

Cortical Activations during judgments about the self and an other person

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Abstract

Self-related thought and other person related thought have received a great deal of study in recent years, but have seldom been examined in the same experiment. This study used functional magnetic resonance imaging (fMRI) to compare the neural correlates of judgments of ones own preferences with judgments of another person's preferences. Each participant viewed food names and made one of three decisions: self (whether he or she liked the food); other (whether a specific friend liked the food), or letter (whether there were more than two vowels in the food name). Self and other decisions both activated bilateral medial areas of the frontal and parietal lobes and the bilateral insula in comparison to the letter task. Self activated superior medial parietal areas in comparison to other, whereas other led to greater activation in inferior medial parietal and left lateral frontal areas than self. These results indicate that the neural networks underlying self processing and other person processing may share common neural substrates, particularly regions associated with representation of the body and mental states.

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1. Introduction

For many years, the debate over the nature of self knowledge belonged to the domain of philosophy. A primary controversy concerned whether self knowledge is qualitatively different from other kinds of knowledge. One extreme answer to this question was proposed by Ryle (1949), who claimed that people make judgments about themselves the same way they do about other people or other phenomena: by collecting observations and making inferences on the basis of these observations. An alternative position was proposed by Ayer (1963), who argued that self knowledge is private in the sense that aspects of it are not accessible to others. According to this view, self knowledge need not be more accurate or more direct; rather, it need only be qualitatively different from other forms of knowledge. Wilson (1992) discussed the difficulties in empirically testing these claims using purely behavioral tests. However, the use of functional brain imaging may provide better evidence concerning whether self knowledge is qualitatively differ-

ent from other forms of knowledge. The present study uses functional magnetic resonance imaging (fMRI) to compare the brain areas recruited when participants make judgments about themselves (self) with when they make judgments about another person (other). The self and other decisions were compared to a nonsemantic baseline task to enable identification of brain areas common to both tasks.

It has been proposed that self awareness is a direct precursor to higher order cognitive processes (Gallup, 1982; Stuss & Benson, 1986; Stuss, Gow, & Hetherington, 1992). Recent research has delineated a network of brain areas involved in representing the self: medial frontal areas including the anterior cingulate (Craig et al., 1999; Frith & Frith, 1999; Kelley et al., 2002; Vogeley et al., 2001; Vogeley & Fink, 2003), medial parietal areas including the posterior cingulate and precuneus (Craig et al., 1999; Fink et al., 1996; Johnson et al., 2002; Kelley et al., 2002; Kircher et al., 2000, 2001, 2002), secondary somatosensory areas including the bilateral insula (Farrer et al., 2003; Farrer & Frith, 2002; Fink et al., 1996; Kircher et al., 2000; Ruby & Decety, 2001), and memory related areas including the hippocampus and anterolateral temporal lobes (Fink et al., 1996; Maguire & Mummery, 1999; Maguire, Mummery, & Buechel, 2000).

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Damasio (1999) proposed a theory of how these brain areas interact. He divides self processing into three levels: the protoself, core self, and autobiographical self. The protoself represents the current state of the organism and is subserved by non-conscious neural systems, including the secondary somatosensory cortexes, medial parietal cortexes, and insula. The core self consists of the transient, conscious representation of events currently involving the organism, and is subserved by the cingulate, thalamus, and superior colliculus. Damasio's view of the anterior cingulate is consistent with the conclusions reached by Frith & Frith (1999) that medial frontal areas represent mental states ranging from action to emotion to pain. The autobiographical self represents the past experiences of the organism; medial and lateral temporal areas support the autobiographical self by retrieving relevant memories and representing them in core consciousness.

Most previous research on the neural bases of the self has concentrated on autobiographical self knowledge. Retrieval of autobiographical memories is reliant on the hippocampus (Maguire & Mummery, 1999; Maguire et al., 2000), lateral temporal lobe (Maguire & Mummery, 1999; Maguire et al., 2000) and the right prefrontal cortex (Fink et al., 1996; Keenan et al., 2000; Stuss & Benson, 1986; Wheeler, Stuss, & Tulving, 1997). Calabrese et al. (1996), Markowitsch (1995; Markowitsch et al., 1997), and Levine, Freedman, Dawson, Black, and Stuss (1999) have all reported case studies in which right fronto-temporal damage leads to deficits in episodic or autobiographical memory processing. Recognition of one's own face also appears to preferentially activate right fronto-temporal circuits (Keenan, McCutcheon, & Pascual-Leone, 2001; Keenan, Nelson, O'Connor, & Pascual-Leone, 2001; Kircher et al., 2000, 2001; Preilowski, 1977; Sugiura et al., 2000), though a recent study indicated the left hemisphere may be important (Turk et al., 2002).

