

Accepted manuscript by *Social Neuroscience*, DOI: 10.1080/17470919.2015.1108931

Common and Distinct Neural Mechanisms of the Fundamental Dimensions of Social Cognition

Mengfei Han,¹ Chongzeng Bi,¹ Oscar Ybarra²

1 Research Center of Psychology and Social Development, Southwest University,
Chongqing, 400715, China

2 Department of Psychology, the University of Michigan, Ann Arbor, 48109, USA

Correspondence: Bi Chongzeng; Faculty of Psychology, Southwest University of Chongqing, China; Email: beech@swu.edu.cn; Phone: +86-23-68367939; FAX: +86-23-68252983. Or Oscar Ybarra; Department of Psychology, University of Michigan, Ann Arbor, USA; Email: oybarra@umich.edu.

This work was supported by the Fundamental Research Funds for the Central Universities (SWU1509118), the Research Team's Construction Project from the Faculty of Psychology at Southwest University (TR201201-4) and NSFC(31371055).

Word count: <8021>

Abstract

In the present study, we used a valence classification task to investigate the common and distinct neural basis of the two fundamental dimensions of social cognition (agency and communion) using functional magnetic resonance imaging (fMRI). The results showed that several brain areas associated with mentalizing, along with the inferior parietal gyrus in the mirror system, showed overlap in response to both agentic and communal words. These findings suggest that both content categories are related to the neural basis of social cognition; further, several areas in the default mode network (DMN) showed similar deactivations between agency and communion, reflecting task induced deactivation (TID). In terms of distinct activations, the findings indicated greater deactivations for communal than agentic content in the ventral anterior cingulate (vACC) and medial orbitofrontal cortex (mOFC). Communion also showed greater activation in some visual areas compared to agentic content, including occipital gyrus, lingual gyrus, and fusiform gyrus. These activations may reflect greater allocation of attentional resources to visual areas when processing communal content, or inhibition of cognitive activity irrelevant to task performance. If so, this suggests greater attention and engagement with communion-related content. The present research thus suggests common and differential activations for agency versus communion-related content.

Key words

Fundamental Dimensions; Social cognition; Communion; Agency; Mentalizing

In order to adapt to the social world, individuals need to attend to, make inferences, and store information about their own and other people's traits, motives, values, and goals (Van Overwalle, 2009). Although numerous inferences can occur, researchers in social cognition have shown that many of the inferences we make about others and also ourselves abide by two general categories of content or fundamental dimensions of social cognition (e.g., Bakan, 1966; Chance, 1988; Hogan, 1983; Wiggins, 1991; Ybarra et al., 2008). The fundamental dimensions go by different labels, such as agency, competence, or ability versus communion, warmth, and morality (e.g., Abele & Wojciszke, 2007; Fiske, Cuddy, & Glick, 2007). Here we use agency and communion, although we are not married to a particular set of labels.

The fundamental dimensions appear central to organizing how people think about their social worlds. Further, their presence in diverse research findings also makes sense because their content reflects two recurring challenges in people's lives, building social connections and gaining and maintaining social acceptance (communion), but also striving for personal goals, status, and developing competencies (agency) (Hogan, 1983; Humphrey, 1976; Wilson, 2012; Ybarra et al., 2008). Hence, the fundamental dimensions have the potential to inform researches on social neuroscience by highlighting the role of content.

Despite this potential, most of the available research documenting the role of the fundamental dimensions in social cognition has focused on behavioral outcomes. Only a modicum of neuroscientific studies has considered social cognitive content (e.g., Mende-

Siedlecki, Baron, & Todorov, 2013; Swencionis & Fiske, 2014). A focus on content matters because content has been shown to affect information processing and likely underlying neural activations, but content is confounded many times with the tasks participants are asked to perform. For example, an important demarcation in social cognition is that between self and other (e.g., Ng, Han, Mao, & Lai, 2010; Zhu & Zhang, 2002). Research on the fundamental dimensions indicates a tendency at times for perceivers to focus on communion when judging others but on agency when thinking about the self (Abele & Wojciszke, 2007). So, to really assess the effect of content, it is important to dissociate content from perspective (self vs. other). In the present research we dealt with this issue by keeping the task constant (classify the favorability of trait words) while varying the content (agency vs. communion) of the trait words.

Processing words with the goal of categorizing their favorability is likely to activate specific neural areas. Several imaging studies have found that the ventral anterior cingulate cortex (vACC), orbitofrontal regions, and amygdale are activated when distinguishing positive from negative words (Fossati et al., 2003; Hughes & Beer, 2012; Straube, Sauer, & Miltner, 2011). Thus, due to the nature of the task and stimuli that vary in valence (although of equivalence within dimension), we expected activations in these areas.

Although communion is related to being accepted and forming social connections, whereas agency is related more to status, achievement, and gaining distinction, at a more

general level both dimensions tell us that an actor has decided on an action to undertake and a social goal to pursue (to try to get along or try to get ahead). Such inferences that an actor is directing their behavior or pursuing a goal is likely to implicate various neural processes involved in mentalizing.

The neural structures consistently involved in mentalizing—inferring others' intentions, goals, preferences, and characteristics—make up a critical network that underlies social cognition (Van Overwalle & Baetens, 2009). Social cognitive tasks that involve mentalizing typically involve the medial prefrontal cortex (mPFC), temporal-parietal junction (TPJ), posterior cingulate cortex (PCC)/ precuneus, and medial orbital frontal cortex (mOFC; Eddy, Beck, Mitchell, Praamstra, & Pall, 2013; Howard-Snyder, 2005). For example, growing evidence indicates that drawing inferences about others' traits and characteristics is mediated by the mPFC (Mitchell, Cloutier, Banaji, & Macrac, 2006). PCC and its neighbor precuneus are responsible for integrating various informational inputs from other brain regions, for example, memory input from the hippocampus, and then using this information to infer the mental states of others (Mar, 2011). The mOFC has been shown to play an important role in a diversity of learning tasks that involve rewards related to understanding personal interactions in social domains (Elliott, Friston, & Dolan, 2000; Nestor et al., 2013). The TPJ is engaged in encoding temporary states, especially the current thoughts or beliefs of others, not the appearance or personality implications of social information (Saxe & Powell, 2006; Van

Overwalle, 2009). In addition to the structures described above, a recent meta-analysis indicated the cerebellum is consistently engaged in tasks that involve some aspects of mentalizing versus no mentalizing (Van Overwalle, Baetens, Mariën, & Vandekerckhove, 2014). Thus, we expected that when presented with trait information to process, participants would consistently show activations in these brain regions regardless of the dimension (agency or communion) the stimuli were related to.

In terms of potential differences, the fundamental dimensions have been shown to impact information processing. Many studies have found that communion-related information is weighted more than agency-related information in judging others. When asked what information they would want to know about an unknown other, individuals were more likely to initially request communal than agentic information (Wojciszke, Bazinska, & Jaworski, 1998). Communion-related traits are also perceived to be more stable over time, thus perceivers may use them more consistently to describe and think about others (Kenworthy & Tausch, 2008). There is also greater agreement in people's judgments of others' communion-related than agency related attributes (Ybarra et al., 2008). Further, in terms of basic metrics such as speed of processing, research indicates that communal information is processed more rapidly than agentic information (Abele & Bruckmüller, 2011; Ybarra, Chan, & Park, 2001).

Although little research has directly examined the differences in the neural correlates involved in processing communal and agentic information (for recent exceptions see Mende-

Siedlecki et al., 2013; Swencionis & Fiske, 2014), there are studies involving content related to communion and agency that can be used to suggest areas of interest. In terms of communion-related content, research has shown that the putamen and globus pallidum are related to affiliation motivation (Quirin et al., 2013). In addition, several fMRI studies dealing with morality, which can be considered a specific component of communion, have shown activations in the ventromedial prefrontal cortex (vmPFC; Shenhav & Greene, 2010; Young & Dungan, 2012) and some temporal regions including the temporo-parietal junction (TPJ; Young & Saxe, 2009) and the superior temporal sulcus (STS; Harenski & Hamann, 2006; Eslinger, Moll, & Oliveira-Souza, 2002). The insular cortex is also implicated in studies of morality, in particular processing information related to rule and regulation violations (Fumagalli & Priori, 2012; Huebner, Dwyer, & Hauser, 2009). Further, other research has shown that the insular cortex plays an important role in processing social warmth information (Inagaki & Eisenberger, 2013), which is also related to the communal dimension (e.g., Wojciszke, Baryla, Parzuchowski, Szymkow, & Abele, 2011).

