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BRAIN REWARD ACTIVITY TO MASKED IN-GROUP SMILING FACES PREDICTS FRIENDSHIP DEVELOPMENT

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Abstract

This study examined whether neural responses in the ventral striatum (VS) to in-group facial expressions—presented without explicit awareness—could predict friendship patterns in newly arrived individuals from China six months later. Individuals who initially showed greater VS activity in response to in-group happy expressions during functional neuroimaging later made considerably more in-group friends, suggesting that VS activity might reflect reward processes that drive in-group approach behaviors.

Keywords

fMRI; reward; face; acculturation; friendship

Introduction

Belonging within social groups is a fundamental human need (Baumeister & Leary, 1995). This need becomes especially prominent when people move from their native culture to a new one, necessitating the formation of an entirely new social network. An early challenge that new arrivals encounter is determining with whom they should interact. Indeed, new

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arrivals vary greatly in their friendship formation patterns: Some individuals make more friends among out-group members, whereas others isolate themselves from out-group members and associate mainly with other newly arrived in-group members (Sam & Berry, 2010). This study attempts to understand why some new arrivals primarily favor in-group over out-group friendships.

Because social affiliation occurs automatically (Powers & Heatherton, 2012), individuals may lack insight into the processes that motivate their friendship patterns. That is to say, implicit processes may play a major role in driving individuals' affiliation behaviors with either in-group or out-group members. Research in intergroup emotion contagion provides insights to understand these implicit processes (Baumeister & Leary, 1995; Epstude & Mussweiler, 2009; Sam & Berry, 2010; van der Schalk et al., 2011; Weisbuch & Ambady, 2008). To examine whether group membership between perceivers and targets can implicitly moderate participants' unintentional reactions to emotional targets, Weisbuch and Ambady (2008) conducted a series of studies in an affective priming paradigm. They found that participants spontaneously responded faster to happy expressions than to fear expressions when expressions were in-group members, suggesting that happy expressions automatically elicit approach responses, whereas fear expressions elicit avoidance responses. However, the opposite patterns for happy and fear expressions were found when the targets became out-group members. This finding indicates that the same emotional expressions may lead to divergent responses due to group membership. Most importantly, this finding suggests that affective responses to in-group or out-group members may implicitly impact affiliative behaviors between groups (Bourgeois & Hess, 2008; Sam & Berry, 2010; van der Schalk et al., 2011; Weisbuch & Ambady, 2008).

Intuitively, it seems likely that friendships will form when social interactions are rewarding. Yet, due to cultural norms, people may feel obligated to report positive relations with their in-group, even in the absence of pleasurable experiences. Therefore, self-reported motives for friendship formation may be biased (Hendrickson, Rosen, & Aune, 2011; Williams & Johnson, 2011). Moreover, since affective responses to in-group and out-group members are by and large automatic, experimental techniques that are sensitive to implicit processing are needed. Functional brain imaging can be used as an alternative means to test the hypothesis that distinct patterns of reward may underlie differential in- vs. out-group interaction patterns.

Prior imaging studies investigating reward activity have provided suggestive evidence for the hypothesis that affiliative behaviors are generally associated with activity in brain reward regions. Among all reward regions, the ventral striatum (VS) is a key player and highly sensitive to primary rewards, such as food or sex (Demos, Heatherton, & Kelley, 2012; Haber & Knutson, 2010; Heatherton & Wagner, 2011). Furthermore, the VS receives dense dopaminergic inputs from mesolimbic dopamine regions, making cue-association learning easily established in the VS (Delgado, 2007; Glimcher, 2011). This cue-association learning allows individuals to associate reward values with different kinds of secondary reinforcers, such as money, status symbols, attractive faces, or emotional expressions (Aharon et al., 2001; Haber & Knutson, 2010; Schultz, 2000). Specifically, studies examining brain reactivity to different kinds of emotional expressions have found that happy

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expressions elicit activation in the VS (Phan, Wager, Taylor, & Liberzon, 2002). Strong VS activation in response to happy, but not to fearful expressions was shown in a go/no-go study that used different emotional expressions as targets. This strong VS activity made it more difficult for participants to inhibit responses in no-go trials (Hare, Tottenham, Davidson, Glover, & Casey, 2005), suggesting that the VS activity induced by happy expressions is likely to motivate approach behaviors (Somerville, Hare, & Casey, 2011).

