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Activations of the dorsolateral prefrontal cortex and thalamus during agentic self-evaluation are negatively associated with trait self-esteem

Ke Jiang^a, Shi Wu^a, Zhenhao Shi^b, Mingyan Liu^a, Maoying Peng^a, Yang Shen^a, and Juan Yang^a

^aFaculty of Psychology, Southwest University, Chongqing 400715, China

^bCenter for Studies of Addiction, Department of Psychiatry, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA 19104, USA

Abstract

Individual self-esteem is dominated more by agency than by communion. However, prior research has mainly focused on one's agentic/communal self-evaluation, while little is known about how one endorses others' agentic/communal evaluation of the self. The present study investigated the associations between trait self-esteem and fundamental dimensions of social cognition, i.e. agency vs. communion, during both self-evaluation and endorsement of others' evaluation of oneself. We also investigated the neural mechanisms underlying the relationship between trait self-esteem and agentic self-evaluation. Behavioral results revealed that self-esteem was positively correlated with the agentic ratings from self-evaluation and endorsement of others' evaluation of the self, and that the agentic self-evaluation was a significant full mediator between self-esteem and endorsement of others' agentic evaluation. Whole-brain regression analysis revealed that self-esteem was negatively correlated with right dorsolateral prefrontal and bilateral thalamic response to agentic self-evaluation. A possible interpretation is that low self-esteem people both hold a more self-critical attitude about the self and have less certainty or clarity of their self-concepts than high self-esteem people do. These findings have important implication for understanding the neural and cognitive mechanisms underlying self-esteem's effect on one's agentic self-evaluations.

Keywords

self-esteem; dorsolateral prefrontal cortex; thalamus; fundamental dimensions of social cognition; functional magnetic resonance imaging (fMRI)

1. Introduction

Self-esteem is an important part of the self and is closely related to self-evaluation (Rosenberg, 1965, Baumeister, 1998, Brown, 2014). In general, people with high self-esteem believe that they are superior to most others in many domains (Brown, 1986, Campbell, 1986) and evaluate themselves as highly positive across a variety of personality traits. For

example, they consider themselves intelligent, attractive, and popular (Baumeister et al., 2003) and believe that they are more capable, compassionate, creative, friendly, and well-liked than others (Brown, 1998). In contrast, low self-esteem involves negative evaluation of personality traits such as worthlessness, incompetence, and lack of value in relationships (Crocker and Park, 2004, Orth and Robins, 2013).

Personality traits can be categorized into two fundamental modalities: agency and communion (Abele and Wojciszke, 2007, Bakan, 1966, Rosenberg and Sedlak, 1972, Tausch et al., 2007). Specifically, agency concerns the intention to control the environment, to assert oneself, and to experience competence, achievement, and power. Communion, instead, concerns the desire to establish relationships, to cooperate, and to merge with others. In other words, agentic traits are those oriented to the self and related to goal-achievement (e.g. 'smart' and 'stupid'), whereas communal ones are about moral judgment and social connection (e.g. 'kind' and 'ruthless') (Abele and Bruckmüller, 2011, Diehl et al., 2004). Prior research has shown that trait self-esteem is dominated more by agentic self-views than by communal ones. In one study, when participants recalled autobiographical events that had affected their self-evaluation, they recalled information involving more agentic content than communal content (Wojciszke, 1994, Abele and Wojciszke, 2007, Wojciszke and Abele, 2008). In another study, when participants rated the self-descriptiveness either agentic or communal trait words, only the agentic rating scores were correlated with self-esteem, and such effect could not be accounted for by gender, age, or the type of self-esteem assessment (Wojciszke et al., 2011).

