Romantic feedbacks influence self-relevant processing: the moderating effects of sex difference and facial attractiveness

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Abstract

Previous works have shown that social rejection influences self-relevant processing. However, it remains unclear how romantic rejection influences self-relevant processing. In addition, men and women show different mate preferences, and facial attractiveness plays an important role in mate selection. The current study investigated how romantic feedbacks influence self-relevant processing and how sex difference and facial attractiveness moderate this process. After receiving social feedback of rejection or acceptance from 30 opposite-sex individuals, 51 men and 54 women completed the label–shape pair trials in which they judged whether shapes (triangle, circle, square) and labels ("self," "friend," "stranger") were matched or mismatched. The results showed that romantic rejection inhibited women's self-processing advantage by improving their response accuracy for matching the friend-label, which was positively associated with their score for perceived social support. By contrast, men rejected by women with high facial attractiveness improved their response accuracy for matching the self-label. Women improved their response accuracy for matching the friend-label not only when rejected by men with high facial attractiveness but also when accepted by men with low facial attractiveness. The results indicate that sex difference and facial attractiveness together moderate the influence of romantic feedback on self-relevant processing, which may be associated with sex differences in mating preferences and response to social threat.

Keywords Social feedback · Romantic rejection · Sex differences · Facial attractiveness · Self-relevant processing

Introduction

Humans need to build and maintain intimate relationships with others (Miller, 2015). Being unable to do so can threaten one's mental health and social adaptation. The mate relationship is an important type of intimate relationship (Miller, 2015). In the process of trying to build a mate relationship, an individual may be rejected by someone of the opposite sex,

which can negatively affect their physiological state and behavior. For example, individuals exhibited greater cortisol reactivity when responding to rejection (Ford & Collins, 2010) and increased aggressive behavior (Blake et al., 2018; Stratmoen et al., 2018); rejection by an opposite-sex individual compared with a same-sex individual had a greater negative impact on self-esteem (Zhang et al., 2018) and resulted in more self-blaming attributions (Ford & Collins, 2010). Others' attitudes toward and evaluations of oneself can strongly influence self-cognitive processing, including the self-processing advantage (Guan et al., 2015). Generally, the self-processing advantage entails recognizing or recalling self-relevant stimuli faster or more accurately, and with self-relevant stimuli eliciting enhanced brain activity relative to other-relevant stimuli (Northoff et al., 2006). Many self-relevant processing paradigms are used to study the self-processing advantage, such as the self-face recognition task, self-referential processing task, and self-relevant label–shape pair trials (Ma & Han, 2010; Northoff et al., 2006; Sui et al., 2012). The self-processing advantage is an important indicator of mental health because it reflects positive self-concept. Rejection by an opposite-sex individual with whom one wants

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to establish a mate relationship may impact on the self-processing advantage, thereby causing mental problems and social maladjustment and negatively affecting subsequent mate selection (Blake et al., 2018; Ford & Collins, 2010; Stratmoen et al., 2018; Zhang et al., 2016; Zhang et al., 2018). Hence, investigating how romantic rejection affects self-relevant processing has great significance. However, though a previous study has found that expressions of social rejection (e.g., angry face) could inhibit the self-face processing advantage (Guan et al., 2015), it remains unclear how romantic rejection influences the self-processing advantage.

Previous studies have suggested differences in self-relevant processing between men and women. Women are more likely to describe themselves in terms of connectedness to others, whereas men tend to describe themselves in terms of separateness from others (Lyons, 1983; Pratt et al., 1990; Stern, 1990). Men are more likely to develop an independent self-construal, whereas women tend to develop an interdependent self-construal (Cross & Madson, 1997; Wang et al., 2011). Target P3 amplitude, a positive amplitude of event-related potential (ERP) over the parietal area and supposed to reflect the function of the orienting attentional system for detecting rare and meaningful events (Herrmann & Knight, 2001; Polich, 2007), was larger for self-face than for mother-face and father-face in men but not in women (Wang et al., 2011). In addition, men and women also show different behavioral tendencies after suffering a social threat, with women more inclined to increase their collective behaviors (Williams & Sommer, 1997). Following a romantic rejection, men behaved more aggressively (Blake et al., 2018; Stratmoen et al., 2018) whereas women lowered their mate selection criteria to improve their chances of being accepted (Zhang et al., 2016). However, whether men and women respond differently to self-relevant processing following social rejection (e.g., rejection by an opposite-sex individual in mate selection) is not yet fully understood.

The needs-threat model suggests that individuals' response to social rejection depends on whether their relational needs (belongingness and self-esteem) or efficacy needs (control and meaningfulness) is threatened (Williams, 1997, 2007). For example, individuals tend to feel sad and show prosocial behaviors when their relational needs are thwarted, but tend to feel angry and show antisocial behaviors when their efficacy needs are frustrated (Warburton et al., 2006; Williams, 2007; Yang et al., 2017). In a previous study exploring the sex difference in needs-threat and self-relevant processing following social rejection, social ostracism inhibited attention to self in women by thwarting their relational needs but increased attention to self in men by frustrating their efficacy needs (Wang & Tu, 2014). Another study found that a socially rejective face (e.g., angry face) inhibited the self-face processing advantage by enhancing friend-face processing (Guan et al., 2015), which may reflect the tendency to seek social support from important others. It seems that paying more attention to important others may be associated with seeking both belongingness and social support, especially after social rejection.

Based on these findings, we hypothesize that sex difference may moderate the influence of romantic rejection on the self-processing advantage. For women, being rejected by an opposite-sex individual could threaten relational needs, which may decrease the self-processing advantage by shifting more attention to important others in search of belongingness and social support; for men, being rejected by an opposite-sex individual could threaten efficacy needs, which may increase attention to self-relevant information to improve meaningfulness, such that the self-relevant processing advantage still appears.

Facial attractiveness plays an important role in attempting to establish an intimate relationship with a potential mate (Miller, 2015). Individuals tend to be attracted to people with high facial attractiveness (Nisbett & Wilson, 1977), with even babies showing a preference for highly attractive faces (Langlois et al., 2000). It is usually believed that highly attractive people have more good qualities (Hughes & Miller, 2016). Attractive people have been found to date more than unattractive people (Berscheid et al., 1971). Opinions differ on whether facial attractiveness is equally important for men and women in mate selection. Several studies suggest that facial attractiveness plays a different role in mate selection for men and women. Sexual strategies theory, based on an evolutionary perspective (Buss & Schmitt, 1993), proposes that men prefer physically attractive women (associated with fertility and reproductive value) in both long- and short-term mate selection, whereas women prefer men with wealth and high social status (associated with providing resources). Conversely, some studies suggest that physical attractiveness is crucial to both women and men during exposure to the opposite sex. Viewing attractive women's faces increased men's desire to show off their status (Otterbring, 2018). Moreover, the late slow wave, a positive component of ERP within the time window of 200–650 ms, was increased when men viewed attractive women's faces, which signifies heightened processing linked to motivated attention (van Hooff et al., 2011). Similarly, women prefer contact with handsome men: for example, they are willing to spend money on healthy foods when exposed to attractive (versus unattractive) men (Otterbring, 2018). It thus appears that facial attractiveness may be important for both men and women in deciding whether to date an opposite-sex individual, especially when this decision is only based on appearance.

