Fairness modulates non-conscious facial mimicry in women

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In societies with high cooperation demands, implicit consensus on social norms enables successful human coexistence. Mimicking other people’s actions and emotions has been proposed as a means to synchronize behaviour, thereby enhancing affiliation. Mimicry has long been thought to be reflexive, but it has recently been suggested that mimicry might also be motivationally driven. Here, we show during an economic bargaining game that automatic happy mimicry of those making unfair offers disappears. After the bargaining game, when the proposers have acquired either a fair or unfair reputation, we observe increased angry mimicry of proposers with an unfair reputation and decreased angry mimicry of fair proposers. These findings provide direct empirical evidence that non-conscious mimicry is modulated by fairness. We interpret the present results as reflecting that facial mimicry in women functions conditionally, dependent on situational demands.

Keywords: bargaining behaviour; facial mimicry; fairness; imitation; social interaction

1. INTRODUCTION

Implicit agreements underlie much of human social behaviour, to the extent that they orchestrate social relations and interactions, and promote organizational and social coordination [1]. Fairness has been proposed as an implicit shaper of social behaviour. For example, fairness has been shown to restrict profit-seeking in economic markets [2], to shape behaviour in economic games as a function of reputation [3] and to mould instant neural responses to economic offers [4]. In general terms, for species with highly developed sharing and cooperation standards, answering to fairness principles is essential to all its members [5].

In recent theoretical accounts of human fairness judgements, the role of emotions is progressively underscored [6,7]. Although earlier perspectives focused on cognitive development in moral reasoning [8], emphasis has now shifted to the role of intuitions, stressing the automatic character of instant affective judgements [6,7]. A recent illustration of the automaticity of moral judgements is provided by a study of facial motor activity in response to several categories of disgust [9]. In their study, the authors show facial expressions in response to moral disgust to be remarkably similar to the expressions in response to both toxic- and contamination-based disgust, suggesting that the categories originally eliciting disgust have been enlarged to include the higher-order forms of moral disgust [9,10]. Interestingly, the study by Chapman et al. [9] shows that automatic facial motor activity as well as self-reported disgust are proportional to the degree of unfairness of offers made in the Ultimatum Game, illustrating its parallel relation with core motivational systems as well as human behaviours.

Facial motor activity has been extensively studied in the context of imitation [11], and is generally referred to as facial mimicry. Mimicry has been proposed as a low-cost, low-risk reflexive behaviour sub-serving the creation of affiliation and bonding [12–14]. The ‘chameleon effect’, as mimicry has been labelled [15], is suggested to result from a perception–action link; inter-individual linkage arises from the integration of the behaviours of others into an individual’s representations, thus facilitating coordinated activity [15,16]. As described in the perception–action model (PAM) by Preston & de Waal, this inter-individual linkage facilitates group-living, with its critical dependency on social cooperation, and this group-living further shaped this mechanism to form the foundation of empathic behaviours such as state matching and emotional contagion [16]. Therefore, through behavioural confirmation to the interaction partner’s attitudes, opinions and behaviours, higher-order social coordination is promoted [12,16,17]. In other words, mimicry serves to automatically and non-consciously synchronize people’s affect and promote social cohesion, but recent evidence shows that mimicry can also be motivationally driven.

Modulation of automatic affiliative mimicry has been illustrated by studies showing that social contexts such as group membership impact facial mimicry [13] and that affiliative mimicry increases in response to social exclusion [14]. In the latter study for example, it was suggested that to reinstate group membership after social exclusion, participants who were excluded in a cyber-ball game mimicked their interaction partner more than included participants [14].

Mimicry can thus be regarded as motor behaviour representing more than mere imitation [14]. It is affected by motivational systems, and although non-conscious, it is an omnipresent characteristic of human non-verbal communication [18]. Social context modulates one’s
mimicry, and one’s mimicking in turn promotes attachment [12,14]. Mimicry facilitates and fosters interpersonal bonding, but to what extent it is able to further support successful human coexistence is unknown.

We here present an experiment in three blocks that incorporates measures of facial mimicry in response to emotional facial expressions during and after an economic bargaining game. First, we determine baseline facial mimicry to morphs of happy and angry facial expressions. In the second block, we manipulate fairness of offers in a bargaining game and investigate whether and how unfair offers directly affect facial mimicry. In the final block, facial mimicry in response to unfair and fair players is assessed to examine whether and how mimicry is affected by the reputation the players acquired in the encounters during the game.