Despite consistent findings, prior research has mainly focused on agentic/communal self-evaluation where participants were instructed to reflect on themselves, while less is known about how they process other people's agentic/communal evaluation of them. It has long been suggested that self-esteem reflects the need for both self-respect and respect from others (Maslow et al., 1970). According to the sociometer theory, self-esteem is essentially an gauge of level of one's social acceptance and exclusion received from others (Leary and Baumeister, 2000, Leary et al., 1995). Moreover, Yang et al. (2016) identified distinct self-esteem-related neurocognitive mechanisms underlying self-evaluation and endorsement of others' evaluation of oneself, although this study did not distinguish between agency and communion. Therefore, it is important to gain a better understanding of how self-esteem is codetermined by trait category (agency vs. communion) and evaluative perspective (self-evaluation vs. endorsement of others' evaluation of oneself). In addition, despite existing behavioral research, the neural mechanisms underlying these processes remain elusive (e.g., Mende-Siedlecki et al., 2013, Swencionis and Fiske, 2014, Han et al., 2016a). Therefore, the aim of the present study was to integrate the behavioral and neuroimaging approach to the study of the mechanisms underlying the association between self-esteem and four different types of self-related processing: the agentic and communal self-evaluation (SA and SC), and the endorsement of others' agentic and communal evaluation of the self (OA and OC).

According to the self-verification theory, people preferentially seek, elicit, and recall feedback from others that can confirm their self-concepts, particularly in some important domains (Swann et al., 1990, Swann and Read, 1981). Given the link between self-esteem and agentic self-evaluation (e.g., Wojciszke, 1994, Abele and Wojciszke, 2007; Wojciszke

and Abele, 2008; Wojciszke et al., 2011), we hypothesized that self-esteem would also be associated with the way people endorse others' agentic evaluation of themselves.

As people with low self-esteem frequently hold negative self-views, it is likely that they are more self-critical than high self-esteem people during agentic self-evaluation (e.g., Blaine and Crocker, 1993, Gilbert and Procter, 2006, Heimpel et al., 2002, Katz and Nelson, 2007, Zuroff et al., 1983). Neuroscientific studies have shown that the neural activity of dorsolateral prefrontal cortex (dlPFC) is associated with self-criticism (e.g., Lord et al., 2012, Paulus and Stein, 2010). For example, Longe et al. (2009) found that self-critical thinking activated the dlPFC, and the intensity of the activation was positively correlated with self-reported self-criticism. Another study reported that self-critical materials yielded greater dlPFC activation compared with neutral materials (Doerig et al., 2014). Moreover, a virtual lesion over right dlPFC, achieved by a repetitive transcranial magnetic stimulation (rTMS), resulted in a less self-critical attitude towards the self (Heinisch et al., 2010). Therefore, we hypothesized that compared to high self-esteem individuals, those with low self-esteem would be more self-critical and have greater dlPFC activation during agentic self-evaluation.

Another characteristic of low self-esteem is reduced clarity of self-concept (Blaine and Crocker, 1993, Campbell, 1990, Campbell et al., 1996). Consequently, individuals with lower self-esteem may face greater uncertainty during agentic self-evaluation. Previous studies suggest that decision making under uncertainty requires greater attentional and cognitive effort (Feldman and Friston, 2010, Vickery and Jiang, 2009, Zaretsky et al., 2010) and need more sources of evidence to be taken into account (Camerer, 2003, Feltovich, 2000, Sutton and Barto, 1998). Meanwhile, it is known that the thalamus is involved in regulating cognitive effort and attention (e.g., Raeva, 2006, Schiff, 2008, Schiff et al., 2007, Schiff et al., 2013, Van der Werf et al., 2003). Therefore, we hypothesized that low self-esteem people would have a greater activation of the thalamus during agentic self-evaluation than high self-esteem people.

2. Results

2.1. Behavioral results

Participants' rating scores and reaction times (RTs) in each condition are listed in Table 1. Correlation analyses showed that participants' self-esteem scores were positively correlated with ratings of both agentic self-evaluation (SA: $r=0.68$, $p<0.001$) and endorsement of others' agentic evaluation of the self (OA: $r=0.59$, $p<0.001$). No such correlation was found for communal ratings (SC: $r=0.33$, $p>0.05$; OC: $r=0.22$, $p>0.05$) (Table 1). Results also showed that RTs were negatively correlated with the self-esteem scores in all conditions (SA/SC/OA/OC: $r=0.40/-0.43/-0.41/-0.39$, $ps<0.05$).

