people and provides support for the colloquial phrase that "if you smile, the world will smile back to you". Specifically, we have shown that expressing happiness, *versus* wearing a neutral expression, biases the processing of neutral facial expressions by enhancing cortical visual-evoked responses to neutral faces, similar to the VEPs typically observed in response to positive faces. This effect was source localized in multisensory associative areas and in associative somatosensory cortex, demonstrating the involvement of multimodal areas in the top-down modulation of low-level sensory visual cortex. Overall, our results provide support for simulationist models of emotion as well as demonstrating the specific contribution of bodily states to visual face processing.

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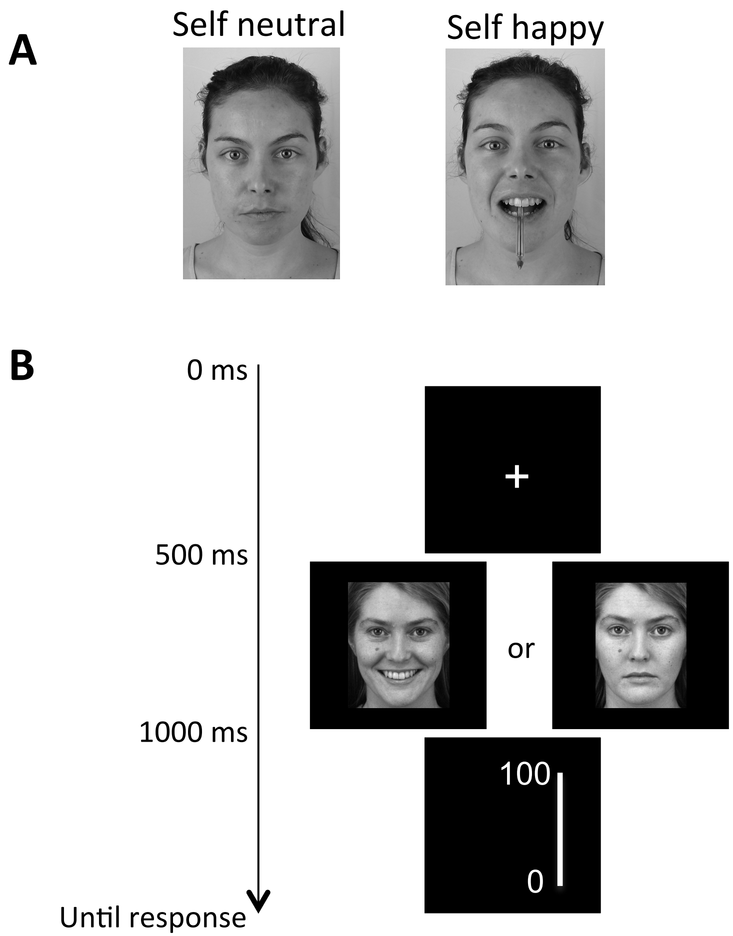
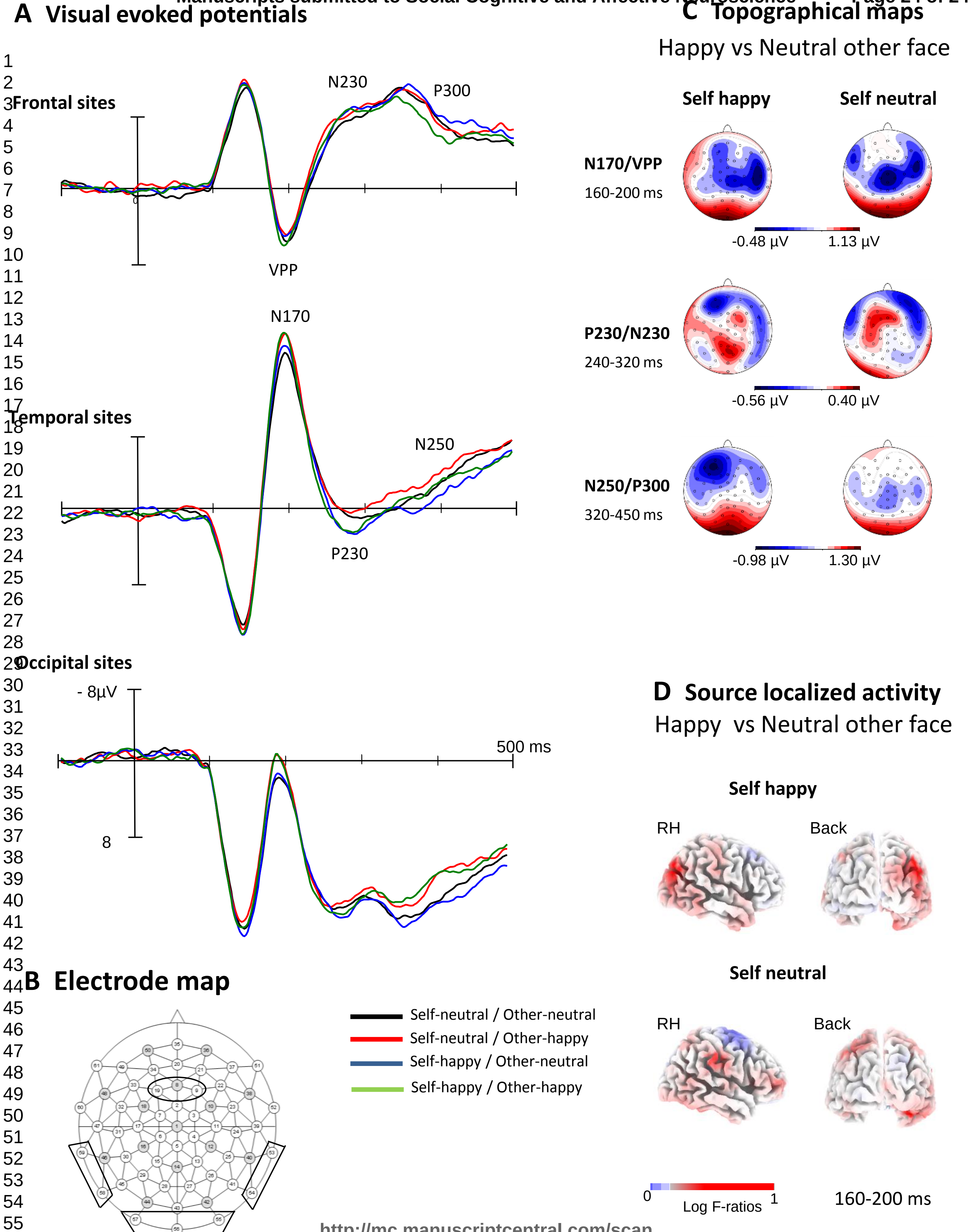
Figure Legends