Another approach to study of the self is to examine the neural correlates of self-evaluation or self-reference, without requiring recall or recognition of particular episodic memories. Several studies have had participants decide if a given trait (e.g. "honest" or "irresponsible") was characteristic of themselves. Craik et al. (1999), Johnson et al. (2002), and Kelley et al. (2002) compared self-trait judgment with impersonal or other person trait judgment; Kircher et al., 2000, 2002) compared judgment of self-relevant traits with self-irrelevant traits. These tasks require access to semantic self knowledge, but not to particular episodic memories. Other studies avoid declarative memory altogether though manipulation of perceived agency or first person point of view: reading stories written in the first person in comparison with the third person (Vogeley et al., 2001), viewing a scene from one's own perspective versus a third person (Vogeley & Fink, 2003) or interpreting an action as being controlled by oneself versus another person (Farrer et al., 2003; Farrer & Frith, 2002; Ruby & Decety, 2001). A third approach is to have participants evaluate their own reactions to a stimulus independent of memory (Gusnard, Akbudak,

Shulman, & Raichle, 2001). In all studies but two (Kircher et al., 2000, 2002) researchers found medial frontal activity and in all but three (Kircher et al., 2001, 2002; Vogeley et al., 2001) found medial parietal activity. Studies that manipulate agency or first person perspective (but not trait judgment or preferences) in addition typically find right lateral parietal activity associated with self processing (Vogeley & Fink, 2003). Vogeley and Fink (2003) link this area to the representation of the body in space. In addition, self-related autobiographical memory studies (Fink et al., 1996; Kircher et al., 2000) and agency studies (Farrer et al., 2003; Farrer & Frith, 2002; Ruby & Decety, 2001) activate secondary somatosensory cortex areas of the insula.

Research investigating how we evaluate other persons has postulated that we do so through a mental model of the other person, sometimes termed theory of mind (TOM) (Premack & Woodruff, 1978). Neuropsychological and functional imaging techniques both implicate the frontal lobes in theory of mind. Across tasks, functional imaging studies find medial prefrontal activation, generally in the anterior paracingulate cortex, when processing the mental state of others (Gallagher & Frith, 2003). This concordance of neural location is especially impressive when the variety of tasks and modalities is considered: verbal tasks ranging from analysis of individual words (Craik et al., 1999) to complex stories (Decety & Chaminade, 2003; Fletcher et al., 1995; Gallagher et al., 2000; Goel, Grafman, Sadato, & Hallett, 1995), nonverbal tasks involving cartoons (Brunet, Sarfati, Hardy-Bayle, & Decety, 2000; Gallagher et al., 2000), and animations (Castelli, Happe, Frith, & Frith, 2000), and game playing in which the opponent is perceived as being another person or an impersonal agent (e.g. a computer) (Gallagher, Jack, Roepstorff, & Frith, 2002; McCabe, Houser, Ryan, Smith, & Trouard, 2001). The anterior paracingulate cortex locus of activation overlaps with the medial frontal loci active in self related processing described above. Many studies with neuropsychological patients have found impairments in TOM associated with frontal lobe damage (Damasio, 1994; Happe, Brownell, & Winner, 1999; Happe, Mali, & Chuckle, 2001; Rowe, Bullock, Polkey, & Morris, 2001; Stone, Baron-Cohen, & Knight, 1998; Stuss, Gallup, & Alexander, 2001), but are inconclusive as to which areas of the frontal lobes are most important (Rowe et al., 2001). Areas with strong anatomical interconnections with the frontal lobes, such as the amygdala (Fink et al., 1996) and basal ganglia (Saltzman, Strauss, Hunter, & Archibald, 2000), have also been implicated in TOM.