We conducted a mediation analysis to test the mediating effect of SA rating scores on the association between self-esteem and OA rating scores. The bias-corrected bootstrap sampling approach was used (Preacher and Hayes, 2004). Gender and age were entered as covariates of noninterest. All variables were mean-centered. Results showed that the SA rating scores fully mediated the effect of the self-esteem scores on the OA rating scores (Fig.

1). The correlation and mediation results suggest that compared to communal traits, self-esteem is more closely related to the processing - especially self-evaluation - of agentic traits.

2.2. fMRI results

The SC vs. SA contrast showed a significant activation of the medial prefrontal cortex. The OA vs. OC contrast showed a significant activation of the left supplementary motor area. No significant activation was found in the contrasts of SA vs. SC or OC vs. OA. (Fig. 2 and Table 2).

Given the behavioral evidence for a strong association between self-esteem and the agentic self-evaluation, we focused on the contrast of SA vs. Fixation in the whole-brain multiple regression analysis. We found that self-esteem scores were negatively correlated with activations of the dlPFC and bilateral thalamus in response to SA vs. Fixation (Fig. 3 and Table 3).

We conducted psychophysiological interaction (PPI) analyses to further investigate the roles of the dlPFC and bilateral thalamus in terms of their functional connectivity with other regions. Results showed greater dlPFC connectivity with the bilateral anterior insula, right lateral prefrontal cortex, and bilateral caudate (extending to thalamus) during the SA condition relative to Fixation (Fig. 4A and B). We also found stronger thalamic connectivity with the precuneus (extending to the right angular gyrus), left lateral temporal gyrus, ventral striatum, dlPFC and ventral anterior cingulate cortex during the SA condition compared to Fixation (Fig. 4C and D). In addition, a decreased connectivity between thalamus and postcentral gyrus was found during SA task relative to Fixation (Table 4).

3. Discussion

The overarching goals of our research were to investigate neurocognitive mechanisms underlying the relationships between self-esteem and two forms of agentic and communal processing: self-evaluation and endorsement of others' evaluation of oneself. Behavioral outcomes revealed that self-esteem was positively correlated with the agentic ratings from both perspectives, and that the SA rating was a full mediator between the self-esteem and the OA rating. The neuroimaging results showed that participants' self-esteem scores were negatively correlated with activations of dlPFC and bilateral thalamus in response to SA.

Our behavioral findings were consistent with the existing literature which has shown that self-esteem matters more to agentic content than to communal content of the self (Wojciszke, 1994, Wojciszke, 1994, Abele and Wojciszke, 2007; Wojciszke and Abele, 2008; Wojciszke et al., 2011). William James (1890) defined self-esteem as the ratio of 'Success/Pretensions', indicating that both failures and successes have a lot to do with self-esteem. In fact, the agentic aspect of the self refers to the traits that are related to personal goal pursuits and accomplishments (Diehl et al., 2004, Abele and Bruckmüller, 2011). In this regard, it is not surprising that one's agentic but not communal evaluation was associated with self-esteem. Interestingly, we found the relationship between self-esteem and the endorsement of others' agentic evaluation of oneself was completely mediated by

the agentic self-evaluation. These findings partly replicated previous studies (Wojciszke, 1994, Abele and Wojciszke, 2007, Wojciszke and Abele, 2008, Wojciszke et al., 2011) while in the meantime shed new light on the possible relationship among self-esteem, self-evaluation, and the processing of social feedback. According to the self-verification theory, people would like to seek, elicit, and recall those social feedbacks that are congruent with their self-views in order to preserve the stability of their self-concepts, especially in the domains which they regard important (Swann et al., 1990, Swann and Read, 1981). In the current study, it is possible that participants strived to maintain stable self-concepts by accepting and internalizing others' feedbacks that are consistent with their self-concepts, especially in the agentic domain which is more closely related to self-esteem.