2. METHOD AND RESULTS

(a) Participants
Thirty female participants (mean age: 20.8 years, s.d. = 2.1 years) performed a series of three experimental blocks. Only female participants were included because it has been shown that females are more facially reactive than males [19]. Electromyographic (EMG) data from four participants were unusable owing to the absence of detectable changes in motor activity, yielding a final number of 26. Participants were told that the electrodes served to monitor ‘physiological changes’ as a cover story. None of the participants had a history of psychiatric or neurological conditions. Written informed consent was obtained, and volunteers received financial compensation for participation. The study was conducted in accordance with local ethical guidelines.

(b) Measures of facial motor activity
EMG responses were recorded from bipolar electrode montages from the left corrugator supercilii and zygomaticus major muscles to assess motor responses to angry and happy facial expressions, respectively [20]. The ground consisted of the active common mode sense and passive-driven right leg electrodes (see www.biosemi.com) that were placed midline on the forehead. EMG was recorded at a sampling rate of 2048 Hz, using a Biosemi ActiveTwo amplifier, and stored for a further off-line analysis.

Raw EMG traces were 30–50 Hz band pass filtered. For each trial, −1000 to +4000 ms response windows were selected, time-locked to morph onsets. Baseline correction was applied by subtracting the averaged EMG activity 1000 ms pre-stimulus onset period from the post-stimulus onset values. EMG signals were then rectified and averaged for 250 ms intervals. The resulting 16 time bins were entered into statistical analyses.

(c) Block 1: baseline facial mimicry
In the first block, 16 morphing neutral-to-happy and 16 morphing neutral-to-angry facial expressions were presented. The morphs were displayed by two female and two male actors, selected from the Ekman and Friesen pictures of facial affect set [21]. Each morph was displayed for 2000 ms, and the last frame displayed the full emotional expression for an additional 2000 ms. Each trial started with a 1000 ms fixation cross followed by the morph, and ended with a variable intertrial interval of 3000–6000 ms to avoid habituation to the presentation of the facial morphs (figure 1a).

(d) Results and discussion
The 2 × 2 × 16 (muscle × emotion × epoch) multivariate ANOVA revealed the typical emotional modulation of muscular activity: for zygomatic major greater activity in response to the happy morph, \( F_{1,15} = 102.8, p < 0.001, \eta^2 = 0.873 \); for corrugator supercilii greater activity in response to the angry morph, \( F_{1,15} = 87.8, p < 0.001, \eta^2 = 0.854 \). Group-averaged EMG traces recorded from zygomaticus major and corrugator supercilii in response to happy and angry morphs, respectively, served as reference data for the blocks 2 and 3.

(e) Block 2: facial mimicry and fairness behaviours
The fairness manipulation was incorporated in the second block. At the beginning of the game, participants were endowed with 1600 points, of which the remainder after the experiment had finished was converted to money and paid to the participant. Each of 64 trials started with a two-option forced choice: two neutral looking confederates are presented, to one of which the participant has to donate 25 points. The confederates are programmed to be either fair (75% of the trials the participant’s donation is doubled and split, each player receives 50%) or unfair (75% of the trials the participant’s donation is not returned, confederate receives 100%, participant 0%). After the feedback window, the confederate who was chosen by the participant displayed either the happy or angry 2000 ms morph, identical to those used in block 1. Figure 1b depicts a single trial of the bargaining game. Here, the instant impact of fair or unfair offers on EMG responses to happy and angry facial morphs during ongoing interaction can be assessed.

(f) Results and discussion
Compared with baseline mimicry, fairness during the bargaining game modulates mimicry of happy facial expressions as measured from zygomatic major; \( F_{2,30} = 46.7, p < 0.001, \eta^2 = 0.757 \). Post hoc analyses of the averaged activity of all epochs showed that the effect was owing to the absence of mimicry after people were confronted with unfair offers; \( t_{15} = 9.65, p < 0.001, d = 1.87 \). Fair offers show a trend towards a small decrease (\( t_{15} = 1.99, p = 0.066, d = 0.33 \)); see figure 2b for the
group-averaged EMG traces plotted against baseline mimicry. Corrugator supercilii also showed a fairness effect on mimicry of the angry morph; $F_{2,30} = 3.5, p = 0.042, \eta^2 = 0.191$. However, follow-up analyses were unable to further specify the effect as separate contrasts remained non-significant, $p's > 0.24$ (figure 2a).