Based on the findings that happy expressions provoke approach behaviors, here we hypothesized that VS activity for in- compared to out-group happy expressions could predict new arrivals' relative percentage of in-group friends, where higher activity predicts a greater increase in this relative percentage over six months. However, VS activity for other expressions would not predict friendship changes. In order to test our hypothesis without participants being explicitly aware of our manipulation, we presented in- and out-group emotional expressions in a backward-masking paradigm (Kim et al., 2010; Whalen et al., 2004; 1998).

Materials and methods

Participants

Twenty-seven newly arrived Chinese international graduate students (age range 22–25, 13 females) were recruited for the current study within the first month of their arrival in the US. None of them had ever stayed or studied in a foreign country for more than two months prior to their arrival in the United States. All of the participants were fluent in both Chinese and English (TOEFL iBT mean score = 102.7 out of 120), right-handed, with normal or corrected vision, and had no history of neurological or psychiatric problems. Their BDI (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), STAI-S, and STAI-I (Spielberger, Gorsuch, & Lushene, 1988) scores were all within normal range. Since previous studies also indicated that specific personality traits, particularly extraversion and openness, are important predictors for successful adaptation during acculturation (Swagler & Jome, 2005; Ward, Leong, & Low, 2004), participants' scores on the Big Five Aspect Scales (BFAS, DeYoung, Quilty, & Peterson, 2007) were also collected. They were paid $45 for participation, and gave informed consent in accordance with the guideline set by the local institutional review board. One participant was excluded from analysis due to excessive movement during scanning (more than 3 mm).

Stimuli

In-group (Chinese) faces with fearful, surprised, happy, and neutral expressions of ten different individuals (five female, five male) were selected from the Chinese Affective Face Picture System (CAFPS; Bai, Ma, Huang, & Luo, 2005). Out-group (Caucasian) faces with these four expressions of ten different individuals (five female, five male) were selected from the NimStim face set (Tottenham et al., 2009). Since the faces from CAFPS were all cropped into ellipses, the faces from the NimStim set were also cropped into the same eclipse shape using Adobe Photoshop software. Luminance and contrast grade were also equalized. In order to examine whether the selected in-group and out-group faces were inherently similar in emotional intensity, a pilot test on emotional intensity (1= not at all, 7 =

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extremely) was conducted in an independent group of Chinese participants (5 female, 5 male). Results showed in-group and out-group expressions were judged similarly for all emotion expressions; for fearful ($t(9) = -0.147$, $p = 0.88$), happy ($t(9) = -0.146$, $p = 0.88$), or surprised ($t(9) = -1.978$, $p = 0.07$) expressions.

In-group and out-group friendship measurement

In order to assess how new arrivals expand their social networks with in-group or out-group members in a new culture, percentages of in- and out-group friends from social networking services (e.g., Facebook) were recorded. Importantly, as Facebook is blocked in China, these Chinese new arrivals had to create a whole new online friendship network in the US, making it possible to track their changing friendship patterns without contamination from their previous friendship networks. Moreover, although Facebook is blocked in China, other social networking services (i.e. Renren) are still allowed. All participants reported that they had at least two years of experience using Renren in China, and began using Facebook within the first month of their arrival without reporting any difficulty in using it. The two criteria for classifying a friend as an in-group member were (1) having a Chinese name and (2) a profile picture that appeared to reflect Chinese ancestry. Otherwise, the friends were classified as out-group members[1]. The percentages of in-group friends on Facebook for each of the participants were recorded immediately after scanning (Time 1; mean = 92.09%, range from 73.33% to 100%, SD = 6.67%) and again six months later (Time 2; mean = 90.94%, range from 73.03% to 97.89%, SD = 6.63%), and subsequently, changes in the percentage of in-group friends were computed (mean = −1.15%, range from -13.17% to 6.67%, SD = 4.74%)[2]. These changes in the percentage of in-group friends were taken as the dependent variable in the linear regression analysis.