Self-critical thinking has been shown to recruit the dlPFC in numerous studies (e.g., Longe et al., 2009, Lord et al., 2012, Paulus and Stein, 2010), and stronger dlPFC activity has been associated with harsher self-criticism (Longe et al., 2009). People with high self-criticism are especially sensitive to failure in daily life, making them more likely to have low self-esteem (Heine et al., 1999). Consistent with this, our results showed that the dlPFC activation in response to the SA condition was negatively correlated with self-esteem. Furthermore, dlPFC showed greater connectivity with brain regions engaged in negative emotion processing, including the anterior insula (Lindquist et al., 2012, Paulus and Stein, 2006, Quartz, 2009, Zaki et al., 2012) and dorsal striatum (Delgado et al., 2000, Delgado et al., 2003, Elliott et al., 2004, Knutson et al., 2000, Knutson et al., 2001, O'Doherty et al., 2004), implying that negative feelings (e.g. feeling of self-punishment) were induced by self-critical thinking in agentic self-evaluation. In addition, dlPFC also showed a stronger connectivity with right lateral prefrontal cortex that is considered as a key region in emotion regulation and cognitive control (Ochsner and Gross, 2004, Ochsner and Gross, 2005, Petrides, 2005), implying that low self-esteem people may have spent greater efforts to regulate emotions and cognitions induced by self-critical thinking in agentic self-evaluation.

Besides the dlPFC, we also found that bilateral thalamus activation during agentic self-evaluation was negatively correlated with self-esteem. The thalamus has extensive connections with distributed cortical regions (Cole et al., 2013, Crossley et al., 2013) and plays an important role in information integration (Bell and Shine, 2016, Hwang et al., 2016) and regulation of attentional and cognitive efforts (Raeva, 2006, Schiff, 2008, Schiff et al., 2007, Schiff et al., 2013, Van der Werf et al., 2003). People with lower self-esteem tend to have lower self-concept clarity and could face greater uncertainty during agentic self-evaluation (Blaine and Crocker, 1993, Campbell, 1990, Campbell et al., 1996). Therefore, the greater thalamic activity among individuals with lower self-esteem may reflect more effortful information processing that is usually required during judgments under uncertainty (Camerer, 2003, Feldman and Friston, 2010, Feltovich, 2000, Sutton and Barto, 1998, Vickery and Jiang, 2009, Zaretsky et al., 2010). Consistently, our behavioral results showed that participants' reaction times were negatively correlated with self-esteem, suggesting that lower self-esteem is associated with more cognitive resources needed to perform self-related tasks. Nevertheless, it should be noted that unlike the thalamic neural response, the reaction times were correlated with self-esteem not only in the agentic self-evaluation but also in other conditions. Future research is needed to elucidate such dissociation between neural and behavioral findings.

Connectivity analyses of the thalamus found that it had greater connectivity with the precuneus, right angular gyrus, left lateral temporal gyrus, ventral striatum, dlPFC and ventral anterior cingulate (vACC). These regions largely overlapped with the default mode network (DMN) that includes the bilateral temporoparietal regions and cortical midline structures (Buckner et al., 2008, Philippi et al., 2015, Svoboda et al., 2006, Yang et al., 2013). Studies have shown that the DMN underlies retrieval of autobiographical memory, a process that may have been involved in agentic self-evaluation in our study (Spreng and Grady, 2010, Svoboda et al., 2006, Yang et al., 2013). In addition, the ventral striatum and vACC are among the brain regions responsible for emotion recognition and emotion generation (Bush et al., 2000), while the dlPFC is involved in regulation of emotion (Phillips et al., 2003). Therefore, through connection with the DMN and the regions underlying emotional processing, the bilateral thalamus may play a key role during agentic self-evaluation by integrating the retrieval of autobiographical information and the emotional processing of that information.