Brain areas active in self-related processing and other person processing overlap, particularly in the medial frontal and medial parietal areas. However, most previous studies have investigated either information processing about one's own self or inferences about the mental states of others, but not both. Only six published studies have directly compared brain activation associated with information processing about self versus others: four of these studies examined perception of agency or point of view (Farrer et al., 2003;

Farrer & Frith, 2002; Ruby & Decety, 2001; Vogeley et al., 2001), and two involved personality trait judgments (Craig et al., 1999; Kelley et al., 2002). In studies that included a neutral baseline task (Craig et al., 1999; Kelley et al., 2002; Vogeley et al., 2001), both self > baseline and other > baseline comparisons found medial prefrontal and medial parietal areas of activation. Two studies found that the medial prefrontal (Craig et al., 1999; Kelley et al., 2002) and medial parietal (Kelley et al., 2002; Vogeley et al., 2001) areas were more active for self than other person trait judgment (Craig et al., 1999; Kelley et al., 2002). Additional areas where activity was greater for self than other were the insula in agency tasks (Farrer et al., 2003; Farrer & Frith, 2002; Ruby & Decety, 2001). Right lateral parietal areas were associated with decreased perceived agency in two studies (Farrer et al., 2003; Farrer & Frith, 2002), but with self perspective in other studies (Vogeley et al., 2001; Vogeley & Fink, 2003).

These previous studies have several limitations. Agency studies involve spatial and motor demands in addition to self processing. In the trait studies, the reference person used in the other person decision was a government figure and presumably not known personally by the participants; judgments therefore may have been more likely to be made on the basis of semantic knowledge gained from newspapers and the like rather than personal experience or “putting oneself in the others shoes”.

The task used in this study was a food preference task, chosen to meet several criteria. It has minimal spatial and motor demands, uses stimuli that can evoke imagery in several sensory modalities, and uses motivationally significant stimuli in order to maximally involve structures involved in bodily representations. It requires subjects to evaluate themselves in reference to an external world stimulus rather than focus attention internally; Gusnard and Raichle (2001) argued that internal focus of attention activates areas that are also commonly active during rest conditions, and thus a task that involved internal focus of attention as well as a baseline task could lead to uninterpretable results.

Participants viewed the names of foods (e.g. hamburger, oysters, ice cream, etc.) during the performance of three tasks: self, other, and letter. In self blocks, participants were instructed to decide if they themselves liked the food item named on the screen. In other blocks, they were instructed to decide whether they thought that a particular reference person would like this food. Each participant was told to choose as a reference person someone that they know fairly well but not extremely well, such as a roommate or casual friend. This was done to equate familiarity: it is likely that not all participants would have a significant other or extremely close friend, but in a university environment all were likely to have roommates or casual friends. The two food judgment tasks were compared to a orthographic evaluation task (letter task) in which the participants merely counted the vowels present in the name of the food. This control task chosen to be nonsemantic, in line with the case judgment and

syllable counting tasks used previously (Craig et al., 1999; Kelley et al., 2002), and to be sufficiently demanding that participants would not have time for extraneous thoughts.

The self-food judgment task was predicted to activate areas involved in representation of bodily state as participants imagined the food such as secondary somatosensory areas, medial parietal areas, and the insula (Damasio, 1999); medial prefrontal areas involved in representation of states of self (Damasio, 1999; Frith & Frith, 1999; Gallagher & Frith, 2003; Vogeley & Fink, 2003), particularly more dorsal areas associated with attention to an outside stimulus (Gusnard et al., 2001); and orbitofrontal areas associated with food preference (O’Doherty, Rolls, Francis, Bowtell, & McGlone, 2001; O’Doherty et al., 2000; Rolls, 1997). It was also possible that participants would either intentionally or incidentally recall episodic memories associated with the foods; to the extent that they did so, medial and lateral temporal areas could be active (Maguire & Mummery, 1999; Maguire et al., 2000).