In addition, the facial attractiveness of opposite-sex individuals moderates the response following rejection. For example, women's interest in meeting unattractive men reduced after rejection by attractive men, but their interest in meeting attractive men was not influenced by feedback from unattractive men (MacDonald et al., 2015); when rejected by

physically attractive women, men became more aggressive (Blake et al., 2018). It seems that rejection by an opposite-sex individual with high (relative to low) facial attractiveness has a stronger influence on individual behaviors for both men and women. Considered together, these findings lead us to hypothesize that sex difference and facial attractiveness both moderate the influence of romantic rejection on self-relevant processing. After being rejected by an attractive opposite-sex individual, women may pay more attention to important others to seek belongingness and social support, while men may pay more attention to self-relevant information to improve their meaningfulness.

Previous studies have mostly focused on how high attractiveness facilitates the process of building an intimate relationship with an opposite-sex individual. However, it remains unclear whether positive social feedback from a facially unattractive opposite-sex individual in the course of mate selection affects self-relevant processing, and whether sex difference moderates this effect. In daily life, individuals often encounter opposite-sex individuals they perceive as unattractive, some of whom might make romantic advances toward them; it is, therefore, worth exploring how the romantic advances of an unattractive opposite-sex individual influence the self-relevant processing of both men and women. People usually believe that unattractive appearance is associated with more bad qualities, which refers to the reverse halo effect (Griffin & Langlois, 2006; Hughes & Miller, 2016), and viewing images of unattractive faces elicited strongly negative emotions such as disgust and fear (Shanmugarajah et al., 2012; Stone & Potton, 2014). Elliot (2008) indicates that individuals usually exhibit an approach orientation to stimuli evaluated as positive and an avoidance orientation to stimuli evaluated as negative.

It is likely that receiving positive feedback from an unattractive opposite-sex individual in mate selection may negatively influence self-relevant processing. Building a mate relationship with an unattractive opposite-sex individual could increase the number of men's offspring, even though they prefer women with high facial attractiveness, whereas women's smaller reproductive potential leads them to carefully select a favorite mate (Buss, 2015; Buss & Schmitt, 1993). Given that women may tend to avoid the romantic advances of unattractive opposite-sex individuals, we hypothesize that positive feedback from such individuals may influence the self-relevant processing of women but not men, and that women will also subsequently pay more attention to important others to seek belongingness and social support.

The current study tests these hypotheses by examining whether sex difference and facial attractiveness together moderate the influence of romantic feedback on self-relevant processing. A social feedback paradigm was used to induce conditions of rejection (20 rejection feedbacks and 10 acceptance feedbacks) and acceptance (20 acceptance feedbacks and 10 rejection feedbacks) (MacDonald et al., 2015; Somerville

et al., 2010; Vanderhasselt et al., 2018). To measure the self-processing advantage, we use a perceptual matching paradigm (Sui et al., 2012; Sui & Gu, 2017), which can effectively avoid the interference of familiarity and has been used in previous studies of self-cognitive processing (Sui et al., 2015; Sui & Gu, 2017). Specifically, participants indicated whether shapes (triangle, circle, square) and labels ("self," "friend," "stranger") were matched or mismatched after learning the associations between them. Men and women completed the label–shape pairs trials after receiving social feedbacks (rejection or acceptance) from opposite-sex individuals.

Methods

Participants

We recruited 105 healthy Chinese undergraduate and graduate heterosexual students (51 men and 54 women, mean age = 21.47 years, SD = 2.19 years) as paid volunteers. Participants were assigned randomly to the four groups: acceptance by opposite-sex individuals with high facial attractiveness (14 men, 14 women, mean age = 22.07 years, SD = 2.09 years); acceptance by opposite-sex individuals with low facial attractiveness (13 men, 14 women, mean age = 20.96 years, SD = 1.91 years); rejection by opposite-sex individuals with high facial attractiveness (13 men, 14 women, mean age = 21.59 years, SD = 2.36 years); and rejection by opposite-sex individuals with low facial attractiveness (11 men, 12 women, mean age = 21.17 years, SD = 2.35 years). A sensitivity power analysis for a three-way analysis of variance (ANOVA) with two between-subjects variables – social feedback priming (rejection vs. acceptance) and sex (men vs. women) – and one within-subjects variable – label (self vs. friend) – was conducted in G*Power (Faul et al., 2007; alpha = 0.05, power = 0.80, group = 4), with a minimum expected effect size of f = 0.164. The number of participants (χ^2 = 0.100, p = 0.751) and the ratio of men to women (χ^2 = 0.032, p = 0.999) did not significantly differ between the four groups. None of the participants had any previous experience of similar tasks. All participants were single, right-handed and had normal or corrected-to-normal visual acuity. Participants provided written informed consent before participation, and the ethics committee of Northeast Normal University approved the research.

Materials

The stimuli were displayed on 14-in. Dell monitor with a 60-Hz refresh rate and a screen resolution of 1024 × 768 pixels. The software package E-prime 2.0 was used to present the stimuli and collect the data.

Facial Stimuli

We selected 311 pictures with oriental male or female faces from the Chinese Academy of Sciences-Pose, Expression, Accessories, and Lighting (CAS-PEAL) database (Gao et al., 2008), the Chicago Face Database (Ma et al., 2015), and Baidu pictures (https://image.baidu.com/, a commonly used website in China) with a neutral or smiling expression and their bodies, heads, and eyes centered in the image. Photoshop CS6 was used to process these pictures. Each picture was grayscale with a white background and presented at 352 × 400 pixels. All pictures were calibrated to ensure consistent brightness and contrast. We asked 20 men and 20 women who did not participate in the formal experiment to score the attractiveness of each opposite-sex face on an 8-point scale from 1 ("very unattractive") to 8 ("very attractive"). Based on those ratings, we selected 30 pictures as high-attractive faces and 30 pictures as low-attractive faces for each sex. The attractiveness scores of the high-attractive faces (men: 4.54 ± 0.30; women: 5.13 ± 0.32) were significantly higher than those of the low-attractive faces (men: 1.36 ± 0.06; women: 1.39 ± 0.08) (all $ps < 0.001$).