Figure 1: *(A)* Left- Self-neutral block, participants were asked to maintain a neutral expression and relax their face. Right- Self-happy block, participants were instructed to hold a happy expression by biting on a pen horizontally with the teeth. *(B)* Timeline of the stimuli presentation.

Figure 2: *(A)* Grand average VEPs when observing happy faces (green: self-happy condition; red: self-neutral condition) and neutral faces (blue: self-happy condition; black: self-neutral condition). *(B)* Selected electrodes included in the ANOVA. *(C)* Topographical maps showing differential activity to happy *versus* neutral other face in the self-happy and self-neutral conditions at N170/VPP, P230/N230 and N250/P300 time windows. *(D)* Three-dimensional representation of sLORETA statistical maps showing candidate regions where maximal happy *versus* neutral differential activity was source localized at N170/VPP latency in the self-happy and self-neutral conditions.


A
Self neutral
Self happy
B
0 ms
+
500 ms
or
1000 ms
100
0
Until response


A Visual evoked potentials
Frontal sites
N230
P300
VPP
0
Temporal sites
N170
N250
P230
Occipital sites
- 8µV
8
500 ms
B Electrode map
Self-neutral / Other-neutral
Self-neutral / Other-happy
Self-happy / Other-neutral
Self-happy / Other-happy
C Topographical maps
Happy vs Neutral other face
Self happy
Self neutral
N170/VPP
160-200 ms
-0.48 µV
1.13 µV
P230/N230
240-320 ms
-0.56 µV
0.40 µV
N250/P300
320-450 ms
-0.98 µV
1.30 µV
D Source localized activity
Happy vs Neutral other face
Self happy
RH
Back
Self neutral
RH
Back
0
Log F-ratios
1
160-200 ms