The other task was predicted to activate the medial prefrontal areas that are commonly active in both self processing and TOM tasks. To the degree to which participants use self information to simulate the other person, the other task could also involve protoself areas like the medial parietal lobes and insula (Damasio, 1999). To the degree to which participants made decisions via processes of memory recall (both episodic memories of events in which the target person ate the food, and semantic memory of what foods are generally liked or disliked by people), medial and lateral temporal areas could be active (Maguire & Mummery, 1999; Maguire et al., 2000), in conjunction with frontal lobe areas associated with attribution and judgments (Blackwood et al., 2000; Parsons & Osherson, 2000).

2. Methods

2.1. Participants

Participants were 12 Stanford community members, 4 male and 8 female, with an average age of 23.6 years (range: 20–32). Participants met criteria for MRI scanning (no metallic implants, no claustrophobia, head size compatible with the custom head coil) and were neurologically healthy (no known neurologic or psychiatric injury or disease, not taking any psychoactive medication or drugs).

2.2. Materials

Materials consisted of a list of 144 food names. These included names of basic vegetables and fruits (mango, celery), meats (duck, trout), and beverages (Pepsi, root beer, milk), as well as complete dishes (lasagna, pizza). Some food names were included that are often disliked by persons (e.g. liver, snails, spinach, anchovy) so as to avoid participants responding favorably to each item.

Three tasks were devised. In the self task, participants were asked to read the food name and decide if they themselves like to eat that food. They were instructed to press the right response button if they liked the food and press the left response button if they did not like the food. For the other task, participants were asked to choose a particular other person who they know fairly but not extremely well. This person might be a roommate or a friend. Participants were asked to read the food name and decide if that particular person would like to eat that food. If the answer was yes, they were instructed to press the right response button; if no, press the left response button. In the letter task, participants were asked to read the food name, count the number of vowels, and decide if there were more than two vowels in the word. If the answer was yes, they were instructed to press the right response button; if no, press the left response button.

2.3. Procedure

2.3.1. FMRI image acquisition

Imaging was performed with a custom-built whole head coil in a 3.0 Tesla MRI Signa LX Horizon EchoSpeed (General Electric Medical Systems). Head movement was minimized for participants using a “bite-bar” formed with the participant’s dental impression. Before the functional scans, three anatomical scans were performed: a coronal T1-weighted localizer scan, a three-dimensional high-resolution T1-weighted spoiled gradient echo scan with 124 contiguous 1.5 mm slices [minimum full echo time (TE); 30° flip angle; 24 cm field of view], and T1-weighted spin-echo anatomical images in 28 contiguous 4 mm axial slices [30 ms TE; 2000 ms TR]. After anatomical imaging, participants completed two functional scans for an unrelated experiment, then the functional scan for the present experiment. Scanning was performed using a T2* sensitive gradient echo spiral pulse sequence (Glover & Lai, 1998) (30 ms TE; 2000 ms TR; 76° flip angle; 20 cm field of view; 64 × 64 acquisition matrix).

During the functional scan, participants performed six blocks of each task (self, other, and letter). Each block consisted of nine trials; the first trial was a phrase indicating the task to be performed (task-self, task-other, or task-letter) and the following eight trials were food names. There was no pause between blocks. Each trial was 2500 ms; thus each block was 22.5 s, and the entire scan was 6 min, 45 s. Blocks were presented in six cycles of one block of each task, with a set order of self, other, letter.

Stimuli were presented using a magnet compatible projector (Resonance Technology Inc., Van Nuys, CA) that back projects visual images onto a screen mounted above the participant’s head. A Macintosh computer, in conjunction with PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993) were used to generate visual stimuli and control experimental parameters; responses were obtained using a fiber optic finger switch response system that interfaces with PsyScope.

2.3.2. Image analysis

Image reconstruction was performed using a gridding algorithm that resampled the raw data into a Cartesian matrix prior to processing with 2D fast Fourier transform. Images were converted into volumes for statistical analyses using SPM99. Volumes were realigned to correct for head motion using the algorithm in SPM99 (Friston, Worsley, Frackowiak, Mazziotta, & Evans, 1994). Using the general linear model approach (Friston, Worsley, & Frackowiak, 1995b) of SPM99, a reference waveform corresponding to the alternating conditions was constructed and convolved with an estimate of the hemodynamic response function. Corrections for multiple voxel comparisons were made by using the cluster size method of Friston et al. (1994).