Agentic goals can usually be represented as power, achievement, and self-mastery (Reisz, Boudreaux, & Ozer, 2013). There are few studies examining tasks that involve agency related content, but researchers have suggested that the medial PFC plays a vital role in behavior related to achievement goals (Matsumoto & Tanaka, 2004). In addition, an fMRI study using anger and surprise faces as stimuli in the study of power motivation showed that

participants with high-power had stronger activations in the lateral OFC, dorsal striatum, and insula when watching these faces (Schultheiss et al., 2008). Another study on power revealed mPFC activations while participants were watching movie clips related to power, such as scenes depicting a dominant boss talking to his subordinate in the “The Godfather” (Quirin et al., 2013).

In conclusion, although there is little research focusing on the differences in the neuromechanisms associated with communal and agentic information, available studies suggest some potential differences, for example, TPJ, OFC, and putamen. But we advance this proposal cautiously given that few comparisons exist in terms of the content dimensions and the studied tasks. Further, the content that has been part of the studied tasks has not been selected to specifically target the communal and agentic aspects of social cognition.

As little research has directly examined the neural correlates of agency and communion, the purpose of the present research was to use a valence classification task and fMRI to demonstrate both the common as well as distinct brain bases of the two content domains. We hypothesized that both the communal and agentic words would predict activity in areas related to mentalizing. However, we also expected distinct activations as a function of content dimension given previous social cognition research on processing differences and neuroscientific research suggesting potential differences involving the frontal cortex, temporal cortex, and subcortical structures. In addition, categorizing the stimulus words –due

to their emotional content—may evoke activations in vACC, orbitofrontal regions, and amygdale. To make sure that such emotion-related processing didn't influence the processing of communal and agentic content, we also examined the interaction between contents and valence.

Materials and methods

Participants

42 Chinese university undergraduates (mean age 21.05 years old, age range 18-25 years old; 22 females) were recruited to participate in a study on trait word recognition. All participants were right-handed, native speakers, had normal or corrected to normal vision, and had no psychiatric history. Due to large head motions (> 3 mm and/ or $> 3^\circ$) or high error rates in judging the stimuli ($> 25\%$), two subjects' fMRI data were excluded for the first run, one for the second run, and four for the third run. All subjects received ¥60 (about \$9.8) for participation and gave written, informed consent in accordance with procedures and protocols approved by the Review Board of the SWU MRI Center for Brain Research.

Materials

The stimuli consisted of a total of 160 trait words that depicted personality characteristics, 80 for each category (communal words and agentic words). The stimulus words were selected from established personality trait adjective pools (Huang & Zhang, 1992; Wang & Cui, 2005; Wang, Zhou, & Lou, 2008). In a pilot study, 49 participants rated the

stimulus words with regard to how representative they were of the agentic and communal dimensions based on given definitions (the scale ranged from -3 = a great amount of communion (agency) but negative, to 0 = little to no communion (agency), and to 3 = a great amount of communion (agency) but positive; Abele & Bruckmüller, 2011). Higher scores represent a higher degree of agency or communion for each word. To isolate the effects of stimulus valence, we also asked participants to separately rate the favorability of each word using 7-point scales as well as their familiarity, -3 = very negative (very unfamiliar), 0 = neither positive nor negative (neither unfamiliar nor familiar), 3 = very positive (very familiar).

The results indicated the agentic words were rated as higher in agentic content ($M = 2.20$, $SD = .37$) than communal words ($M = 1.68$, $SD = .31$), $t(158) = 9.76$, $p < 0.001$; Communal words were rated as higher in communal content ($M = 2.18$, $SD = .27$) than agentic words ($M = 1.75$, $SD = .27$), $t(158) = 9.29$, $p < 0.001$. Agentic words (positive: $M = 2.46$, $SD = .21$, negative: $M = -1.90$, $SD = .37$) and communal words (positive: $M = 2.49$, $SD = .22$, negative: $M = -2.04$, $SD = .32$) were rated on a separate scale as equally favorable, both $t_s < 1.88$, $p_s > 0.5$. In addition, the number of written strokes, frequency rank (Research Group, 2008), and familiarity were balanced between communion (strokes: $M = 17.54$, $SD = .32$, frequency rank: $M = 12894.81$, $SD = 8212.95$, familiarity: $M = 2.50$, $SD = .27$) and agency (strokes: $M = 18.54$, $SD = 4.96$, frequency rank: $M = 13279.78$, $SD = 8364.18$, familiarity: $M = 2.47$, $SD = .24$), t_s

(158) < 1.22; $p > 0.05$ (Han, Ybarra, & Bi, 2015).

Procedure

We used a block design in the current study. There were three different kinds of blocks depending on the stimuli: the valence classification task for agentic words (agentic condition), the valence classification task for communal words (communal condition), and a fixation task as the baseline task (Kuo et al., 2004).

Upon arrival at the lab, the experimenter asked participants to practice to confirm their understanding of the instructions and materials. For this they completed a valence classification task (words used were different from the ones used in the final experiment) and a fixation task. After participants were familiarized with the experimental procedure, they were taken to the fMRI scanner to complete the experimental tasks in the scanner. A total of 19 blocks (5 valence classification blocks each for agentic words and communal words, and 9 fixation blocks) were distributed into three runs pseudo-randomly. Each participant completed all of the three runs in the experiment. Functional images were collected during the intervals corresponding to the second and third runs.

After performing the tasks, participants completed the Chinese version of the Positive Affect and Negative Affect Scale (PANAS; Huang, Yang, & Ji, 2003), and they provided information on their age, gender, and handedness before they were thanked and debriefed.

Behavioral tasks

During the scanning, each participant needed to complete two kinds of tasks: the valence classification task and the fixation task. In the valence classification task, participants were asked to decide as quickly as possible whether the word that appeared on the screen was positive or negative by pressing one of two keys on the keyboard. The mapping of keys corresponded to response type and was counter-balanced across participants. At the beginning of each block, instructions appeared for 3s, which defined the task (e.g., judge whether the word is positive or negative) for each block of trials. Then, the stimulus word appeared on the screen for 2000 ms, during which participants responded to the stimulus. Following this was a fixation task lasting 1000ms. Each block contained 16 trials. In the agentic block, the stimuli were all agentic words, while in the communal block, they were all communal words. For the fixation task, a crosshairs was presented in the center of the screen for 16s; participants were asked to fixate on the crosshairs without any response.

fMRI Data Acquisition

Images were acquired with a Siemens 3T scanner (Siemens Magnetom Trio TIM, Erlangen, Germany). Functional data were collected by a T2-weighted gradient Echo-Planar imaging (EPI) sequence with TR = 2000 ms; TE = 30 ms; flip angle = 90°; FoV = 192 × 192 mm²; matrix size = 64 × 64; voxel size = 3 × 3 × 3 mm³; interslice skip = 0.99 mm Slices = 32. T1-weighted high-resolution anatomical images were acquired with TR = 1900ms, TE = 2.52ms, slice thickness = 1 mm, flip angle = 9°, matrix size = 256×256.

fMRI Data Analysis

We used SPM8 (<http://www.fil.ion.ucl.ac.uk/spm/spm8>) to analyze the functional data (Friston et al., 1994). For T2*-weighted images, slice order was corrected through slice timing, and six parameters of head movement were estimated and removed using the realign option, and the first five images were discarded to achieve steady magnet state. Then the anatomical images were co-registered with the functional images for each participant. The anatomical and functional images were spatially normalized to an EPI template provided in SPM8. Finally, the images were smoothed by a Gaussian kernel with 8-mm full width at half maximum. The resulting images had cubic voxels of $3 \times 3 \times 3\text{mm}^3$.

We analyzed the Functional MRI using the first level of the General Linear Model (GLM) framework (Lidzba, Ebner, Hauser, & Wilke, 2013). The data were defined into three types: communal condition, agentic condition, and fixation task. For each participant, there were contrast images created for each comparison. First, we separately evaluated the agentic words and the communal words, contrasted with fixation trials. Second, we used a conjunction analysis between the contrast of communion vs. fixation and agency vs. fixation, to explore the regions activated by both communion and agency. Finally, we used pair-sampled t-tests to compare communal with agentic trials. The data obtained on the PANAS were used as a covariate to control for participants' affective state. Results were corrected with AlphaSim error correction at 0.01 level (voxel threshold $p < 0.005$; cluster size > 105

voxels; Hamberger, Habeck, Pantazatos, Williams, & Hirsch, 2013). This correction was confined within the group GM mask (size: 67855) and determined by Monte Carlo simulations (Ledberg, Åkerman, & Roland, 1998) using the REST AlphaSim program (www.restfmri.net).