Shapes and Labels for Matching Task

Three geometric shapes (triangle, circle, and square) were assigned to labels representing three people ("self," "friend," and "stranger"). The visual angles of shapes, labels, and the fixation cross were $3.8° × 3.8°$, $3.1°/3.6° × 1.6°$, and $0.8° × 0.8°$, respectively.

Perceived Social Support Scale

Perceived level of social support was measured using the perceived social support scale (Blumenthal et al., 1987). This scale comprises 12 items, such as "There is a special person who is around when I am in need." Participants rated the items on a 7-point Likert scale from 1 ("strongly disagree") to 7 ("strongly agree"). Cronbach's α was 0.883 in this study.

Procedure

Participants were initially informed that this was a study about first impressions and mate selection. A week before the experiment, we asked participants for a photo of themselves and told them that after evaluating their facial attractiveness, 30 opposite-sex individuals would decide whether they wanted to be their girlfriend/boyfriend. In the formal experiment participants first evaluated their own facial attractiveness. After receiving social feedbacks from 30 opposite-sex individuals (social feedback paradigm), participants reported the extent to which they felt rejected on a 10-point scale, ranging from 1 ("totally accepted") to 10 ("totally rejected"). They then

completed perceptual match pairs. Finally, participants were asked to complete the perceived social support scale. Before leaving experiment venue, participants were debriefed in detail about the true purpose of the experiment.

Social Feedback Paradigm

The social feedback paradigm (MacDonald et al., 2015; Somerville et al., 2010) comprised 30 trials with each trial including social feedback from a person of the opposite sex with high or low facial attractiveness. Participants mainly received positive social feedback (20 out of 30 trials) in the acceptance condition, whereas they mainly received negative social feedback (20 out of 30 trials) in the rejection condition (Vanderhasselt et al., 2018).

In each trial, participants first rate the facial attractiveness of an opposite-sex individual ("How attractive do you think he/she is?") on an 8-point scale from 1 ("very unattractive") to 8 ("very attractive"). Participants then had to respond "yes" or "no" to the question, "Do you want to be his/her girlfriend/boyfriend?" They responded by pressing the appropriate key with their left or right index finger, and then their answer was displayed on the left side of the screen (3 s). Subsequently, the response of the opposite-sex individual to the same question (referring to the respondent) was displayed on the right of the screen (3 s, inside a square). Participants were then asked to respond "yes" or "no" to the question, "Did he/she want to be your boyfriend/girlfriend?" This final question served to ensure that participants understood the feedback (see Fig. 1a).

Perceptual Matching Paradigm

We used the perceptual matching paradigm to test the self-processing advantage (Sui et al., 2012). In the task, three geometric shapes (triangle, square, and circle) were separately associated with three labels ("self," "friend," and "stranger"). The association was counterbalanced across participants. To become familiar with the experimental task, participants were asked to complete 12 practice trials before the test. The formal task included 360 trials divided into three blocks. There were 60 trials for each condition (self-matched, self-mismatched, friend-matched, friend-mismatched, stranger-matched, stranger-mismatched). In each trial, a white fixation cross appeared at the center of the screen for 500 ms. A shape and a label were then displayed together for 100 ms, followed by a blank screen with a duration of 800–1200 ms (randomly varied) during which participants were asked to judge whether the shape and label were correctly matched by pressing one of two assigned keys with their left or right index finger. Finally, the feedback of "Correct" (correct response), "Mistake" (wrong response), or "Too late" (no response) was displayed for 500 ms (see Fig. 1b).
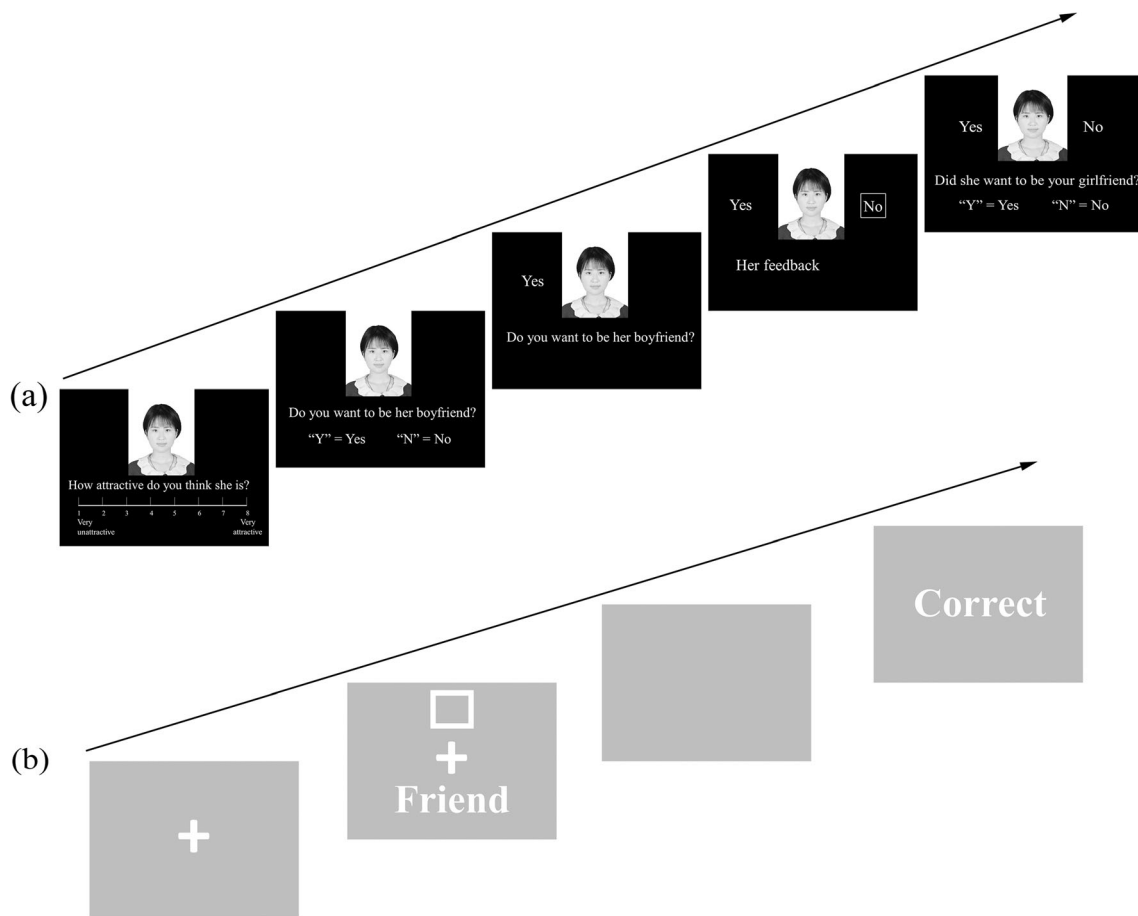
Fig. 1 (a) Illustrations of the experimental stimuli and procedure for the social feedback paradigm (b) Illustrations of the experimental stimuli and procedure for the perceptual matching paradigm

Results

Subjective Report of Rejection during the Priming Task

The results are provided in the Supplementary Results. In the current study, Bonferroni adjustment was used for multiple comparisons in post-hoc tests.