In the contrast of SC vs. SA, we found the activation of medial prefrontal cortex (mPFC), which is repeatedly involved in the self-related processing (e.g., Beer and Hughes, 2010, Han et al., 2016b, Moran et al., 2009, Ochsner et al., 2005). A growing body of fMRI research has found greater mPFC response during trait judgment of oneself versus that of others (Heatherton et al., 2006, Kelley et al., 2002, Moran et al., 2011, Zhu et al., 2007). Moreover, traits of higher self-relevance induce greater activation of mPFC (Moran et al., 2006, Northoff et al., 2006). Thus, in the current study, a significant activation of the mPFC in the contrast of SC vs. SA may imply that the communal traits were more self-related compared with the agentic ones, which is consistent with our behavioral data showing that the SC rating is higher than the SA rating. However, similar mPFC activity was not observed in the contrast of OC vs. OA, a result that may be due to the fact that the endorsement of others' evaluation of oneself is a relatively indirect way of self-reflection than the self-evaluation.

The communal personality traits are considered as more self-related than agentic ones in the current studied population (i.e. Chinese adults) does not necessarily contradict the fact that a closer relationship between self-esteem and agentic (vs. communal) self-evaluation. This is because self-esteem reflects the valence of one's perception of the self (positive vs. negative), while self-relatedness concerns the content of one's self-concept. On one hand, agentic traits are those related to personal goal-pursuit and achievement and thus are directly associated with one's evaluation of self-worth (Diehl et al., 2004, Abele and Bruckmüller, 2011). Likewise, William James (1890) defined self-esteem as the ratio of 'Success/Pretensions', indicating one's agentic attributes have a lot to do with self-esteem. On the other hand, collectivistic cultures (e.g., cultures in East Asia) emphasize communion, while individualistic cultures (e.g., cultures in the West) emphasize agency (Fiske et al., 2007, Sedikides et al., 2003). Thus, it is reasonable that Chinese people, by clinging to the collectivistic cultural norm, possess more communal traits as part of their self-concepts. As a result, when it comes to self-evaluation, Chinese participants may regard more communal traits as self-descriptive, while basing their self-worth and self-esteem on their agentic attributes.

The current study is not without limitations. First, as behavioral analysis showed that self-esteem was more directly associated with the SA rating than with the OA rating, we only focused on the contrast of SA vs. Fixation in the fMRI regression analysis in relation to self-esteem. Future studies should test whether and how neural activity for other conditions (i.e. SC, OA, OC) is associated with self-esteem. Second, the social feedbacks were provided to the participants in an indirect manner - that is, by displaying others' evaluation on a computer screen, instead of engaging participants in direct social interactions with others. A more sophisticated design, preferably in combination with the hyper-scanning technique, will better reveal the neural underpinnings of real-life social information processing. Lastly, the correlation and mediation findings of the current study do not necessarily imply causal relationships between variables. While testing causality was beyond the scope of our study, we hope that such causality will be revealed in future studies by manipulating the independent variables and/or taking a longitudinal approach.

4. Conclusion

In summary, our study adds to a growing body of literature linking self-esteem and agentic self-evaluation and suggests that 1) people's self-esteem is dominated more by agency than by communion regardless of self-evaluation or thinking about other's evaluation on oneself; 2) and low self-esteem people both hold a more self-critical attitude about self and have less certainty or clarity of their self-concepts than high self-esteem people do during agentic self-evaluation. These findings may have important implications for understanding how people's self-esteem affects perception of social feedbacks and the potential cognitive processes underlying the way self-esteem moderates agentic self-evaluation.

5. Methods and materials

5.1. Participants

Thirty-six right-handed healthy participants (18 females, 19–24 years) were recruited from the Southwest University, China. Five participants were excluded (2 because of the head motion > 2 mm, 2 because of the poor image quality, 1 because of the experimenter's incorrect manipulation), leaving 31 individuals in the final analysis (15 males, mean age $\pm$ SD = 21.16 $\pm$ 1.34 years). No participants reported a current or past psychiatric or neurological history, head injury, or alcohol/drug abuse. Participants gave the informed consent prior to the formal experiments, and the experiments were approved by the Ethics Committee of Southwest University.