In addition, because the processing of communal and agentic words during the classification task involved emotional information, we used a repeated measures ANOVA with dimension (communion vs. agency) and valence (positive vs. negative) as the two factors to determine whether there was a valence main effect during word classification.

Although during the fixation task participants were asked to attend to the crosshairs at the center of the screen, it is difficult to ensure that participants did not engage in unconstrained thought or other self-referential aspects of consciousness. So, the fixation task could be associated with significant cognitive activity (Stark & Squire, 2001). Hence, we also used the implicit baseline as a control, which is the average intensity across all trials calculated by SPM (Adcock, Thangavel, Whitfield-Gabrieli, Knutson, & Gabrieli, 2006). We separately evaluated the agentic words and the communal words, compared with implicit baseline, and we used a conjunction analysis between these two contrasts.

Results

Behavioral Results

We conducted a two-way analysis of variance on mean reaction times with word content

dimension (agency/ communion) and valence (negative/ positive) as within participants' factors. The main effect of word content dimension was significant, $F(1, 41) = 4.32$, $MSE = 1263.52$, $p = 0.044$; mean reaction times were shorter for communal words ($M = 776.02$, $SD = 96.90$) than agentic words ($M = 787.65$, $SD = 96.75$). Participants also were faster responding to positive ($M = 759.63$, $SD = 94.88$) than negative words ($M = 804.90$, $SD = 102.79$), $F(1, 41) = 32.81$, $MSE = 2623.54$, $p < 0.001$. The interaction of the two factors was not reliable, $F(1, 41) = 0.10$, $MSE = 848.27$, $p = 0.754$ (See Table 1), which indicated that content dimension was independent of valence, at least with regard to the behavioral aspects.

fMRI Results

In order to explore brain region activations as a function of processing the communal and agentic words, we focused on agentic and communal trials contrasted with baselines without regard to word valence (see Fig. 1).

Based on the conjunction analysis, a number of brain areas revealed significant increased activations for both agentic and communal contents. These similar activations have been associated with social cognitive processing and included the cerebellum, superior frontal gyrus, inferior parietal gyrus (IPL), insula, and putamen. The similar brain responses between agency and communion also included some deactivations, such as mOFC, vACC, the middle temporal gyrus, the posterior superior temporal gyrus, and precuneus (see Table 2, Fig. 2).

Using the implicit baseline, we found that the results for agency, communion and the

conjunction analysis were similar to the results using the fixation baseline (see Table 2, Fig. 1, Fig. 2).

To investigate brain activation differences between agentic and communal content, we contrasted responses to the communal trials with agentic trials without the baseline (fixation task or implicit baseline). Agency showed greater activation in vACC and mOFC than communal content, whereas communal content resulted in greater activation for several visual areas, including occipital gyrus, lingual gyrus, and fusiform gyrus (see Table 3, Fig. 3).

When contrasted with the baselines, however, both agency and communion showed reduced activation in vACC and mOFC (see Fig. 1), which was even lower for communion than agency. That is, communal content appears to involve greater deactivation during the word classification task.

To identify whether or not there was an effect of valence on word categorization, we computed the main effect of valence and the interaction of content dimension (agency/communion) and valence (negative/positive). Our primary interest areas, vACC, mOFC, and other brain regions discussed above, showed no significant differences ($-2.31 < t_s < 2.44$) in activation as a function of word valence or the interaction of word valence and content dimension (Alphasim corrected, $p < 0.01$). Hence, the effects obtained as a function of content dimension were independent of valence.

Discussion

The current research explored brain activations related to the processing of communal and agentic content by using a valence classification task. Regions related to mentalizing including the cerebellum, superior frontal gyrus, insula, putamen, along with the inferior parietal gyrus related to the mirror system, were activated. mOFC, vACC, the middle temporal gyrus, superior temporal gyrus, and precuneus were deactivated by both communal and agentic words. The results further indicated that when comparing content dimension, communal words led to more deactivation in vACC and mOFC than agentic words, and communal content compared to agentic content led to increased activations in certain visual areas (e.g., middle occipital gyrus, fusiform gyrus). These activation patterns were present regardless of the emotional valence of the communal and agentic words.

The common neural mechanisms of agency and communion

The role of mentalizing in categorizing the favorability of agentic and communal words

Among the similarities in activation patterns, the cerebellum's role was highlighted. The cerebellum is known as a sensorimotor area, however, it also involves higher-order cognitive, affective, and personality related processing, especially cerebellum lobule VI (Picerni et al., 2013; Stoodley, Valera, & Schmahmann, 2012). The activations of cerebellum lobule VI in the present study suggest it may play a role in processing social cognitive information (Van Overwalle et al., 2014; Garrard, Martin, Giunti, & Cipolotti, 2008).

Another area activated in response to both agentic and communal information was the

insula. Activations of the insular cortex have been associated with the motivation to approach others, such as cooperation, compassion, admiration, and romantic or maternal love (Lamm & Singer, 2010). These responses fit under the communion category. On the other hand, recent evidence points to the insula as important for the sense of agency and attribution of actions to the self (Craig, 2009; Farrer & Frith, 2002). In other words, the insula has been identified as participating in the experience of self, suggesting that insular activations are also related to agentic content.

The superior frontal gyrus is activated when perceivers are modeling and trying to predict others' behaviors, for example, engaging theory of mind (Cui, Bryant & Reiss, 2012). In the current task, activations in the superior frontal gyrus also contained parts of dorsal ACC/posterior mPFC (see, Fig. 2), which play an important role in modulation of attention and executive functioning (Bush, Luu, & Posner, 2000; Bush, Luu, & Posner, 2000). Hence, it makes sense that activations of the superior frontal gyrus could be related to the agency and communion content, or the cognitive processing during the whole task.

The putamen also showed activation for both agency and communion-related content. This finding is concordant with reports in recent neuroimaging research indicating that the putamen is engaged in inferring and comprehending others' mental states (Herve', Razafimandimby, Jobard & Tzourio-Mazoyer, 2013; Abu-Akel & Shamay-Tsoory, 2011). In addition to mentalizing processes, both communion-related stimuli (Maternal and romantic

love) and agency related stimuli (goal accomplishment) have been implicated in recruitment of the putamen (Balleine, Delgado, & Hikosaka, 2007; Bartels & Zeki, 2004).

Finally, the IPL, which is related to social cognitive processing in the mirror system, also activated in response to both agentic and communal content (Van Overwalle, 2009). The IPL is involved in imitating social behaviors and encoding intentions behind others' actions (Koenigs, Barbey, Postle, & Grafman, 2009). Moreover, even imagining actions can influence IPL activation (Gerardinet al., 2000). Thus, IPL activation may not only have occurred because agentic and communal traits can be used to describe others' behaviors, but also because they can convey motivation (Trapnell & Paulhus, 2012), which may have prompted people to imagine the related behaviors.

In summary various neural activation similarities exist when processing both communal and agentic content, despite dissociating content from perspective (self vs. other) in the present study. Many of these similarities may have their basis in the recruitment of shared social cognitive processes to simulate and infer meaning about others and their behavior.

The role of DMN in categorizing the favorability of agentic and communal words

In addition, the similar brain responses between agency and communion also included some deactivations, such as mOFC, vACC, the middle temporal gyrus, the posterior superior temporal gyrus, and precuneus. These areas all play core roles in mentalizing. Specifically, the vACC and mOFC are part of the mPFC, which is not only subserves executive

functioning (Gazzaniga, Ivry, & Mangun, 2008), but also is typically associated with inferring enduring dispositions of others and the self (Van Overwalle, 2009). In the present study, deactivations were also present for parts of TPJ (e.g. the posterior superior temporal gyrus, see Fig.2; cf. Michael et al., 2014), which have been implicated in diverse social cognitive experimental paradigms that manipulate decision making or making inferences of others' goals and desires (Carter & Huettel, 2014; Van Overwalle, 2009). Complex social processes, such as mental state inference, impression formation, spontaneous trait inferences, and behavioral predictions also rely on the precuneus (Lee & Harris, 2013). In the present study, these core mentalizing areas showed deactivations. Such deactivations may be implicated in task processing.