Effects of Social Feedback Priming and Sex on the Self-Processing Advantage

To examine how social feedback priming and sex influenced self-processing advantage, the self-processing advantage in response accuracy (self-label accuracy minus friend-label accuracy) and the self-processing advantage in reaction time (friend-label reaction time minus self-label reaction time) were subjected to separate three-way ANOVAs with social feedback priming (rejection vs. acceptance) and sex (men vs. women) as between-subjects variables, and with match pairs (match vs. mismatch) as a within-subjects variable.

Self-Processing Advantage in Response Accuracy

Table 1 shows the mean self-processing advantage in response accuracy of men and women in the acceptance and rejection conditions. The interaction effect between social feedback priming and sex was significant [$F (1, 101) = 6.462$, $p = 0.013$, $\eta_p^2 = 0.060$]. Post-hoc analysis showed there was no significant difference between men and women ($M_{diff} = -0.019$, $SE = 0.026$, $p = 0.476$, 95% CI [-0.071, 0.033], $t (53) = -0.717$, Cohen's $d = 0.193$) in the acceptance condition, while the self-processing advantage was greater in men than in women ($M_{diff} = 0.073$, $SE = 0.024$, $p = 0.005$, 95% CI [0.023, 0.122], $t (39) = 2.945$, Cohen's $d = 0.834$) in the rejection condition. For men, there was no significant difference in the self-processing advantage between the acceptance and rejection conditions ($M_{diff} = -0.044$, $SE = 0.029$, $p = 0.141$, 95% CI [-0.103, 0.015], $t (49) = -1.498$, Cohen's $d = 0.420$), whereas for women the self-processing advantage after being rejected was significantly lower than that after being accepted ($M_{diff} = 0.047$, $SE = 0.021$, $p = 0.028$, 95% CI [0.005, 0.089], $t (52) = 2.262$, Cohen's $d = 0.616$) (see Fig. 2). Additional results are provided in the Supplementary Results.

Table 1 Mean self-processing advantage in response accuracy (%) and reaction time (ms) of men and women in the acceptance and rejection conditions

		Response accuracy		Reaction time	
	Match pairs	Acceptance (SD)	Rejection (SD)	Acceptance (SD)	Rejection (SD)
Men	Match	0.121±0.169	0.165±0.173	81.971±85.447	94.955±80.663
	Mismatch	0.037±0.103	0.081±0.102	35.588±38.136	48.267±34.855
Women	Match	0.136±0.124	0.076±0.116	86.721±58.348	79.379±57.060
	Mismatch	0.058±0.104	0.026±0.098	36.164±29.720	36.789±28.837

Self-Processing Advantage in Reaction Time

Table 1 shows the mean self-processing advantage in reaction time of men and women in the acceptance and rejection conditions. There was no significant interaction effect between social feedback priming and sex. Further details are provided in the Supplementary Results.

The Effects of Social Feedback Priming and Sex on Self-Label Processing and Friend-Label Processing

To further examine whether being rejected weakened the self-processing advantage by inhibiting self-label processing or boosting friend-label processing, response accuracy and reaction time were subjected to separate four-way ANOVAs with social feedback priming (rejection vs. acceptance) and sex (men vs. women) as between-subjects variables, and with match pairs (match vs. mismatch) and label (self vs. friend) as within-subjects variables.

Response Accuracy

Table 2 shows the mean response accuracy of self-label and friend-label processing for men and women in the acceptance and rejection conditions. There was a
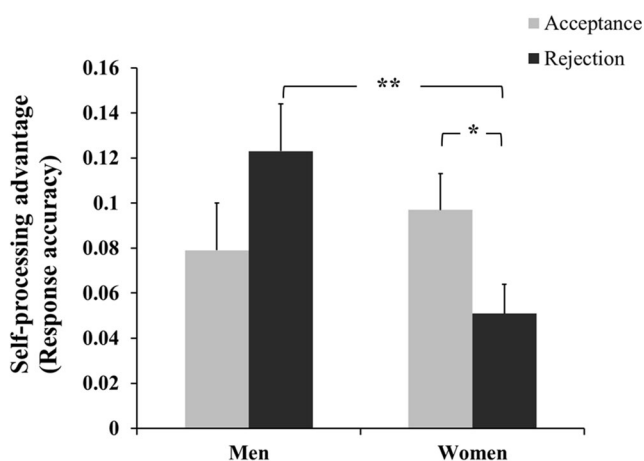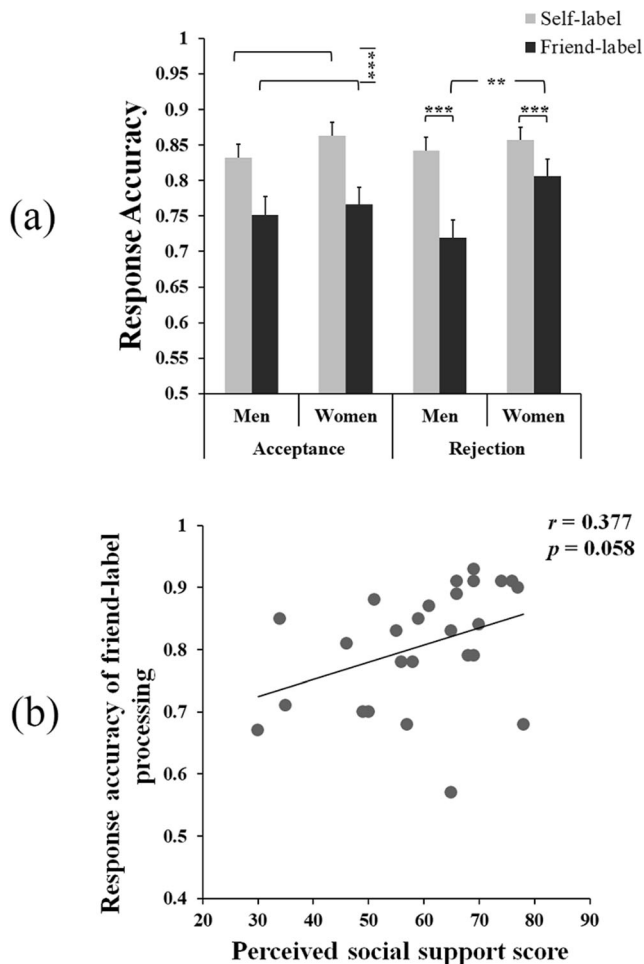