Procedure

Based on previous findings of regional brain activity to emotional stimuli without subjective awareness (Whalen et al., 1998), the current study presented emotional expressions in a backward masking paradigm. While in the scanner, participants were asked to passively view block-presented masked faces in three functional imaging runs. Three kinds of in-group and out-group emotional expressions (fearful, happy, and surprised) were used in the current study, with six conditions in total. In each run, twelve 20 s masked-face blocks were presented and every three blocks were interleaved with a 20 s fixation block, which resulted in sixteen 20 s blocks in one run. The order of the masked-face blocks was pseudo-counterbalanced by group (in-group or out-group) and emotional expression (fearful, happy or surprised) across runs and subjects. Each trial began with an emotional face (target) presented for 17 ms, followed by a 183 ms neutral face (mask) and a 300 ms ISI fixation (Fig. 1). Based on the procedure of our previous work (Kim et al., 2010; Whalen et al., 1998), the target and its corresponding mask were different face identities. Each target and mask was repeated four times and the order of the faces was pseudo-counterbalanced within

[1]The same undergraduate research assistant, who grew up in China and was blind to our hypothesis, did the classifying work for in-group and out-group Facebook friends both at Time 1 and Time 2.

[2]At Time 1, mean number of total friends was 72.2 with SD = 26.4 (in-group friends: mean = 66.0, SD = 22.8; out-group friends: mean = 6.2, SD = 5.9). At Time 2, mean number of total friends was 145.7 with SD = 42.5 (in-group friends: mean = 132.4, SD = 39.2; out-group friends: mean = 13.3, SD = 10.1).

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each masked-face block. Thus, a total of 40 emotional faces from the same condition were presented in each maskedface block.

To be consistent with the analysis of our previous studies (Whalen et al., 1998), participants with subjective awareness were excluded from further analysis. Therefore, immediately after the scanning, participants were asked to report whether they noticed any emotional expressions (fearful, happy, or surprised), or any part of these emotional expressions (i.e. a smile, teeth, etc.). Four out of the 26 participants had reported seeing at least one masked emotional expression during scanning, and these four participants were excluded from further analysis.

Functional imaging and pre-processing

Imaging data were collected on a Philips Intera Achieva 3T scanner at Dartmouth College with a thirty-two channel head coil. Structural images were acquired by using a T1-weighted MPRAGE sequence (160 sagittal slices, TR = 9.9 ms, TE = 4.6 ms, 8 flip angles, 1 × 1 × 1 mm voxels). A T2*-weighted echo-planar sequence (TR = 2,500 ms, TE = 35 ms, 90 flip angles) was used to acquire functional images. 168 volumes with whole brain coverage (39 axial slices, 3 × 3× 3 mm^3 voxel size) were collected during each run.

SPM8 (Wellcome Department of Cognitive Neurology, London, UK) was used to analyze the imaging data. Images were first corrected for the differences in slice timing across slices, realigned for head motion correction, and unwarped to reduce residual movement-related image distortions. The images were then normalized to MNI standard space, and were spatially smoothed with a 6 mm full-width-at-half-maximum Gaussian kernel. A general linear model incorporating task effects (convolved with a canonical hemodynamic response function) and covariates of no interest (linear trend, session man, and six movement parameters) was used to compute contrast images.

Contrast images for each participant, comparing the brain response to each of the six emotional expressions (three kinds of expressions for both of in-group and out-group category) with baseline (e.g. fixations), were then submitted to a second-level repeated measures analysis of variance (ANOVA). This ANOVA generates statistic parametric maps of F-values for the main effect of Group (in-group vs. out-group), the main effect of Expression (happy vs. fearful vs. surprised expressions), and the interaction effect of Group × Expression. Monte Carlo simulations using AFNI’s AlphaSim were used to calculate the minimum cluster size for all of the whole-brain main effects as well as the interaction effect at uncorrected threshold at $P < 0.001$ for a whole-brain correction of $P < 0.05$, which was 44 continuous voxels.

Results

Preliminary analysis and data reduction

A whole-brain main effect of Group found one significant in-vs.-out-group difference, located in the ventral striatum (peak activation: 12, 6, 0, MNI coordinates; see Table 1 & Fig. 2a). This peak coordinate was selected as the primary region-of-interest (ROI), with 4mm radius, for subsequent analyses. In order to examine whether this group difference in

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the VS is different across three emotional expressions (happy, fearful, or surprised), this VS ROI was used to extract parameter estimates. The in-vs.-out-group difference scores of the parameter estimates for each of these three comparisons (comparisons for in-vs.-out-group happy, fearful, or surprised expressions) were calculated separately.