5.2. Materials and questionnaire

The stimuli were three-character Chinese words selected from the well-established Chinese Adjective Words System for Fundamental Dimensions of Social Cognition (Han et al., 2015). We included 80 traits considered most typical for communion (e.g. 'kind' and 'ruthless') and 80 traits considered most typical for agency (e.g. 'flexible' and 'stupid'). Moreover, the communal and agentic trait words were matched along several dimensions including positive/negative valence, familiarity, number of written strokes, and frequency rank.

Rosenberg self-esteem scale (RSES) was used to assess participants' global trait self-esteem (Rosenberg, 1965). The RSES is a 10-item self-report scale scored on a 4-point scale from 1 (strongly disagree) to 4 (strongly agree) (e.g. 'On the whole, I am satisfied with myself'). Reversing scoring was applied to the negative items.

5.3. Procedure

The current experiment was a 2 (evaluative perspectives: self-evaluation/endorsement of others' evaluation of oneself) $\times$ 2 (dimensions of social cognition: agency/communion) within-subject design. To create a context of social feedback for the fMRI task, we first asked 256 students to evaluate five of their classmates on 30 trait words (1=strongly disagree, 4=strongly agree). Then, 36 of these students were randomly recruited for the current fMRI investigation. Prior to the fMRI scanning, participants completed RSES. During the scanning, participants completed the task of self-evaluation and the task of endorsing others' evaluation of oneself. In the self-evaluation task, participants were presented with 80 agentic and 80 communal traits, and for each trait they answered 'Does this adjective describe the self?' by pressing one of 4 buttons (1=does not describe me at all, 4=describes me most). In the task of endorsement of others' evaluation of oneself, participants were presented a different set of 80 agentic and 80 communal traits that they believed were used to describe them by their classmates, and answered 'Do you agree with the other's evaluation of you?' by a button press (1=strongly disagree, 4=strongly agree) on each trait adjective. Therefore, trials were sorted into 4 conditions, i.e., the agentic self-evaluation (SA), the endorsement of others' agentic evaluation of oneself (OA), the communal self-evaluation (SC), and the endorsement of others' communal evaluation of oneself (OC). Ratings of negative traits were reversely scored in all analyses.

A mixed block/event-related design was applied. Participants completed 7 runs of fMRI scanning. In each run, there were 1 block for each of the 4 conditions, resulting in a total of 4 blocks per run. Blocks were separated by 10-s inter-block intervals of grey screen. Each block contained 12 trials in first 6 runs, and 8 trials in the last run. During each trial, the category of evaluative perspective (either 'self-self' for self-evaluation or 'class-self' for endorsement of others' evaluation), the trait adjective and the rating scale were presented in black color at the center of a grey screen. Each item lasted 4 s, followed by a jittered inter-trial interval of 2, 4 or 6 s during which a fixation crosshair was shown at the center of the screen. Illustration of one example block of the SC condition is shown in the Fig. 5.

5.4. fMRI data acquisition

Functional and anatomical whole-brain images were acquired in a 3 T Siemens TRIO MRI scanner. 1483 volumes functional images acquired with T2*-weighted gradient echo planar imaging (EPI) sequence were collected from each subject. We obtained 32 echo planar images per volume sensitive to blood oxygenation level-dependent (BOLD) contrast (repetition time (TR)=2000 ms, echo time (TE)=30 ms, 64×64 matrix with $3 \times 3 \times 3$ mm³ spatial resolution, FOV= 192×192 mm²). Slices were acquired in an interleaved order and oriented parallel to the AC-PC plane, with 0.99 mm gap. High-resolution T1-weighted 3D fast-field echo (FFE) sequences were obtained for anatomical reference (176 slices,

TR=1900 ms; TE=2.52 ms; slice thickness=1 mm; FOV=256 mm × 256 mm; voxel size=1 × 1 mm × 1 mm).