(g) **Block 3: facial mimicry and fairness reputation**
Block 3 essentially resembles block 1, but with the critical additional circumstance that now the confederates displaying, the morph have earned the reputation of being either fair or unfair. Now, the interaction of fairness reputation with emotional expression can be assessed.

(h) **Results and discussion**
Here, corrugator supercilii reveals modulation by reputation ($F_{2,30} = 20.73, p < 0.001, \eta^2 = 0.58$), an effect quantified by increased angry mimicry towards unfair confederates; $t_{15} = -4.21, p = 0.001, d = 0.26$, and decreased angry mimicry towards fair confederates; $t_{15} = 3.66, p = 0.002, d = 0.36$ (figure 3a). Zygomatic major here showed no effect of fairness; $F_{2,30} = 0.62, p = 0.54, \eta^2 = 0.04$ (figure 3b).

3. **GENERAL DISCUSSION**
In a series of three blocks, we recorded facial mimicry in response to emotional facial expressions. In the first block, baseline facial mimicry in response to emotional expressions was determined. In block 2, the instant impact of fair and unfair offers in an economical bargaining game on facial mimicry was assessed. Block 3 served to evaluate whether mimicry would show modulation by fairness reputation earned during the bargaining game.

We found that when compared with baseline facial mimicry, unfair offers attenuate the imitation of emotional facial expressions during the bargaining game. Notably, mimicry of happy facial expressions after unfair offers is virtually absent. Here, we observe that a remarkable divergence from the imitate-to-facilitate character mimicry has been ascribed. In the context of norm violation, facial mimicry, contrary to actively promoting interpersonal bonding in social interaction, shows clear attenuation. Attenuation of happy mimicry after unfair offers might passively communicate resentment, thereby discouraging the preceding behaviour by not providing reinforcing feedback. After the bargaining game has ended, mimicry shows distinct modulation by reputation as acquired during the game. Compared with the baseline, mimicry of happy facial expressions is unaffected, irrespective of reputation. In response to facial anger however, mimicry reveals a selective modulation: attenuated in response to fair reputation but strengthened in response to unfair reputation. In line with studies illustrating the importance of social reputation in societies [3,22], reputation selectively affects facial mimicry.

A possible interpretation of the observed modulation of facial mimicry is provided by the framework of the PAM as well as psychological theories stating that the
extent to which an individual perceives the state of an interaction partner is affected by their interdependence [16,23,24]. This interdependence has been suggested to vary over time and between situations: proximate goals can increase interdependence to facilitate cooperation, but also decrease interdependence when efforts are frustrated [16]. Long-term goals in a similar fashion are modulators of interdependence, but here social relationships or groups might have goals spanning up to, or even beyond a lifetime [16]. Within this framework, the differential modulation of facial mimicry can be rooted in fairness-modulated interdependence, where proximate and distal goals show different modulation of facial mimicry. This remains speculative however, and future studies might incorporate further behavioural measures to be able to ascribe function to measures of facial mimicry.

Therefore, our data suggest mimicry to be a context-sensitive means of adaptive non-conscious communication. They empirically corroborate the recently coined suggestion that there are circumstances in which mimicry is not merely assimilative, but can act in a complementary way [18]. Moreover, the data illustrate that implicit processes such as mimicry may serve one’s own as well as group benefit by reinforcing norm compliance [25]. The pattern of mimicry modulation observed in the two experimental blocks may suggest a strategic and adaptive property arising from the repertoire observed: it is not only able to adopt a low-risk strategy when profitable future interaction is at stake, but can turn to enforcement strategies when favourable.

These results may well inform and aid future research on the nature and purpose of non-conscious processes involved in human social interaction. Mimicry may, although involuntary and automatic, serve concrete and instant social goals, as well as goals that transcend immediate individual concern. It further demonstrates that non-conscious processes have adaptive properties [26,27], in that they are recruited dependent on situational demands [14,28]. We conclude that fairness is a shaper of the process of non-conscious mimicry, and that mimicry should be regarded as a behaviour that extends beyond the facilitation of affiliation, and may be strategically employed to enforce norm compliance.

The study was conducted in accordance with local ethical guidelines.

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