The mPFC, precuneus, and lateral temporal cortex can be regarded as part of the default mode network (DMN; Gazzaniga, Ivry, & Mangun, 2008; Mannell et al., 2010). When people are in the resting-state, DMN activation relates to explicit, conscious representations of the self (Gusnard & Raichle, 2001). The present tasks including valence classification and the fixation baseline did not ask participants to contemplate the self. Thus, high neuronal activity in DMN during resting-state was inhibited in the present tasks, which required participants to attend to complex external stimuli that did not refer to the self (Grimm et al., 2008; Mannell et al., 2010). This appears to reflect task induced deactivation (TID) in DMN. Previous studies have argued that the magnitude of TID reflects the reallocation of attention from rest

state to task state or from task irrelevant regions to task relevant regions (Takeuchi et al., 2011). The fixation baseline task is easier to perform than the valence classification task, so fewer resources in mPFC, precuneus, and lateral temporal cortex during baseline will be reallocated compared to performing the valence classification task. So, communion and agency appear to represent deactivations when contrasted separately with the baseline. Such deactivations may play a role in preparing for deeper social-cognitive processing.

The distinct neural mechanisms of agency and communion

Apart from these similar brain responses, the main differences between the processing of agentic and communal information were restricted to vACC and mOFC. The results indicated that vACC and mOFC showed greater deactivations in the communal condition than agentic condition.

The role of vACC in categorizing the favorability of agentic and communal words

The different activations between agency and communion are unlikely to result from differences in emotional information. The vACC is usually activated during emotional and motivational information processing (Bush, Luu, & Posner, 2000), but it also can be characterized by deactivation in various emotional-cognitive tasks (Grimm et al., 2006). However, the emotional valence of the stimulus words in the present study were balanced between communion and agency, so the distinct activations may be due to people having different understandings and consequent cognitive activity for communion compared to

agency, rather than emotional information differences. Therefore, deactivation in vACC in the present study can be viewed as a part of TID. Communion showed greater deactivation in vACC than agency in the present study, which could be due to larger allocation of attentional resources to posterior visual areas including the occipital gyrus and fusiform gyrus (Koshino et al., 2011). Consistent with this view, various visual areas evinced greater activation in response to communal information, suggesting that participants needed more processing resources to judge communal words, and these resources likely came from vACC. In addition, the increased activation of visual areas in response to communal content, which is also associated with spatial attention (Mangun, Buonocore, Girelli, & Jha, 1998), has been shown to enhance the visual representation of stimuli (Fan et al., 2007; Prinzmetal, McCool, & Park, 2005). These results suggest that compared to agentic information, communal information is more likely to capture visual attention, which can be taken as an indication that participants cared more about communal information.

There is another potential explanation for the distinct deactivations in vACC, which speak more broadly about cognitive activity and not allocation of attentional resources. The observed deactivations may represent attempts to inhibit cognitive activity irrelevant to task performance (Takeuchi et al., 2011). Combining the behavior and fMRI results, deactivation in vACC may represent greater suppression of distributed cognitive processing, which may facilitate behavior performance. This is consistent with the previous research findings

indicating a positive relationship between the magnitude of TID and task performance (Sambataro et al., 2010).

In addition, these different activations also accord with previous research on the two fundamental dimensions showing that communion information is preferentially processed (Wojciszke et al., 1998; Ybarra et al., 2001). Although whether another person can act in ways that benefit or harm the self depends on their capacity to carry out different behaviors (e.g., to lie, to help) (cf. Abele & Wojciszke, 2007; Fiske et al., 2007), a perceivers' assessments of another's capabilities to enact actions (i.e., be agentic) has limited meaning if others' intentions and interpersonal purposes (to help or harm) are not known. Thus, it makes sense that communal information is preferentially processed, as it is relatively more important for social navigation. It is possible that the greater deactivations of vACC may serve to inhibit irrelevant cognitive processing to provide more processing resources to visual areas, ensuring people pay more attention to communion-related information. Put differently, the processing of communal information may induce more concentrated effort.

The role of mOFC in categorizing the favorability of agentic and communal words

The other unique activations between communion and agency involved mOFC, which is implicated in higher order cognition including social decision-making and monitoring reward- and punishment-related learning (Powell, Lewis, Dunbar, García-Fiñana, & Roberts, 2010; Rolls, Everitt, & Roberts, 1996). Deactivation in the mOFC can also be regarded as

potentially reflecting a reallocation of attention, or inhibition of irrelevant cognitive activity similar to the vACC (Powell et al., 2010).

It is important to note that the differences in neural activations in response to the agentic and communal content were small. The size of the observed effects may be limited by the nature of the present task (classification of a word's valence) and the degree of processing and elaboration the task elicits. It may be that tasks that induce deeper social cognitive processing or differing perspectives (other vs. self) may elicit greater differences in the neural correlates of the fundamental dimensions.

Related to the issue of the task used in this study, we hypothesized that some brain regions in the frontal and temporal lobes would activate, such as the PFC and TPJ. In contrast, these hypothesized areas showed deactivations. These brain regions are usually implicated in tasks that induce deeper social-cognitive processing, such as making trait-inferences and identifying intentions (Mitchell et al., 2006; Van Overwalle, 2009). It may be that the simpler word valence classification task used in the present study, without instruction to make sense of others or the self, did not induce this deeper kind of social cognitive processing.

Nevertheless, the simple nature of the task provided a context for isolating the effects of communion and agency related content. In addition, although we expected that the amygdala would be activated when classifying the valence of the words, the absence of amygdala activation in the present study may be due to the stimulus words not arousing strong enough

emotional responses.

It is necessary to repeat and extend our experiment in future research. First, the magnitude of the activations for agentic and communal words were lower than the baseline. This may be due to the nature of the implicit baseline or fixation task. For example, the fixation task may be associated with unconstrained thought, and the implicit baseline averages over several variables, some of which may be difficult to control. Thus, in future research, a baseline task that can control for muscle recruitment or eye movement unrelated to the studied tasks will be useful to implement, such as a font judgment task. Second, the current research focused mainly on the brain regions relevant for mentalizing. However, apart from mentalizing, the mirror system is implicated in the understanding of others' non-verbal behaviors and movements (Van Overwalle et al., 2014). Although the current study did not require participants to infer the purpose of others' actions, an area of the mirror system was activated nevertheless. Many other studies of social cognition have also relied on non-action based stimuli for processing. Thus, it would be interesting to assess the neuromechanisms implicated when people process communion and agency related actions and not personality adjectives that represent more generalized or abstract behavioral tendencies and even mental states.

Conclusions

The present research is one of the first to directly explore the neural representation of the

two fundamental dimensions of social cognition. Our findings suggest that some areas such as the cerebellum, insula, and superior frontal gyrus—areas closely related to mentalizing, and the inferior parietal gyrus — related to the mirror system, were activated by both communal and agentic words. Because the current task did not ask participants to contemplate the self, some areas of the DMN, such as mOFC, vACC, and TPJ, showed deactivations in both the agentic and communal condition, reflecting task induced deactivation. Furthermore, vACC and mOFC were marked by greater deactivations when categorizing communal words than agentic words, which may reflect greater attention and engagement with communion-related content. The findings indicate both similarities but also differences when individuals process information from the fundamental dimensions. Such differences have potential implications for the many studies that examine social cognitive processing, as it may be less than clear the degree to which the task or the content of the information to be processed plays a role in the observed activations.

Acknowledgements

We thank Dr. Ethan Kross for his comments and suggestions on an earlier version of the manuscript; Dr. Pan Feng, Dr. Yangmei Luo, and Hongwen Song for technical help in analyzing the data; we also thank Jiyuan Zhang for assistance in designing the experiment, and we thank Xuan Li for help in the data collection for the pilot study.

References

- Abele, A. E., & Bruckmüller, S. (2011). The bigger one of the “Big Two”? Preferential processing of communal information. *Journal of Experimental Social Psychology*, 47(5), 935-948. doi:10.1016/j.jesp.2011.03.028.
- Abele, A. E., & Wojciszke, B. (2007). Agency and communion from the perspective of self versus others. *Journal of Personality and Social Psychology*, 93(5), 751-763. doi:10.1037/0022-3514.93.5.751.
- Abele, A. E., & Wojciszke, B. (2013). The Big two in social judgment and behavior. *Social Psychology*, 44(2), 61-62. doi:10.1027/1864-9335/a000137.
- Abu-Akel, A., & Shamay-Tsoory, S. (2011). Neuroanatomical and neurochemical bases of theory of mind. *Neuropsychologia*, 49, 2971-2984. doi:10.1016/j.neuropsychologia.2011.07.012.
- Adcock, A., Thangavel, A., Whitfield-Gabrieli, S., Knutson, B., & Gabrieli, J., D., E. (2006). Reward-motivated learning: Mesolimbic activation precedes memory formation. *Neuron*, 50, 507-517. doi:10.1016/j.neuron.2006.03.036.
- Bakan, D. (1966). *The duality of human existence*. Chicago: Rand McNally.
- Balleine, B., Delgado, M., & Hikosaka, O. (2007). The role of the dorsal striatum in reward and decision-making. *The Journal of Neuroscience*, 27(31), 8161-8165. doi:10.1523/jneurosci.1554-07.2007.
- Bartels, A., & Zeki, S. (2004). The neural correlates of maternal and romantic love.