Fig. 2 Results for the self-processing advantage in response accuracy, Error bars represent standard errors. $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

significant interaction effect among social feedback priming, sex, and label [F (1, 101) = 6.462, $p = 0.013$, $\eta_p^2 = 0.060$] (see Fig. 3a). To further reveal the influence of social feedback priming and sex on self-label and friend-label processing, we conducted separate two-way ANOVAs with sex (men vs. women) as a between-subjects variable and with label (self vs. friend) as a within-subjects variable for the acceptance condition and rejection condition. In the acceptance condition, we only found a significant main effect of label [F (1, 53) = 46.239, $p < 0.001$, $\eta_p^2 = 0.466$], suggesting that the accuracy of self-label processing ($M = 0.851$, $SE = 0.012$) was higher than that of friend-label processing ($M = 0.763$, $SE = 0.017$). The main effect of sex [F (1, 53) = 0.333, $p = 0.566$, $\eta_p^2 = 0.006$] and the interaction effect between sex and label [F (1, 53) = 0.515, $p = 0.476$, $\eta_p^2 = 0.010$] were not significant. In the rejection condition, the results showed a significant main effect of label [F (1, 48) = 51.141, $p < 0.001$, $\eta_p^2 = 0.516$], suggesting that the accuracy of self-label processing ($M = 0.850$, $SE = 0.014$) was again higher than that of friend-label processing ($M = 0.763$, $SE = 0.017$). The main effect of sex was marginally significant [F (1, 48) = 3.233, $p = 0.078$, $\eta_p^2 = 0.063$], suggesting that women ($M = 0.832$, $SE = 0.020$) tended to show better response accuracy than men ($M = 0.781$, $SE = 0.020$). There was a significant interaction effect between label and sex [F (1, 48) = 8.958, $p = 0.004$, $\eta_p^2 = 0.157$]. Post-hoc analysis showed that in the rejection condition, men and women did not show significantly different response accuracy in self-label processing ($M_{diff} = 0.014$, $SE = 0.027$, $p = 0.600$, 95% CI [−0.040, 0.069], t (48) = 0.528, Cohen's $d = 0.150$), but women showed better response accuracy than men in friend-label processing ($M_{diff} = 0.087$, $SE = 0.034$, $p = 0.013$, 95% CI [0.019, 0.155], t (48) = 2.578, Cohen's $d = 0.730$). The accuracy of self-label processing was higher than that of friend-label processing for both men ($M_{diff} = 0.123$, $SE = 0.021$, $p < 0.001$, 95% CI [0.080, 0.166], t (23) = 5.904, Cohen's $d = 0.971$) and women ($M_{diff} = 0.050$, $SE = 0.013$, $p = 0.001$, 95% CI [0.023, 0.077], t (25) = 3.830, Cohen's $d = 0.569$). Additional results are provided in the Supplementary Results.

Table 2 Mean response accuracy (%) and mean reaction time (*ms*) of processing self-label and friend-label for men and women in the acceptance and rejection conditions

Feedback	Sex	Match pair	Label	Response accuracy (SD)	Reaction time (SD)
Acceptance	Men	Match	Self-label	0.890 ± 0.096	483.786 ± 88.334
			Friend-label	0.769 ± 0.178	565.757 ± 75.656
		Mismatch	Self-label	0.786 ± 0.130	596.429 ± 73.400
			Friend-label	0.750 ± 0.138	632.017 ± 65.859
	Women	Match	Self-label	0.914 ± 0.070	469.015 ± 53.429
			Friend-label	0.778 ± 0.137	555.736 ± 64.029
		Mismatch	Self-label	0.812 ± 0.122	573.718 ± 54.194
			Friend-label	0.754 ± 0.112	609.882 ± 57.022
Rejection	Men	Match	Self-label	0.889 ± 0.117	504.032 ± 60.967
			Friend-label	0.724 ± 0.183	598.986 ± 70.474
		Mismatch	Self-label	0.796 ± 0.126	595.480 ± 54.672
			Friend-label	0.715 ± 0.127	643.747 ± 53.444
	Women	Match	Self-label	0.905 ± 0.083	490.832 ± 62.151
			Friend-label	0.829 ± 0.125	570.211 ± 55.781
		Mismatch	Self-label	0.808 ± 0.110	577.721 ± 58.941
			Friend-label	0.783 ± 0.114	614.510 ± 56.588

Fig. 3 (a) Response accuracy (b) Correlation analysis between the perceived social support score and the response accuracy of friend-label processing for women in the rejection condition. Error bars represent standard errors. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Reaction Time

Table 2 shows the mean reaction times of self-label and friend-label processing for men and women in the acceptance and rejection conditions. There was no significant interaction effect among social feedback priming, sex, and label. Further details are provided in the Supplementary Results.

Correlations

To further test whether the increased attention to friend-label processing in the rejection condition was associated with women's tendency to seek social support, we performed Pearson correlation analyses between the perceived social support score and the response accuracy of friend-label processing. The results showed a marginally significant positive correlation ($r = 0.377$, $p = 0.058$) (see Fig. 3b), suggesting that the more women perceive social support, the more attention they tend to pay to friend-labels after being rejected by opposite-sex individuals. Additional results are provided in the Supplementary Results.

Moderating Effect of Facial Attractiveness

To further test whether facial attractiveness moderated the effects of social feedback on the response accuracy of self-label and friend-label processing by for men and women, we conducted moderation analyses using PROCESS 3.3. So as to exclude the influence of participants' own facial attractiveness, we used the relative facial attractiveness of opposite-sex individuals (opposite-sex individual's facial attractiveness minus participant's own facial attractiveness). To reduce

collinearity among variables, the score of relative facial attractiveness was standardized and the social feedback variable (0 = rejection, 1 = acceptance) and sex variable (0 = women, 1 = men) were dummy coded.