5.5. fMRI data analysis

Preprocessing of fMRI data was performed using Data Processing Assistant for Resting-State fMRI (DPARSF) (Yan and Zang, 2010), and other analyses were conducted using SPM12 (Wellcome Trust Centre for Neuroimaging, University College London, UK). The preprocessing steps included removing the first 5 volumes, slice timing, head motion correction, co-registration with the anatomical image, segmentation, normalization to the standard T1 Montreal Neurological Institute template image with voxel size of $3 \times 3 \times 3$ mm³ and smoothing (6 mm full-width at half maximum Gaussian kernel). First-level effects were estimated by creating general linear model (GLM) which incorporated 6 conditions (SA, SC, OA, OC, Fixation, and the blank between two blocks) convolved with the canonical hemodynamic response function and 6 movement parameters as covariates of noninterest. A high-pass temporal filter with a cutoff period of 128 s was applied. The second-level analyses were conducted using random-effects models to investigate group effects. Significant activations in all fMRI analyses were identified using the threshold at a voxel-wise $p < 0.001$ (uncorrected) and cluster-level $p < 0.05$ (FWE-corrected) for correction of multiple comparisons.

In order to investigate the differences between communion and agency during the tasks of self-evaluation and endorsement of others' evaluation of oneself, contrasts of (SC vs. SA) and (OC vs. OA) were calculated, respectively. Moreover, to identify the brain regions whose neural responses were associated with self-esteem, the self-esteem scores obtained from the RSES were entered as a regressor in a whole-brain multiple regression analysis. In order to further explore the role of the self-esteem-related brain regions, we conducted the psychophysiological interaction (PPI) analyses (Friston et al., 1997) with the activated brain regions as the seed regions to investigate the differences of neural relationships between the seed regions and the rest of brain. Specifically, the time series of each seed region was extracted by averaging the signal values across voxels and entered into the GLM as the physiological regressor. Also entered into the GLM are the mean-centered regressors from the condition (i.e. the psychological regressor) and the interaction between the psychological and physiological regressors (namely the PPI regressor). In our study, the PPI analyses were focused on the SA vs. Fixation contrast, which revealed the brain regions whose connectivity with the seed regions varied between the two conditions.

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Fig. 1.

The mediation analysis between self-esteem scores and the OA rating with the SA rating as the mediator. Results showed that the SA rating was a significant full intermediate variable between the self-esteem scores and the OA rating. CI: confidence interval.

Fig. 2. Differences in neural response between the ratings of agentic and communal traits during (A) self-evaluation (SC vs. SA) and (B) the endorsement of others' evaluation of oneself (OA vs. OC). The color bar shows statistical t value. Statistical criteria: uncorrected $P < 0.001$ and cluster-level FWE-corrected $P < 0.05$. mPFC, medial prefrontal cortex; SMA, supplementary motor area.

Fig. 3. Brain regions with neural activity negatively correlated with self-esteem in response to SA rating compared with Fixation. The color bar shows statistical t value. Statistical criteria: uncorrected $P < 0.001$ and cluster-level FWE-corrected $P < 0.05$. dlPFC, dorsolateral prefrontal cortex.

Fig. 4.

Brain areas whose connectivity with the seed regions increased during SA rating compared with Fixation, with (A) (B) the dorsolateral prefrontal cortex treated as the seed region, and (C) (D) the thalamus treated as the seed region. The color bar shows statistical t value.

Statistical criteria: uncorrected $P < 0.001$ and cluster-level FWE-corrected $P < 0.05$. IPFC, lateral prefrontal cortex; INs, insula; AG, angular gyrus; vACC, ventral anterior cingulate; ITG, lateral temporal gyrus.

Fig. 5.
Illustration of one example block of communal self-evaluation (SC).