NeuroImage, 21: 1155-1166. doi:10.1016/j.neuroimage.2003.11.003.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in cognitive sciences*, 4(6), 215-222. doi:10.1016/S1364-6613(00)01483-2.

Chance, M. R. A. (1988). *Social fabrics of the mind*. Hillsdale, NJ: Lawrence Erlbaum.

Craig, A. (2009). How do you feel—now? The anterior insula and human awareness. *Neuroscience*, 10, 59-70. doi:10.1038/nrn2555.

Cui, X., Bryant, D. M., & Reiss, A. L. (2012). NIRS-based hyperscanning reveals increased interpersonal coherence in superior frontal cortex during cooperation. *NeuroImage*, 59(3), 2430-2437. doi:10.1016/j.neuroimage.2011.09.003.

Eddy, C. M., Beck, S. R., Mitchell, I. J., Praamstra, P., & Pall, H. S. (2013). Theory of mind deficits in Parkinson's disease: a product of executive dysfunction? *Neuropsychology*, 27(1), 37. doi:10.1037/a0031302.

Elliott, R., Friston, K. J., & Dolan, R. J. (2000). Dissociable neural responses in human reward systems. *The Journal of Neuroscience*, 20(16), 6159-6165. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/10934265>.

Eslinger, P., Moll, J., & Oliveira-Souza, R. (2002). Emotional and cognitive processing in empathy and moral behavior. *Behavioral and Brain Science*, 25(1), 34. doi:10.1017/S0140525X02360011

Fan, J., Kolster, R., Ghajar, J., Suh, M., Knight, R. T., Sarkar, R., & McCandiss, B.D. (2007).

Response anticipation and response conflict: an event-related potential and functional magnetic resonance imaging study. *The Journal of Neuroscience*, 27(9), 2272-2282.
doi:10.1523/jneurosci.3470-06.2007.

Farrer, C., & Frith, C. D. (2002). Experiencing oneself vs. another person as being the cause of an action: the neural correlates of the experience of agency. *NeuroImage*, 15, 596-603. doi:10.1006/nimg.2001.1009.

Fiske, S. T., Cuddy, A. J., & Glick, P. (2007). Universal dimensions of social cognition: Warmth and competence. *Trends in cognitive sciences*, 11(2), 77-83.
doi:10.1016/j.tics.2006.11.005.

Fossati, P., Hevenor, S. J., Graham, S. J., Grady, C., Keightley, M. L., Craik, F., ... Mayberg, H. (2003). In search of the emotional self: An fMRI study using positive and negative emotional words. *American Journal of Psychiatry*, 160(11), 1938-1945.
doi:10.1176/appi.aip.160.11.1938.

Friston, K. J., Holmes, A. P., Worsley, K. J., Poline, J. P., Frith, C. D., & Frackowiak, R. S. J. (1994). Statistical parametric maps in functional imaging: a general linear approach. *Human Brain Mapping*, 2(4), 189-210. doi: 10.1002/hbm.460020402.

Fumagalli, M., & Priori, A. (2012). Functional and clinical neuroanatomy of morality. *Brain*, 135(7), 2006-2021. doi:10.1093/brain/awr334.

Garrard, P., Martin, N., Giunti, P., & Cipolotti, L. (2008). Cognitive and social cognitive

functioning in spinocerebellar ataxia. *Journal of neurology*, 255(3), 398-405.

doi:10.1007/s00415-008-0680-6.

Gazzaniga, M., S., Ivry, R., B., Mangun, G., R. (2008). *Cognitive neurosciences: The biology*

of the mind (3rd Edition). New York: W. W. Norton & Company press.

Gerardin, E., Sirigu, A., Lehericy, S., Poline, J-B., Gaymard, B., Marsault, C., ... Le Bihan, D.

(2000). Partially overlapping neural networks for real and imagined hand movements.

Cerebral Cortex, 10(11), 1093-1104. doi:10.1093/cercor/10.11.1093.

Grimm, S., Schmidt, C., F., Bermpohl, F., Heinzl, A., Dahlem, Y., Wyss, M., ... Northoff, G.

(2006). Segregated neural representation of distinct emotion dimensions in the

prefrontal cortex- an fMRI study. *NeuroImage* 30 (1), 325-340.

doi:10.1016/j.neuroimage.2005.09.006.

Grimm, S., Boesiger, P., Beck, J., Schuepbach, D., Bermpohl, F., Walter, M., ...Northoff, G.

(2008). Altered negative BOLD responses in the default-mode network during

emotion processing in depressed subjects. *Neuropsychopharmacology*, 34(4), 932-943.

doi:10.1038/npp.2008.81.

Gusnard, D., A., & Raichle, M., E. (2001). Searching for a baseline: functional imaging and

the resting human brain. *Nature Reviews Neuroscience*, 2(10), 685-694.

doi:10.1038/35094500.

Hamberger, M. J., Habeck, C. G., Pantazatos, S. P., Williams, A. C., & Hirsch, J. (2013).

Shared space, separate processes: neural activation patterns for auditory description and visual object naming in healthy adults. *Human Brain Mapping*, 35(6), 2507-2520. doi:10.1002/hbm.22345.

Han, M. F., Ybarra, O., & Bi, C. Z. (2015). Chinese Adjective Words System for

Fundamental Dimensions of Social Cognition. *Journal of Southwest University (Natural Science Edition)*, 37. (in Chinese). doi:10.13718/j.cnki.xdzk.2015.08.001.

Harenski, C. L., & Hamann, S. (2006). Neural correlates of regulating negative emotions

related to moral violations. *Neuroimage*, 30(1), 313-324. doi:10.1016/j.jpsychires.2010.09.007.

Herve', P-Y., Razafimandimby, Y., Jobard, G., & Tzourio-Mazoyer, N. (2013). A shared

neural substrate for mentalizing and the affective component of sentence comprehension. *PloS one*, 8(1), e54400. doi:10.1371/journal.pone.0054400.

Hogan, R. (1983). A socioanalytic theory of personality. In M. M. Page (Ed.), *Nebraska*

symposium on motivation (pp. 336-355). Lincoln, NE: University of Nebraska Press.

Howard-Snyder, F. (2005). It's the Thought that Counts. *Utilitas*, 17(3), 265-281.

doi:10.1017/S0953820805001640.

Huang, L., Yang, T. Z., & Ji, Z. M. (2003). Applicability of positive and negative affect scale

in Chinese. *Chinese Mental Health Journal*, 17(1), 54-56. (in Chinese).

- Huang, X. T., & Zhang, S. L. (1992). Desirability, meaningfulness and familiarity ratings of 562 personality-trait adjectives. *Journal of Psychological Science*, 5, 17-22. (in Chinese).
- Huebner, B., Dwyer, S., & Hauser, M. (2009). The role of emotion in moral psychology. *Trends in cognitive sciences*, 13(1), 1-6. doi:10.1016/j.tics.2008.09.006.
- Hughes, B. L., & Beer, J. S. (2012). Orbitofrontal cortex and anterior cingulate cortex are modulated by motivated social cognition. *Cerebral Cortex*, 22(6), 1372-1381. doi:10.1093/cercor/bhr213.
- Humphrey, N., K. (1976). The social function of intellect. In P. P. G. Bateson & R. A. Hinde (Eds.), *Growing points in ethology* (pp. 303-317). Cambridge, UK: Cambridge University Press.
- Inagaki, T. K., & Eisenberger, N. I. (2013). Shared neural mechanisms underlying social warmth and physical warmth. *Psychological Science*, 24, 2272-2280. doi:10.1177/0956797613492773.
- Kenworthy, J. B., & Tausch, N. (2008). Expectations about the accuracy and stability of warmth versus competence traits: An intergroup analysis. *European Journal of Social Psychology*, 38(7), 1121-1129. doi:10.1002/ejsp.543.
- Koenigs, M., Barbey, A. K., Postle, B. R., & Grafman, J. (2009). Superior parietal cortex is critical for the manipulation of information in working memory. *The Journal of*