Moderating Effect of Facial Attractiveness on the Relationship between Social Feedback and Response Accuracy

We first conducted a simple moderation using Hayes' Model 1 (Hayes, 2018) with social feedback as the predictor, response accuracy to the self-label or friend-label as outcome variables, and facial attractiveness as the moderator for men and women, respectively (see Fig. 4a). As illustrated in Table 3 and Fig. 4b, there was a significant moderating effect of facial attractiveness on the relationship between social feedback and response accuracy to the self-label in men. For men, neither social feedback priming ($\beta = -0.010$, $SE = 0.028$, t (47) = -0.351, $p = 0.727$, 95% CI [-0.067, 0.047]) nor facial attractiveness ($\beta = 0.020$, $SE = 0.014$, t (47) = 1.372, $p = 0.177$, 95% CI [-0.010, 0.048]) were significantly related to the response accuracy of self-label processing. The interaction between social feedback priming and facial attractiveness negatively predicted the response accuracy of self-label processing ($\beta = -0.061$, $SE = 0.028$, t (47) = -2.155, $p = 0.036$, 95% CI [-0.118, -0.004]). Simple slope analyses

showed that the relationship between social feedback priming and the accuracy of self-label processing was not significant ($B_{simple} = 0.051$, $SE = 0.040$, t (47) = 1.291, $p = 0.203$, 95% CI [-0.029, 0.131]) when men received feedbacks from unattractive opposite-sex individuals (mean - 1SD), while this relationship was negative and marginally significant ($B_{simple} = -0.071$, $SE = 0.040$, t (47) = -1.767, $p = 0.084$, 95% CI [-0.152, 0.010]) when men received feedbacks from attractive opposite-sex individuals (mean + 1SD) (see Fig. 4b). These results suggest that the response accuracy of self-label processing was marginally significantly higher in men rejected by attractive opposite-sex individuals than in men accepted by such individuals. By contrast, the moderating effect of facial attractiveness on the relationship between social feedback and the response accuracy of friend-label processing in men was not significant ($p > 0.322$). For women, facial attractiveness did not significantly moderate social feedback's relationship with self-label response accuracy or friend-label response accuracy ($ps > 0.144$).

Moderating Effects of Facial Attractiveness and Feeling Rejected

To further test whether facial attractiveness influenced the sex effect on self-relevant processing by moderating the feeling of

Table 3 Results for the moderating effect of facial attractiveness on the relationship between social feedback and the accuracies of processing labels

Sex	Outcome	Predictor	B	SE	t	p
Men	Self-label accuracies	Social feedback priming	−0.010	0.028	−0.351	0.727
		Evaluator's attractiveness	0.020	0.014	1.371	0.177
		Social feedback priming ×Evaluator's attractiveness	−0.061	0.028	−2.155*	0.036
		R^2	0.086			
		F	4.643			
	Friend-label accuracies	Social feedback priming	0.034	0.041	0.839	0.406
		Evaluator's attractiveness	0.021	0.021	1.001	0.322
		Social feedback priming ×Evaluator's attractiveness	−0.038	0.041	−0.915	0.365
		R^2	0.017			
		F	0.838			
Women	Self-label accuracies	Social feedback priming	0.006	0.022	0.277	0.783
		Evaluator's attractiveness	0.005	0.012	0.442	0.660
		Social feedback priming ×Evaluator's attractiveness	0.001	0.025	0.025	0.980
		R^2	0.000			
		F	0.001			
	Friend-label accuracies	Social feedback priming	−0.042	0.028	−1.484	0.144
		Evaluator's attractiveness	0.010	0.015	0.664	0.510
		Social feedback priming ×Evaluator's attractiveness	0.000	0.031	0.011	0.991
		R^2	0.000			
		F	0.001			

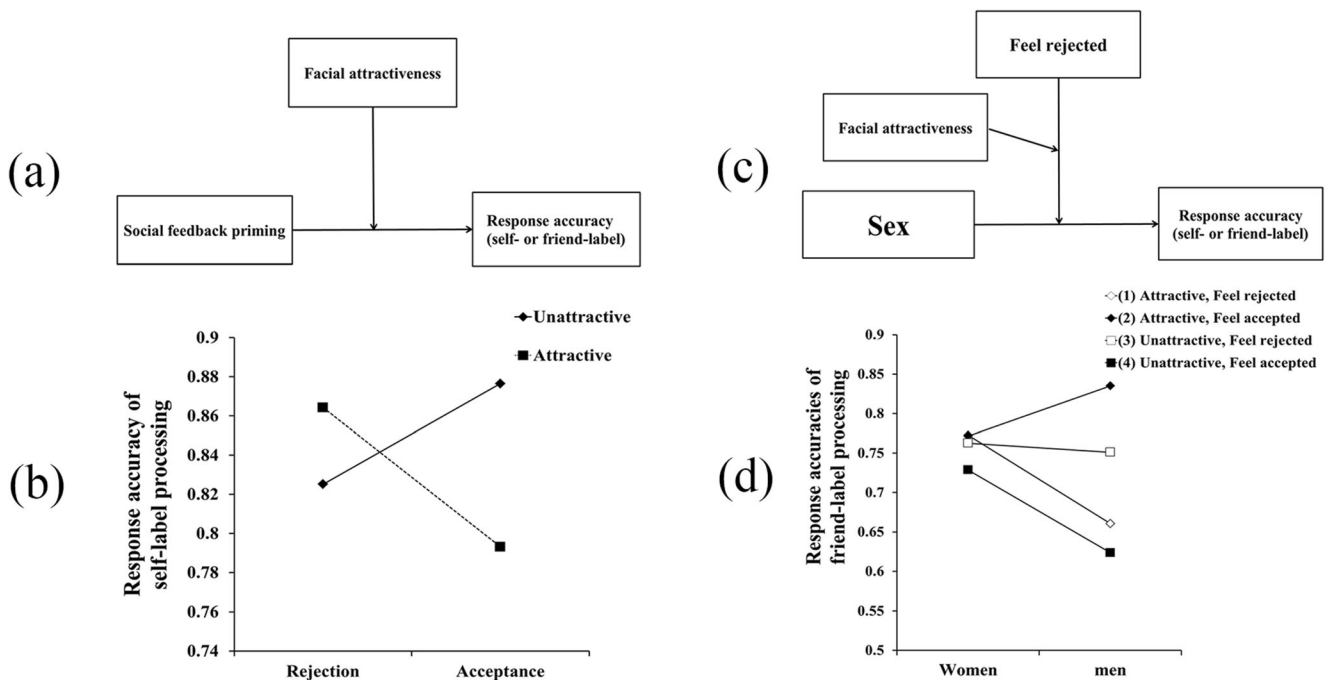note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fig. 4 (a) Conceptual diagram of simple moderation (b) Moderating effect of facial attractiveness on the relationship between social feedback and the response accuracy of self-label processing for men (c) Conceptual diagram of moderated moderation (d) Moderation by facial attractiveness of the moderating effect of feeling rejected on the relationship between sex and the response accuracy of friend-label processing

being rejected, we used a moderated moderation model to examine this effect through the PROCESS macro (Model 3; Hayes, 2018). In this moderated moderation model, feeling rejected (W) and facial attractiveness (Z) were the moderators, sex was the independent variable, and accuracy (of self-label or friend-label processing) was the dependent variable (see Fig. 4c).