Primary analysis

First, an offline one-way ANOVA showed that the VS activity for in-vs.-out-group comparisons was marginally different across three expressions ($F(2, 42) = 2.752$, $p = .075$, Fig. 2b). Specifically, VS activity for the in-vs.-out-group comparison of happy expressions was greater than the activity for the comparison of surprised expressions ($t(21) = 2.889$, $p = 0.009$), but not greater than the activity for the comparison of fearful expressions ($t(21) = 1.669$, $p = 0.11$).

Second, difference scores from these three comparisons were taken as independent variables into an offline multiple regression analysis in order to test which emotional expression significantly predicted relative friendship changes six months later. In addition, in order to examine whether specific personality traits can also predict friendship changes, participants' extraversion and openness scores from the BFAS were also taken as independent variables in the same multiple regression analysis. Thus, five scores (extraversion, openness, and VS parameter estimate difference scores comparing in-group to out-group happy, fearful, or surprised expressions, respectively) were taken as independent variables in the multiple regression analysis.

Results showed that, at Time 1, all five independent variables, including the ventral striatal activity comparing in-group vs. out-group happy expressions (beta = −1.809, t(21) = −0.149, p = 0.883), were not related to percentages of in-group friends. By contrast, over six months, among all independent variables, only the ventral striatal activity comparing in-group vs. out-group happy expressions predicted changes in percentages of in-group friends (beta = 17.203, t(21) = 2.462, p = 0.026, Fig. 3). None of the other four independent variables significantly predicted changes in percentages of in-group friends over six months (in-vs.-out-group fearful expression: beta = −6.882, $t(21) = -1.525$, $p = 0.147$; in-vs.-out-group surprised expressions: beta = 1.665, $t(21) = 0.291$, $p = 0.775$; extraversion: beta = 2.009, $t(21) = 1.027$, $p = 0.32$; openness: beta = −2.543, $t(21) = -1.304$, $p = 0.211$). That is, individuals with the highest in-group reactivity for happy expressions showed an increase in the percentage of in-group friends, whereas those with the lowest in-group reactivity showed a reduction in the percentage of in-group friends.

Discussion

New arrivals generally showed greater reward reactivity for in-group than for out-group masked expressions, which supports the general idea of in-group favoritism (Baumeister & Leary, 1995; Cikara, Botvinick, & Fiske, 2011; Van Bavel, Packer, & Cunningham, 2008). Importantly, this reward reactivity was stronger for happy than surprised expressions, but not different between happy and fearful expressions. Although this in-group reward reactivity might not be specific for happy expressions, individual differences in this in-group reward reactivity for happy expressions were the only factor that successfully predicted in-

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group friendship patterns six months later. Those with the greatest reward reactivity to in-group happy expressions subsequently developed more friendships with in-group members, compared to those who showed equivalent reactivity for ingroup and out-group happy expressions, who developed more balanced in-and-out-group friendship patterns. This finding suggests that individual differences in reward reactivity induced by in-group happy expressions are likely to reflect individual differences in motivation for approaching in-group members.

This in-group favoritism might originate from in-group biases, which have been found in previous studies (Van Bavel et al., 2008; Van Bavel & Cunningham, 2008). In those studies, when Caucasian participants are assigned to a classical minimal-group paradigm, participants usually rate their new in-group members more favorably than out-group members, regardless of their race. For example, participants rate in-group Black members higher than out-group Black members in the liking scale and the ratings do not differ between in-group Caucasian and Black members. Thus, the key process underlying this in-group bias might be that people categorize themselves as members of a particular group (Sporer, 2001; Van Bavel & Cunningham, 2008). Once individuals have identified with a group, their favoritism for other members of this group occurs without subjective awareness. This possibility is also supported by findings from research in intergroup emotion contagion, indicating that the affective responses to different group members are automatic and may be crucial in moderating the affiliative behaviors toward in-group or out-group members (van der Schalk et al., 2011; Weisbuch & Ambady, 2008). It is therefore possible that individuals in the current study who showed greater in-group reward reactivity had a stronger tendency to categorize themselves as identifying with their original racial group.