- Neuroscience, 29(47), 14980-14986. doi:10.1523/jneurosci.3706-09.2009.
- Koshino, H., Minamoto, T., Ikeda, T., Osaka, M., Otsuka, Y., & Osaka, N. (2011). Anterior medial prefrontal cortex exhibits activation during task preparation but deactivation during task execution. *PloS one*, 6(8), e22909. doi:10.1371/journal.pone.0022909.
- Kuo, W.-J., Yeh, T.-C., Lee, J.-R., Chen, L.-F., Lee, P.-L., Chen, S.-S., ... Hsieh, J.-C. (2004). Orthographic and phonological processing of Chinese characters: an fMRI study. *NeuroImage*, 21(4), 1721-1731. doi:10.1016/j.neuroimage.2003.12.007.
- Lamm, C., & Singer, T. (2010). The role of anterior insular cortex in social emotions. *Brain Structure and Function*, 214 (5-6), 579-591. doi:10.1007/s00429-010-0251-3.
- Ledberg, A., Åkerman, S., & Roland, P. E. (1998). Estimation of the probabilities of 3D clusters in functional brain images. *NeuroImage*, 8, 113–128. doi:10.1006/nimg.1998.0336.
- Lee, V., K., & Harris, L., T. (2013). How social cognition can inform social decision making. *Neuroscience*, 7, 1-13. doi: 10.3389/fnins.2013.00259.
- Lidzba, K., Ebner, K., Hauser, T-K., & Wilke, M. (2013). Complex visual search in children and adolescents: effects of age and performance on fMRI activation. *PloS one*, 8(12), e85168. doi:10.1371/journal.pone.0085168.
- Mangun, G. R., Buonocore, M. H., Girelli, M., & Jha, A. P. (1998). ERP and fMRI measures of visual spatial selective attention. *Human Brain Mapping*, 6(5-6), 383-389.

doi:10.1002/(SICI)1097-0193(1998)6:5/6<383::AID-HBM>3.0.CO;2-Z.

Mannell, M. V., Franco, A. R., Calhoun, V. D., Cañive, J. M., Thoma, R. J., & Mayer, A. R.

(2010). Resting state and task-induced deactivation: A methodological comparison in patients with schizophrenia and healthy controls. *Human Brain Mapping*, 31(3), 424-437. doi:10.1002/hbm.20876.

Mar, R. A. (2011). The neural bases of social cognition and story comprehension. *Annual*

Review of Psychology, 62, 103-134. doi: 10.1146/annurev-psych-120709-145406.

Matsumoto, K., & Tanaka, K. (2004). The role of the medial prefrontal cortex in achieving

goals. *Current Opinion in Neurobiology*, 14(2), 178-185.

doi:10.1016/j.conb.2004.03.005.

Mende-Siedlecki, P., Baron, S. G., & Todorov, A. (2013). Diagnostic value underlies

asymmetric updating of impressions in the morality and ability domains. *The Journal of Neuroscience*, 50, 19406-19415. doi:10.1523/jneurosci.2334-13.2013.

Michael, B., Cindy, L., H., Lisa, B., Ashok, K., M., Ridha, J., & Martin, L. (2014). Cortical

thinning in temporo-parietal junction (TPJ) in non-affective first-episode of psychosis patients with persistent negative symptoms. *Plos one*, 9(6), p. e101372.

doi:10.1371/journal.pone.0101372.

Mitchell, J. P., Cloutier, J., Banaji, M. R., & Macrae, C. N. (2006). Medial prefrontal

dissociations during processing of trait diagnostic and nondiagnostic person

information. *Social Cognitive and Affective Neuroscience*, 1(1), 49-55.

doi:10.1093/scan/nsl007.

Nestor, P. G., Nakamura, M., Niznikiewicz, M., Thompson, E., Levitt, J. J., Choate,

V., ...McCarley, R. W. (2013). In search of the functional neuroanatomy of sociality:

MRI subdivisions of orbital frontal cortex and social cognition. *Social Cognitive and*

Affective Neuroscience, 8(4), 460-467. doi:10.1093/scan/nss018.

Ng, S. H., Han, S., Mao, L., & Lai, J. C. L. (2010). Dynamic bicultural brains: fMRI study of

their flexible neural representation of self and significant others in response to culture

primes. *Asian Journal of Social Psychology*, 13, 83-91. doi:10.1111/j.1476-

839X.2010.01303.x.

Picerni, E., Petrosini, L., Piras, F., Laricchiuta, D., Cutuli, D., Chiapponi, C., ...Spalletta, G.

(2013). New evidence for the cerebellar involvement in personality traits. *Frontiers in*

behavioral neuroscience, 7, 133. doi: 10.3389/fnbeh.2013.00133.

Powell, J. L., Lewis, P. A., Dunbar, R. I., García-Fiñana, M., & Roberts, N. (2010). Orbital

prefrontal cortex volume correlates with social cognitive competence.

Neuropsychologia, 48(12), 3554-3562. doi:10.1016/j.neuropsychologia.2010.08.004.

Prinzmetal, W., McCool, C., & Park, S. (2005). Attention: reaction time and accuracy reveal

different mechanisms. *Journal of Experimental Psychology General*, 134(1), 73-92.

doi:10.1037/0096-3445.134.1.73.

Quirin, M., Meyer, F., Heise, N., Kuhl, J., Küstermann, E., Strüber, D., & Cacioppo, J. T.

(2013). Neural correlates of social motivation: an fMRI study on power versus affiliation. *International Journal of Psychophysiology*, 88(3), 289-295.

doi:10.3389/fnhum.2013.00902.

Reisz, Z., Boudreaux, M. J., & Ozer, D. J. (2013). Personality traits and the prediction of personal goals. *Personality and Individual Differences*, 55(6), 699-704.

doi.org/10.1016/j.paid.2013.05.023.

Research Group. (2008). *Lexicon of common words in contemporary Chinese*. Beijing: The Commercial Press.

Rolls, E. T., Everitt, B., & Roberts, A. (1996). The orbitofrontal cortex. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*,

351(1346), 1433-1444. doi:10.1016/j.jrp.2013.01.007.

Sambataro, F., Murty, V. P., Callicott, J. H., Tan, H-Y., Das, S., Weinberger, D. R., & Mattay,

V. S. (2010). Age-related alterations in default mode network: impact on working memory performance. *Neurobiology of Aging*, 31(5), 839-852.

doi:10.1016/j.neurobiolaging.2008.05.022.

Sax, R., & Powell, L. J. (2006). It's the thought that counts: Specific brain regions for one component of theory of mind. *Psychological Science*, 17(8), 692-699.

doi:10.1111/j.1467-9280.2006.01768.x.

Schultheiss, O. C., Wirth, M. M., Waugh, C. E., Stanton, S. J., Meier, E., & Reuter-Lorenz, P.

(2008). Exploring the motivational brain: effects of implicit power motivation on brain activation in response to facial expressions of emotion. *Social Cognitive and Affective Neuroscience*, 3(4), 333-343. doi:10.1093/scan/nsn030.

Shenhav, A., & Greene, J. D. (2010). Moral judgments recruit domain-general valuation

mechanisms to integrate representations of probability and magnitude. *Neuron*, 67(4), 667-677. doi:10.1016/j.neuron.2010.07.020.

Stoodley, C. J., Valera, E. M., & Schmahmann, J. D. (2012). Functional topography of the

cerebellum for motor and cognitive tasks: an fMRI study. *NeuroImage*, 59(2), 1560-1570. doi: 10.1016/j.neuroimage.2011.08.065.

Straube, T., Sauer, A., & Miltner, W. H. (2011). Brain activation during direct and indirect

processing of positive and negative words. *Behavioural brain research*, 222(1), 66-72. doi: 10.1016/j.bbr.2011.03.037.

Stark, C., E., L., & Squire, L., R. (2001). When zero is not zero: The problem of ambiguous

baseline conditions in fMRI. *PNAS*, 98(22), 12760-12766. doi:10.1073/pnas.221462998.

Swencionis, K., J., & Fiske, S., T. (2014). How social neuroscience can inform theories of

social comparison. *Neuropsychologia*, 56, 140-146. doi:10.1016/j.neuropsychologia.2014.01.009.

Takeuchi, H., Taki, Y., Hashizume, H., Sassa, Y., Nagase, T., Nouchi, R., & Kawashima, R.

(2011). Failing to deactivate: the association between brain activity during a working memory task and creativity. *NeuroImage*, 55(2), 681-687.

doi:10.1016/j.neuroimage.2010.11.052.

Trapnell, P. D., & Paulhus, D. L. (2012). Agentic and Communal Values: Their Scope and Measurement. *Journal of Personality Assessment*, 94(1), 39-52.

doi:10.1080/00223891.2011.627968.

Van Overwalle, F. (2009). Social cognition and the brain: a meta-analysis. *Human brain mapping*, 30(3), 829-858. doi: 10.1002/hbm.20547.