As illustrated in Table 4 and Fig. 4d, there were no significant effects when the response accuracy of self-label processing was designated as the outcome variable ($ps > 0.114$). However, the three-way interaction of sex, feeling rejected, and facial attractiveness significantly negatively predicted the accuracy of friend-label processing ($\beta = -0.067$, $SE = 0.030$, $t(97) = -2.212$, $p = 0.029$, 95% CI [-0.128, -0.007]). Simple slope analyses showed that when participants felt accepted (mean $-$ 1SD) by opposite-sex individuals with high facial attractiveness (mean $+$ 1SD), there was no significant difference in the accuracy of friend-label processing between men and women ($B_{simple} = 0.063$, $SE = 0.057$, $t(97) = 1.112$, $p = 0.270$, 95% CI [-0.050, 0.177]), but when participants felt rejected (mean $+$ 1SD) by opposite-sex individuals with high facial attractiveness (mean $+$ 1SD), sex was significantly negatively correlated with the accuracy of friend-label processing ($B_{simple} = -0.112$, $SE = 0.049$, $t(97) = -2.300$, $p = 0.024$, 95% CI [-0.209, -0.015]), with women showing higher response accuracy than men. When participants felt accepted (mean $-$ 1SD) by opposite-sex individuals with low facial attractiveness (mean $-$ 1SD), sex was negatively correlated with the accuracy of friend-label processing ($B_{simple} = -0.105$, $SE =$

0.052, $t(97) = -2.016$, $p = 0.047$, 95% CI [-0.209, -0.002]), suggesting that women showed higher accuracy than men. However, when participants felt rejected (mean $+$ 1SD) by opposite-sex individuals with low facial attractiveness (mean $-$ 1SD), there was no significant difference in the accuracy of friend-label processing between men and women ($B_{simple} = -0.012$, $SE = 0.055$, $t(97) = -0.210$, $p = 0.834$, 95% CI [-0.121, 0.098]) (see Fig. 4d). These results indicated that facial attractiveness moderated the moderating effect of feeling rejected on the relationship between sex and the response accuracy of friend-label processing.

Discussion

The current work used a social feedback paradigm and a perceptual matching paradigm to test the hypothesis that sex difference and facial attractiveness together moderate the influence of romantic feedback on self-relevant processing. We evidenced that being rejected by opposite-sex individuals inhibited the self-processing advantage by diverting attention to important others in women. Furthermore, men tended to pay more attention to themselves after being rejected by opposite-sex individuals with high facial attractiveness. However, women paid more attention to important others not only after rejection by opposite-sex individuals with high facial attractiveness but also after acceptance by opposite-sex individuals with low facial attractiveness.

Table 4 Results for the moderation by facial attractiveness of the moderating effect of feeling rejected on the relationship between sex and the accuracy of label processing

Outcome	Predictor	B	SE	t	p
Self-label accuracies	Sex	−0.019	0.018	−1.012	0.314
	Feeling rejected	0.011	0.010	1.053	0.295
	Evaluator's attractiveness	0.012	0.009	1.304	0.196
	Sex × Feeling rejected	0.013	0.020	0.635	0.527
	Sex × Evaluator's attractiveness	0.015	0.018	0.796	0.428
	Feeling rejected ×Evaluator's attractiveness	−0.006	0.011	−0.552	0.582
	Sex × Feeling rejected × Evaluator's attractiveness	−0.036	0.023	−1.595	0.114
	R^2	0.025			
	F	2.545			
Friend-label accuracies	Sex	−0.041	0.025	−1.684	0.095
	Feeling rejected	0.009	0.013	0.664	0.509
	Evaluator's attractiveness	0.013	0.012	1.073	0.286
	Sex × Feeling rejected	−0.021	0.027	−0.764	0.447
	Sex × Evaluator's attractiveness	0.017	0.025	0.694	0.490
	Feeling rejected × Evaluator's attractiveness	−0.008	0.015	−0.541	0.590
	Sex × Feeling rejected × Evaluator's attractiveness	−0.067	0.030	−2.212[*]	0.029
	R^2	0.045			
	F	4.892			

note: [*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$

A previous study found that angry emotional faces as a negative social evaluation inhibited the self-face processing advantage by enhancing friend-face processing (Guan et al., 2015), but that study did not investigate the sex difference in this process or the effect of social rejection by opposite-sex individuals. The current study further revealed that romantic rejections from opposite-sex individuals weakened the self-processing advantage by increasing attention to friend-relevant information in women; this may reflect women's tendency to seek social support to satisfy their relational needs after being rejected by opposite-sex individuals. The needs-threat model suggests that social rejection may threaten individuals' relational needs (belongingness, self-esteem) and efficacy needs (control, meaningfulness) (Williams, 1997). A previous study further revealed that social rejection principally threatens women's relational needs, which they redress by diverting attention away from themselves (Wang & Tu, 2014). Although we did not find weakened processing of self-information, the enhancement of friend-information processing in the current study may also reflect women's need to seek belongness and social support from important others, especially after being rejected by opposite-sex individuals.

In addition, when people encounter social rejection, they tend to turn to important others to obtain emotional support and reduce stress, as friends are important resources for social support (Cohen et al., 1984). The present results showed a marginally significant positive correlation between rejected women's accuracy of friend-label processing and their perceived social support score ($r = 0.377$, $p = 0.058$), suggesting that the more women perceived social support, the more they tended to pay attention to the friend-label after being rejected by opposite-sex individuals. Hence, one possibility is that after such rejection, women need to enhance their close relations with friends to help them to reduce stress and satisfy relational needs. Therefore, they may become more sensitive and allocate more attentional resources to friend-relevant information.