In addition, the current study also demonstrated the usefulness of the brain-as-predictor approach to understanding the dynamic process of immigrants' friendship formation patterns as well as other aspects of acculturation. Previous attempts using more explicit tools, i.e. self-report measures, to predict immigrants' acculturation styles have been unsuccessful (Sam and Berry, 2010). For instance, studies that used the Big Five personality traits (Ward et al., 2004), motivation (Kosic, Kruglanski, Pierro, & Mannetti, 2004), or attachment styles (Bakker, van Oudenhoven, & van der Zee, 2004) produced conflicting findings. A similar conflicting finding was also found in the current study. We found that individual differences in Big Five personality traits, particularly extraversion and openness, could not predict changes in in-group friendships. Instead, we found that the brain-as-predictor approach, which links brain imaging data to outcomes beyond the lab setting (Berkman & Falk, 2013), may be an alternative way to explore acculturation processes. By using this approach, neural responses that encode information can be used to make predictions for subsequent real-world behaviors (Berkman & Falk, 2013), which might be useful for understanding different aspects of the acculturation process and where possible individual differences arise (Chen, Heatherton, & Freeman, 2015).

There are several limitations in the current study. First, this study lacks explicit measurement of English proficiency, which is a crucial factor for immigrants' acculturation outcomes (Berry, 1997; Clément, 1986; Noels, Pon, & Clément, 1996; Sam & Berry, 2010). It is possible that people who had more out-group friends six months later were those who

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had higher English proficiency at the beginning. Their above-average English proficiency might drive them to interact with out-group friends more, resulting in increases in the percentage of out-group friends six months later. Their motivation to interact with out-group friends might also reveal in their equivalent reward reactivity to both in-group and out-group members, suggesting that these individuals had greater reward reactivity for out-group members compared to those who developed friendship predominantly with in-group members. Second, our measurement of friendship includes only online friendships, but not offline friendships. Some studies have found that although online and offline friendships differ in some aspects, such as rating of friendship closeness, these two types of friendships are similar in most of the facets (Mesch & Talmud, 2007; Subrahmanyam, Reich, & Waechter, 2008). However, in order to get a more comprehensive understanding of friendship developments within immigrants, researchers might need to incorporate some kinds of offline friendship measurement in future studies.

Humans have a basic desire to form social affiliations (Baumeister & Leary, 1995) as research on sports teams (Cikara et al., 2011; Cikara & Van Bavel, 2014) and political parties (Jost, Nam, Amodio, & Van Bavel, 2014; Krosch, Berntsen, Amodio, Jost, & Van Bavel, 2013) has shown. From an evolutionary perspective, in-group membership provides not only resources, but also security, both of which are vital for survival. Thus, the finding that in-group reward activity drives in-group friendship patterns may apply to formation of friendships more generally.

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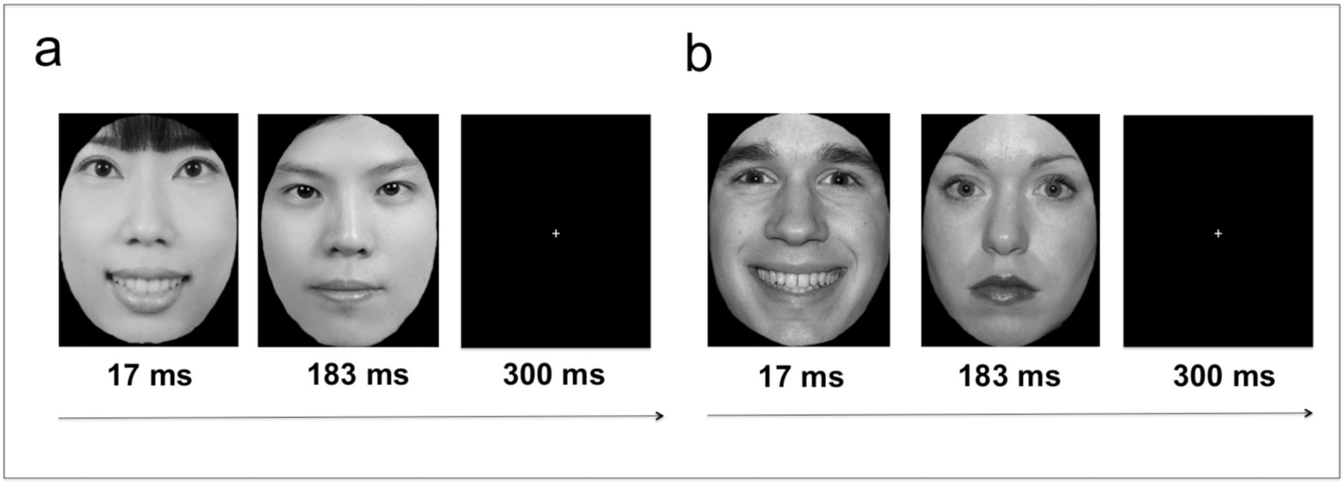

Figure 1.
Examples of (a) an in-group masked-face trial and (b) an out-group masked-face trial. Each trial began with an emotional face (target) presented for 17 ms, followed by a 183 ms neutral face (mask) and a 300 ms ISI fixation.