Van Overwalle, F., & Baetens, K. (2009). Understanding others' actions and goals by mirror and mentalizing systems: a meta-analysis. *Neuroimage*, 48(3), 564-584.

doi:10.1016/j.neuroimage.2009.06.009.

Van Overwalle, F., Baetens, K., Mariën, P., & Vandekerckhove, M. (2014). Social cognition and the cerebellum: A meta-analysis of over 350 fMRI studies. *Neuroimage*, 86, 554-

572. doi:10.1016/j.neuroimage.2013.09.033.

Wang, D. F., & Cui, H. (2005). Explorations of Chinese personality. Beijing: Social Sciences Academic Press. (in Chinese).

Wang, Y. N., Zhou, L. M., & Lou, Y. J. (2008). The pilot establishment and evaluation of

Chinese affective words system. *Chinese Mental Health Journal*, 22(8), 608-612. (in

Chinese).

- Wiggins, J. S. (1991). Agency and communion as conceptual coordinates for the understanding and measurement of interpersonal behavior. In D. Cicchetti & W. M. Grove (Eds.), *Thinking clearly about psychology: Essays in honor of Paul E. Meehl*, Vol. 2: Personality and psychopathology (pp. 89–113). Minneapolis, MN: University of Minnesota Press.
- Wilson, E. O. (2012). *The social conquest of earth*. New York: Liveright.
- Wojciszke, B., Baryla, W., Parzuchowski, M., Szymkow, A., & Abele, A. E. (2011). Self-esteem is dominated by agentic over communal information. *European Journal of Social Psychology* 41(5): 617-627. doi:10.1002/ejsp.791.
- Wojciszke, B., Bazinska, R., & Jaworski, M. (1998). On the dominance of moral categories in impression formation. *Personality and Social Psychology Bulletin*, 24(12), 1251-1263. doi:10.1177/01461672982412001.
- Ybarra, O., Chan, E., & Park, D. (2001). Young and old adults' concerns about morality and competence. *Motivation and Emotion*, 25(2), 85-100. doi:10.1023/A:1010633908298.
- Ybarra, O., Chan, E., Park, H., Burnstein, E., Monin, B., & Stanik, C. (2008). Life's recurring challenges and the fundamental dimensions: An integration and its implications for cultural differences and similarities. *European Journal of Social Psychology*, 38(7), 1083-1092. doi:10.1002/ejsp.559.

- Young, L., & Dungan, J. (2012). Where in the brain is morality? Everywhere and maybe nowhere. *Social Neuroscience*, 7(1), 1-10. doi:10.1162/jocn.2009.21137.
- Young, L., & Saxe, R. (2009). An fMRI investigation of spontaneous mental state inference for moral judgment. *Journal of cognitive neuroscience*, 21(7), 1396-1405. doi:10.1162/jocn.2009.21137.
- Zhu, Y., & Zhang, L. (2002). An experimental study on the self-reference effect. *Science in China Series C: Life Sciences*, 45(2), 120-128. doi:10.1360/02yc9014.

Table 1

Response latencies for the word judgment task (msec).

Traits	Mean	Std. Deviation
Agency positive	766.04	99.44
Agency negative	809.89	103.04
Communion positive	753.22	94.97
Communion negative	799.91	108.28

Table 2

Conjunction of BOLD Signal for Agentic and Communal Words.

Anatomical region	Compared to implicit baseline					Compared to fixation task				
	MNI Coordinates (X, Y, Z)			<i>t</i> -value	cluster size	MNI Coordinates (X, Y, Z)			<i>t</i> -value	cluster size
Activation										
Cerebellum										
L cerebellum VI						-42	-57	-24	6.87	313
R cerebellum VI	26	-54	-24	7.50	353	30	-54	-24	9.48	483
R cerebellumIV- V	22	-50	-24	6.71	148					
Frontal gyrus										
L superior frontal gyrus	-14	-8	74	6.18	203	-30	-9	69	6.45	161
L supplement motor area	-4	6	52	10.38	911	-3	9	51	9.42	382
R supplement motor area	2	6	54	8.67	616	3	6	54	6.28	188
L precentral gyrus	-32	-14	68	6.63	793	-36	-12	66	7.49	611
Occipital gyrus										
L middle occipital gyrus	-24	-98	-2	15.13	647	-15	-90	-6	14.55	452
R middle occipital gyrus	28	-94	0	14.36	188	24	-96	6	11.51	140
L inferior occipital gyrus	-26	-96	-6	14.69	620	-18	-93	-9	13.84	292
R inferior occipital gyrus	28	-94	-2	14.75	521	24	-93	-3	9.20	230
L fusiform gyrus	-36	-86	-14	8.87	378	-30	-78	-12	10.00	395
R fusiform gyrus	40	-52	-24	4.35	74	27	-81	-9	9.86	365
Temporal gyrus										
R inferior temporal gyrus	44	-74	-8	5.29	96					
L lingual gyrus						-18	-90	-12	12.79	171
R lingual gyrus	24	-90	-2	12.93	93	21	-87	-3	11.26	279
Parietal gyrus										
L inferior parietal gyrus	-56	-24	50	7.09	346	-27	-57	42	6.54	227
L postcentral gyrus	-60	-18	26	6.78	743	-57	-18	48	6.76	480
Insula										
L insula	-44	0	6	7.80	646	-33	18	12	5.50	244
Subcortical structures										
L putamen	-24	-6	14	6.29	386	-24	12	12	5.38	204

A correct voxel-wise threshold of $p < 0.01$ (AlphaSim corrected) was used, and the coordinates, cluster size, and t-values relate to activations of the single brain region listed in the table.

Table 3

Identification of BOLD Signal for Agentic and Communal Words.

Region	MNI coordinates			<i>t</i> -value	Cluster
	x	y	z		Size
Agency vs. Communion					
Frontal gyrus					
R medial orbitofrontal gyrus	0	24	-10	4.04	110
L ventral anterior cingulate	0	24	-6	4.60	94
R ventral anterior cingulate	2	24	-6	4.62	86
L caudate	-4	18	-6	3.80	133
Communion vs. Agency					
Occipital gyrus					
R middle occipital gyrus	30	-86	8	4.19	196
Temporal gyrus					
R fusiform gyrus	26	-66	-12	3.63	222

A correct voxel-wise threshold of $p < 0.01$ (AlphaSim corrected) was used, and the coordinates, cluster size, and *t*-values relate to activations of the single brain region listed in the table.