Table 1

Correlation analysis for RSES scores and the behavioral results in four tasks

	SA		SC		OA		OC	
	Ratings	RTs	Ratings	RTs	Ratings	RTs	Ratings	RTs
	(M=2.77, SD=0.26)	(M=1669.65, SD=243.33)	(M=3.05, SD=0.19)	(M=1581.97, SD=230.75)	(M=2.88, SD=0.23)	(M=1659.51, SD=224.67)	(M=3.11, SD=0.21)	(M=1587.18, SD=237.50)
Self-esteem (M=29.23, SD=3.68)	$r=0.68^{***}$	$r=-0.40^*$	$r=0.33$	$r=-0.43^*$	$r=0.58^{***}$	$r=-0.41^*$	$r=0.22$	$r=-0.39^*$

The negative items were reversely scored. SA: the agentic self-evaluation; SC: the communal self-evaluation; OA: the endorsement of others' agentic evaluation of oneself; OC: the endorsement of others' communal evaluation of oneself.

* $p<0.05$,

*** $p<0.001$

Differences in neural response between the ratings of agentic and communal traits during the self-evaluation and during the endorsement of others' evaluation of oneself

Table 2

Contrast	Anatomical region	BA	L/R	X	Y	Z	k	t
SA vs. SC	none							
SC vs. SA	Medial prefrontal cortex	9/10/11		-9	51	-6	297	5.07
OA vs. OC	supplementary motor area	6/32	L	-3	12	60	48	4.43
OC vs. OA	none							

BA refers to putative Bradman's Area; L and R refer to left and right hemispheres; x, y, and z refer to MNI coordinates in the left-right, anterior-posterior, and inferior-superior dimensions, respectively; t refers to the t score at those coordinates (local maxima); k refers to the number of voxels in each significant cluster. Statistical criteria: uncorrected $P < 0.001$ and cluster-level FWE -corrected $P < 0.05$.

Table 3

Brain regions with neural activity negatively correlated with self-esteem in response to SA rating compared with Fixation

Contrast	Anatomical region	BA	L/R	X	Y	Z	k	t
SA vs. Fixation	dorsolateral prefrontal cortex	8/9	R	39	12	48	49	-5.12
	thalamus		R	9	-27	-9	130	-5.51
			L	-9	-18	0	89	-5.28

BA refers to putative Bradman’s Area; L and R refer to left and right hemispheres; x, y, and z refer to MNI coordinates in the left–right, anterior–posterior, and interior–superior dimensions, respectively; t refers to the t score at those coordinates (local maxima); k refers to the number of voxels in each significant cluster. Statistical criteria: uncorrected $P < 0.001$ and cluster-level $FWE P < 0.05$.

Table 4

Results of psychophysiological interaction (PPI) analysis

Seed region	BA	L/R	X	Y	Z	k	t
dlPFC as the seed region SA > Fixation							
anterior insula	13/45/47	L	-27	27	-6	168	5.28
anterior insula/lateral prefrontal cortex	9/13/45/46/47	R	30	24	-3	676	8.17
thalamus/caudate			12	0	0	239	5.35
Inferior frontal lobe(white matter)	6	L	-39	6	24	74	5.16
Fixation >SA							
None							
thalamus as the seed region SA > Fixation							
precuneus/angular gyrus	5/7/19/31/40/39	R	3	-36	45	2173	7.21
lateral temporal gyrus	19/39	L	-42	-72	18	76	4.96
dorsolateral prefrontal cortex	8/9/10	R	30	42	39	118	5.65
ventral striatum			3	9	-3	85	5.22
ventral anterior cingulate	10/32	R	18	51	-3	136	4.30
Fixation >SA							
postcentral gyrus	3/4/40	L	-48	-30	51	55	4.75

BA refers to putative Brodmann's Area; L and R refer to left and right hemispheres; x, y, and z refer to MNI coordinates in the left-right, anterior-posterior, and interior-superior dimensions, respectively; t refers to the t score at those coordinates (local maxima); k refers to the number of voxels in each significant cluster. Statistical criteria: uncorrected $P < 0.001$ and cluster-level $FWE P < 0.05$.