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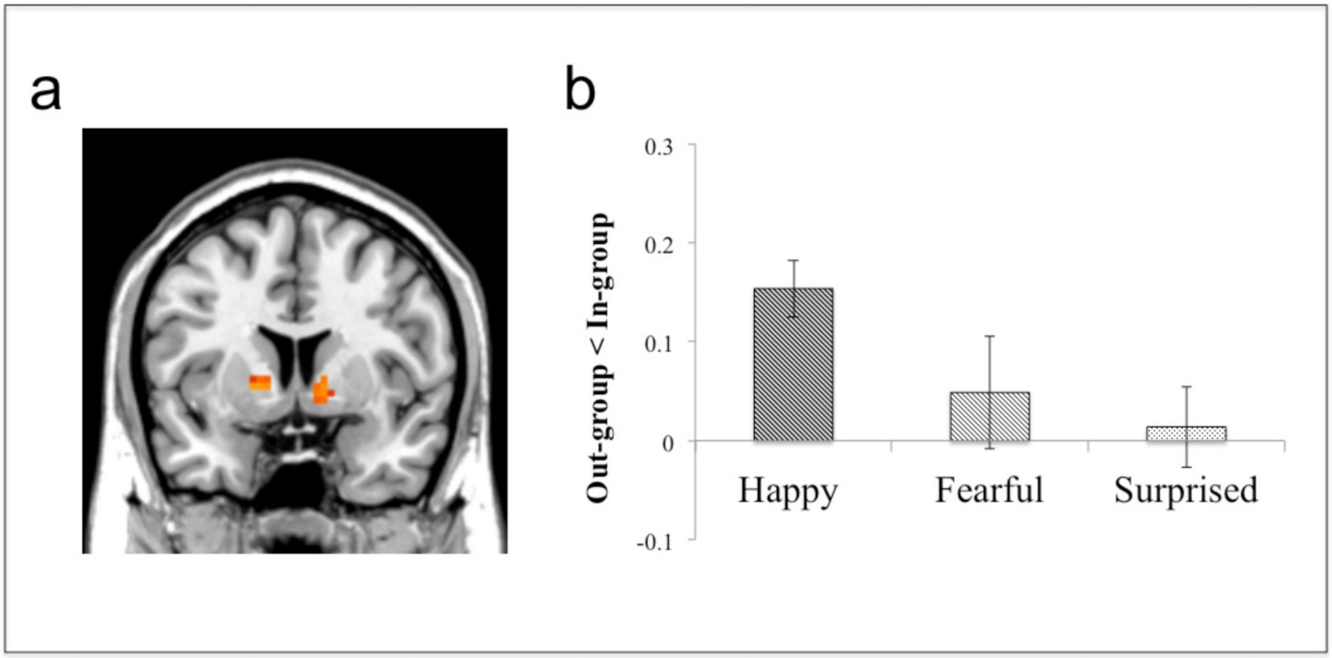

Figure 2.
Main effect of Group. (a) The VS showed significant differences between in-group and out-group expressions (across all three types of expressions). (b) Parameter estimate difference scores to compare in-vs.-out-group happy expressions were greater than the comparison of surprised expressions, but not greater than the comparison of fearful expressions.