Although rejection did not significantly affect self-relevant processing in men, facial attractiveness may have moderated this process. The results showed that, compared with being rejected by unattractive women, being rejected by attractive women tended to increase men's accuracy of self-label processing. The needs-threat model and previous studies indicate that social rejection primarily threatens men's efficacy needs (control and meaningfulness), such that social rejection leads men to pay more attention to themselves (Wang & Tu, 2014; Williams, 1997). It seems that enhanced attention to self-relevant information may reflect men's need to increase their sense of meaningfulness after being rejected by attractive opposite-sex individuals. For women, the results showed that the facial attractiveness of the opposite-sex individuals giving social feedback influenced their emotional and cognitive processing. Feeling rejected by an attractive opposite-sex individual, but not rejection per se, boosted the processing of friend-relevant information in women. This may reflect that

emotional feelings are more likely to affect women's subsequent cognition and behavioral responses (Beck et al., 2015; Zack et al., 2003). Specifically, relative to men, women tended to increase the response accuracy of friend-label processing when they felt rejected by attractive opposite-sex individuals, which may reflect that women need to increase their belongingness by seeking social support (Cohen et al., 1984; Williams, 1997). Therefore, being rejected, especially by attractive opposite-sex individuals, influenced both self-relevant and friend-relevant processing, but men and women showed different response strategies to rejection: men tended to enhance the processing of self-relevant information to increase their sense of meaningfulness, while women enhanced the processing of friend-relevant information to increase belongingness via social support.

Interestingly, the current work also revealed that women paid more attention to the friend-label when they felt accepted by unattractive opposite-sex individuals. Based on Elliot's (2008) approach–avoidance motivation theory, it is likely that women had a negative perception of unattractive opposite-sex individuals or even regarded them as threatening, as men are usually taller and stronger than women, which may lead women to tend to avoid unattractive opposite-sex individuals who make romantic advances toward them. Hence, when rejected by unattractive men, women would keep away from them as hoped, thus their self-relevant and friend-relevant processing were steady; but when accepted by unattractive men, women felt threatened and were inclined to increase their sense of belongingness by seeking social support, which led them to pay more attention to friend-relevant information. By contrast, acceptance by unattractive women did not influence men's self-relevant processing. Although men prefer attractive women, building romantic relationships with unattractive women could still increase the number of their offspring, whereas women tend to carefully select a favorite mate due to their smaller reproductive potential and huge parental investment compared to men (Buss, 2015; Buss & Schmitt, 1993). It is likely that women are more inclined than men to avoid the romantic advances of unattractive opposite-sex individuals, thus feeling accepted by unattractive men leads women to pay more attention to friend-relevant information. The results also suggested that individuals have the need to not only integrate into a group they like but also avoid a group they do not like. Whichever need is threatened, the self-relevant or other-relevant processing would be influenced.

Our current work extends the needs-threat model in the following respects. First, building on the model's proposal that individuals' response to social rejection depends on whether their relational need (belongingness and self-esteem) or efficacy need (control and meaningfulness) is threatened (Williams, 1997, 2007), we further revealed the effects of sex difference and facial attractiveness on social rejection, and found that being rejected by opposite-sex individuals, especially those considered attractive, men and women showed different responses to self-relevant information and friend-relevant information. Second, the finding that women rejected by attractive opposite-sex individuals and women accepted by unattractive opposite-sex individuals both paid more attention to the friend-label suggested that social rejection per se did not threaten women's relational need: in the case of unattractive opposite-sex individuals, acceptance (rather than rejection) may have actually posed the threat. Moreover, our results improve sexual strategies theory (Buss & Schmitt, 1993) by revealing that while both men and women prefer to be accepted than rejected by attractive opposite-sex individuals, women dislike being accepted by opposite-sex individuals with low facial attractiveness.

Our findings also have implications for how people respond to social rejection in their everyday life and how people behave in mate selection. When feeling threatened, whether by rejection by attractive men or acceptance by unattractive men, women paid more attention to friend-relevant information to seek social support; accordingly, establishing or maintaining reciprocal, close, and supportive interpersonal relationships with their important others might be a key way for women to buffer against the negative effect of social threat. For men, improving their sense of meaningfulness and control might be a suitable way to buffer against the negative effect of rejection by attractive women. Since women in our study did not want to be courted by unattractive men, men should not only focus on the pursuit of power and status but also pay attention to their appearance, which may increase their success in courting attractive women.

Although the attractiveness scores of the faces with high attractiveness (men: 4.535 ± 0.301; women: 5.127 ± 0.319) were significantly higher than those of the faces with low attractiveness (men: 1.358 ± 0.057; women: 1.392 ± 0.080) (all ps < 0.001), the former set of attractiveness scores were only slightly above the mid-point of the 8-point scale from 1 ("very unattractive") to 8 ("very attractive"). Accordingly, our study's results should be interpreted with caution. Also, as we conducted an experimental study in which the conditions could be controlled, the extent to which the experiment reflected the real situation of rejection in a romantic relationship is questionable. Our study was designed to closely simulate a real situation of rejection in a romantic relationship, with individuals required to decide whether to date an opposite-sex individual after exchanging photos, and facing the possibility of rejection. Another potential limitation of our findings is that the study's sample comprised only Chinese participants and the facial stimuli were all Asian faces. Individuals in different race groups have previously shown different racial preferences in facial attractiveness perception and mate selection (Fisman et al., 2008; Kleisner et al., 2017; Lin & Lundquist, 2013; Voegeli et al., 2021; Wade et al., 2004). Therefore, it would be worthwhile investigating how

romantic feedbacks from individuals with own-race faces and other-race faces influence self-relevant processing, and how sex difference and facial attractiveness moderate this process in different race groups, such as Caucasian and Afro-American.

In conclusion, the current research revealed the different responses to self-relevant processing between men and women after receiving romantic feedbacks, and the moderating effect of facial attractiveness. Following romantic rejections by women with high facial attractiveness, men tended to enhance the processing of self-relevant information to increase their sense of meaningfulness. However, both rejection by attractive men and acceptance by unattractive men led women to pay more attention to their important others to increase belongingness via social support. The dual mechanism for responding to romantic feedbacks between men and women may be an important survival advantage for humans.

Code Availability The software package E-prime 2.0 was used to present the stimuli and collect the data.

Author Contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Yang Xu, Yuan Yuan, Xiaochun Xie and Hui Tan. The first draft of manuscript was written by Yang Xu and Lili Guan. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics Approval and Consent to Participate Ethical board approval was obtained from Northeast Normal University. Informed consent was obtained from all individual participants included in the study. This article does not contain any studies with animals performed by any of the authors.

Cosent to Participate Informed consent was obtained from all individual participants included in the study.

Cosent to Publish The authors affirm that human research participants provided informed consent for publication of the images in Figure(s).

Declaration of Interests The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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