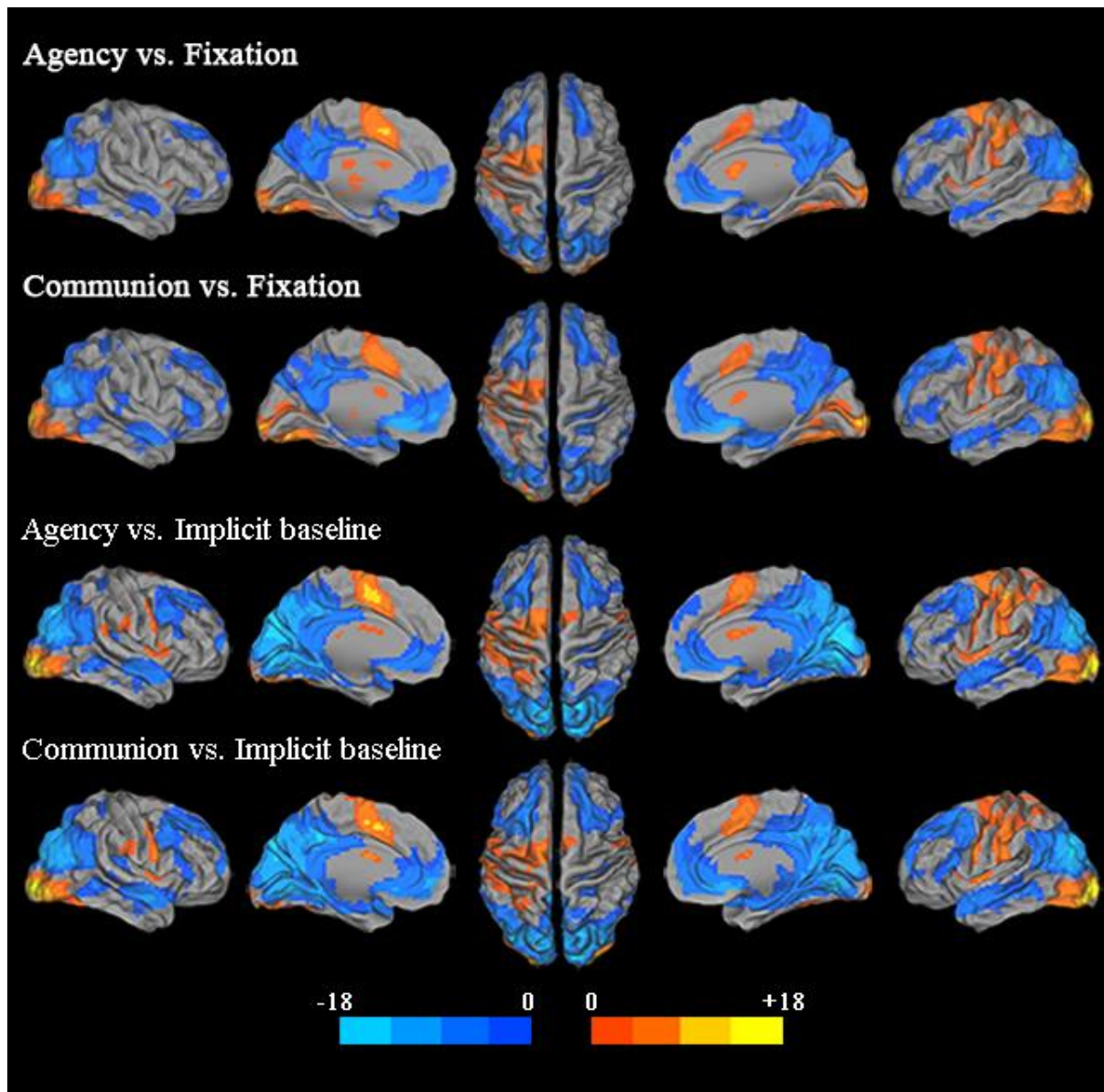


Fig.1. Regions showing significant increased (red) and decreased (blue) activation in the contrast of Agency vs. Fixation, Communion vs. Fixation, Agency vs. Implicit baseline, and Communion vs. Implicit baseline. The activations were reported with Alphasim correction of $p < 0.01$.

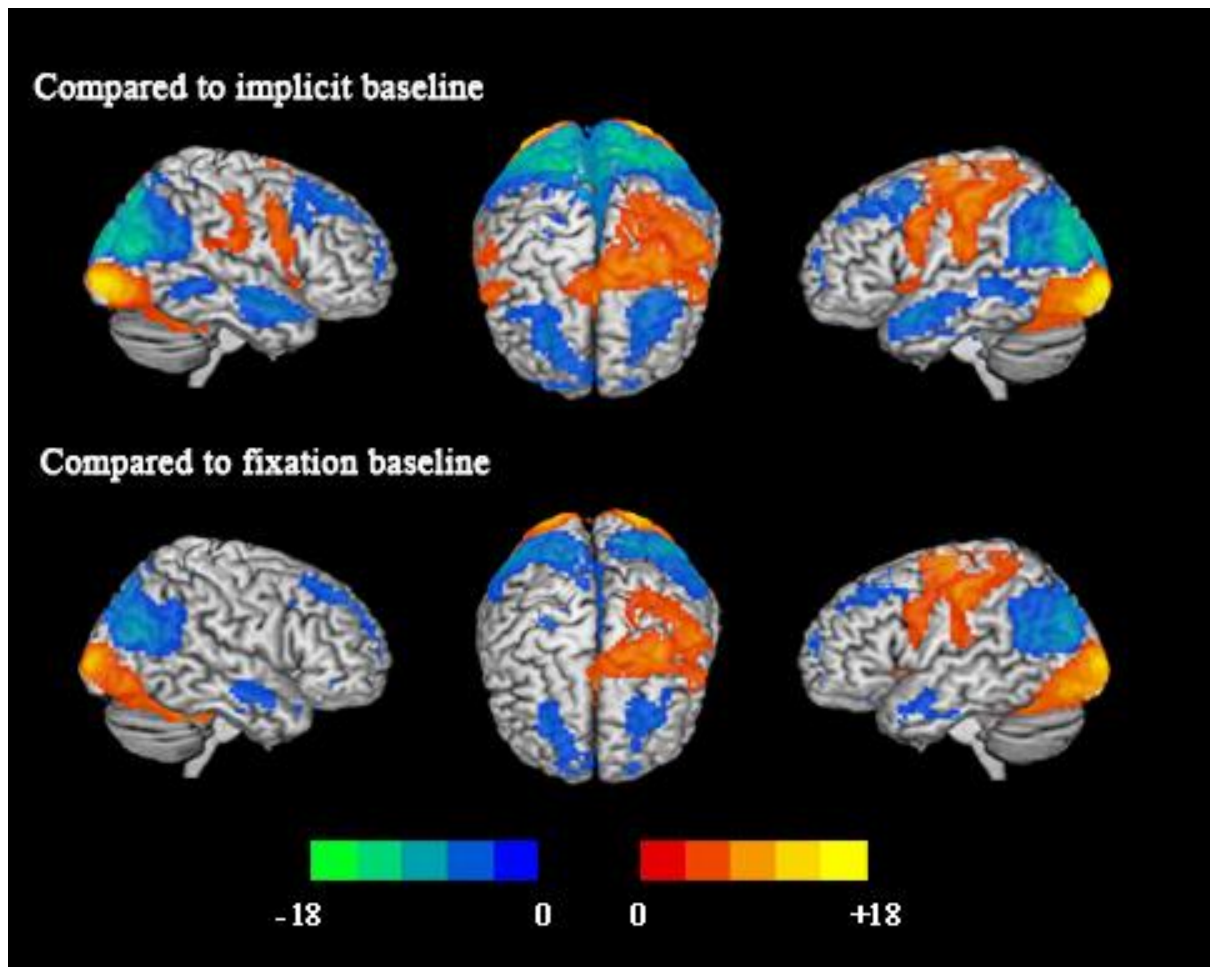


Fig.2. Results of conjunction analysis (Alphasim correction of $p < 0.01$).

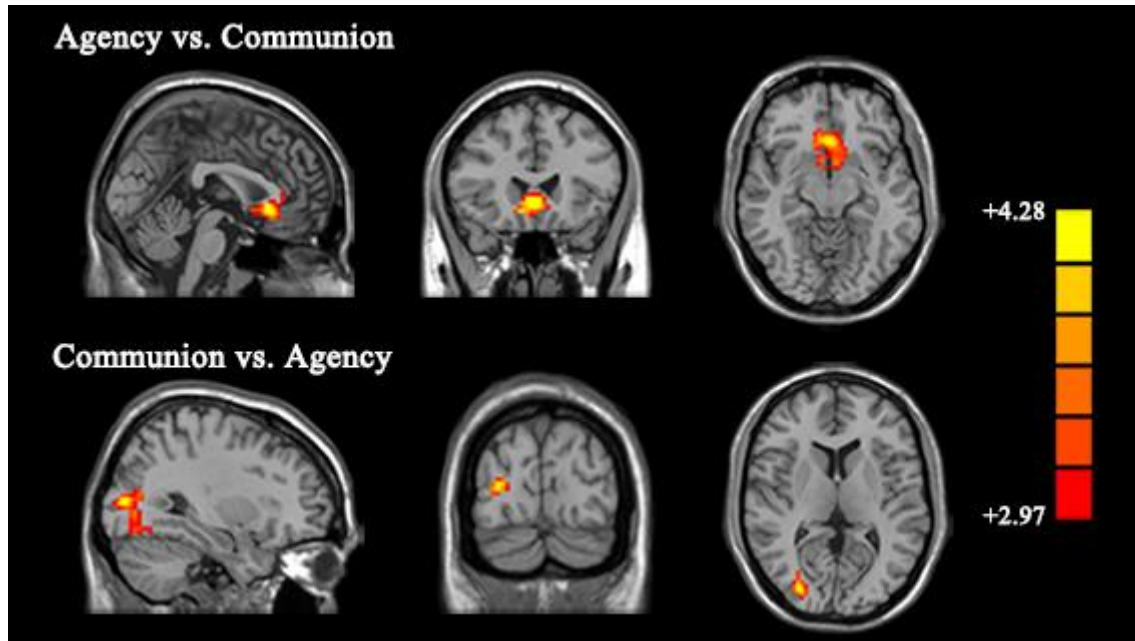


Fig.3. Statistical activation maps comparing agentic to communal trials demonstrate greater activity in the anterior cingulate (ACC; 6, 24, -3) and medial orbitofrontal cortex (OFC; 0, 24,-6). The activations were reported with Alphasim correction of $p < 0.01$.