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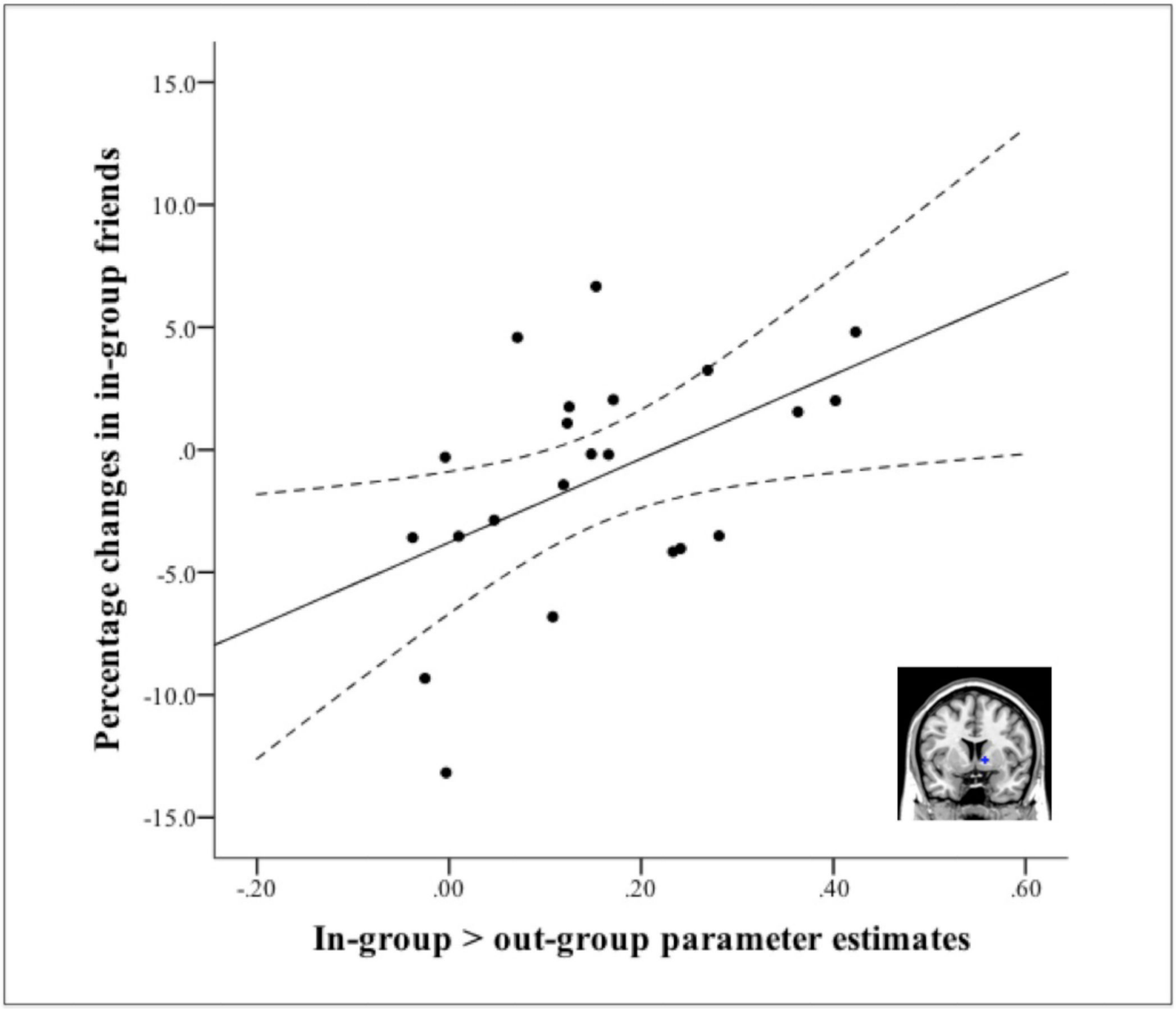

Figure 3.
Individual differences in in-group reward reactivity predict percentage changes in in-group friends after six months. X-axis indicates parameter estimate difference scores for the comparison of in-group vs. out-group happy expressions. Y-axis indicates changes in the percentage of in-group friends. Dashed lines indicated the 95 % confidence intervals.

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Table 1

Brain regions showing in the whole-brain ANOVA

				Coordinates		
Brain Region	**Side**	**No. of voxels**	***Z***	***x***	***y***	***z***
Interaction effect						
No supra-threshold activation						
Main effect of Expression						
No supra-threshold activation						
Main effect of Group						
Inferior temporal gyrus	R	127	4.96	48	−72	−3
Cerebellum	L	171	4.57	−12	−84	−30
	R	75	3.93	36	−66	−30
Ventral Striatum	R	47	4.40	12	6	0
	L	67	4.17	−18	−3	6
Inferior occipital gyrus	L	59	3.84	−42	−72	−3

Note: Regions showing significant differences ($P < 0.05$, corrected) between in-group and out-group expressions are listed along with their locations. Coordinates are in Montreal Neurological Institute (MNI) stereotaxic space.