To identify the location of functional activation and to facilitate reporting data in a standardized coordinate system (Talairach & Tournoux, 1988), averaging across participants was performed by transforming the data into a standardized anatomical space provided by a normalized template image. Using SPM99 (Friston et al., 1995a), normalization to the Montreal Neurological Institute brain template was performed on each participant’s anatomical MRI image using a 12 parameter affine transformation followed by an elastic deformation. The resulting set of transformations was applied to the participant’s functional image volumes. These normalized functional volumes were spatially smoothed with a Gaussian kernel, full width at half maximum of 8.0 mm.

Statistical analysis of data across participants proceeded by collapsing each participant’s single session data into a set of representative contrast images, with low frequency signal drifts and other confounds removed. The resulting images were subjected to a second level group analysis, which meets the requirements for random effects analysis given by Friston, Holmes, and Worsley (1999), using the general linear model provided by SPM99.

The functional scans were examined to determine the areas of the brain from which inadequate signal was received due to susceptibility artifacts. The frontal lobes anterior and inferior to $y = 15$ and $z = 5$, roughly the area corresponding to orbitofrontal cortex, had significant signal dropout.

3. Results

3.1. Behavioral results

Reaction times differed significantly across the three tasks, $F(2, 10) = 6.16$, $P = 0.008$. Participants responded significantly faster in the self condition ($M = 913$ ms) than the other condition ($M = 1024$ ms; $t(11) = 4.5$, $P = 0.0009$), and letter condition ($M = 1090$ ms; $t(10) = 3.0$, $P = 0.013$). The reaction time difference between the letter and other conditions was not significant ($t(10) = 1.23$, $P = 0.25$).

In addition to reaction time, the percentage of time that the participant responded affirmatively was calculated for

each task. An affirmative answer was pressing the button corresponding to liking the food item in the self and other task, and pressing the button corresponding to a decision that there were more than two vowels in the food name in the letter task. A one-way ANOVA indicated that the proportion of affirmative answers differed across conditions ($F(2, 10) = 11.4, P = 0.0005$). There were significantly fewer affirmative answers in the letter condition ($M = 55\%$) than the self condition ($M = 65\%$; $t(10) = 3.6, P = 0.0049$) and other condition ($M = 66\%$; $t(10) = 5.3, P = 0.0004$). There was no significant difference in number of affirmative answers between the self and other conditions, $t < 1.0$.

3.2. Imaging results

3.2.1. *Self > letter and other > letter*

In comparison to the letter task, the self and other tasks activated several areas (see Fig. 1 and Table 1). The areas of activation were primarily in medial cortical areas. Both other > letter and self > letter comparisons revealed significant clusters of activation in medial portions of the frontal lobe, including the superior frontal gyrus. These areas were primarily left lateralized, but did extend into the right hemisphere. These activations extended inferiorly to BA 10 and superiorly to BA 6 and 8. In the other > self comparison, the medial frontal cluster included the left head of the caudate. Both the other > letter and self > letter comparisons also showed significant clusters of activation in medial parietal

areas. One common region of activation encompassed the posterior cingulate and precuneus, BA 31 and 23. A second region was superior and anterior to this, located in paracentral lobule. Finally, the insula was activated bilaterally in both comparisons.

3.2.2. *Self > other and other > self*

Two significant clusters of activation were found in the self > other comparison. As shown in Fig. 2, one cluster extended from the left paracentral lobule anteriorly and inferiorly to the posterior cingulate and precuneus. The second cluster of activation encompassed similar areas of the right hemisphere. In the other > self comparison, there were two significant clusters of activation. One encompassed lateral portions of the superior frontal gyrus in the left hemisphere. The second was centered in the posterior cingulate and precuneus, bilaterally. This area was inferior and posterior to the areas of the posterior cingulate and precuneus that were active in the self > other comparison.

3.3. *Letter > self and letter > other*

In both the letter > other and letter > self comparisons, clusters of activation were found in the bilateral inferior and superior parietal lobes (BA 40, 7). There was significant activation in the right middle and lateral superior frontal gyri (BA 9) in both comparisons, and activation in the left inferior frontal gyrus that reached significance only in the letter >

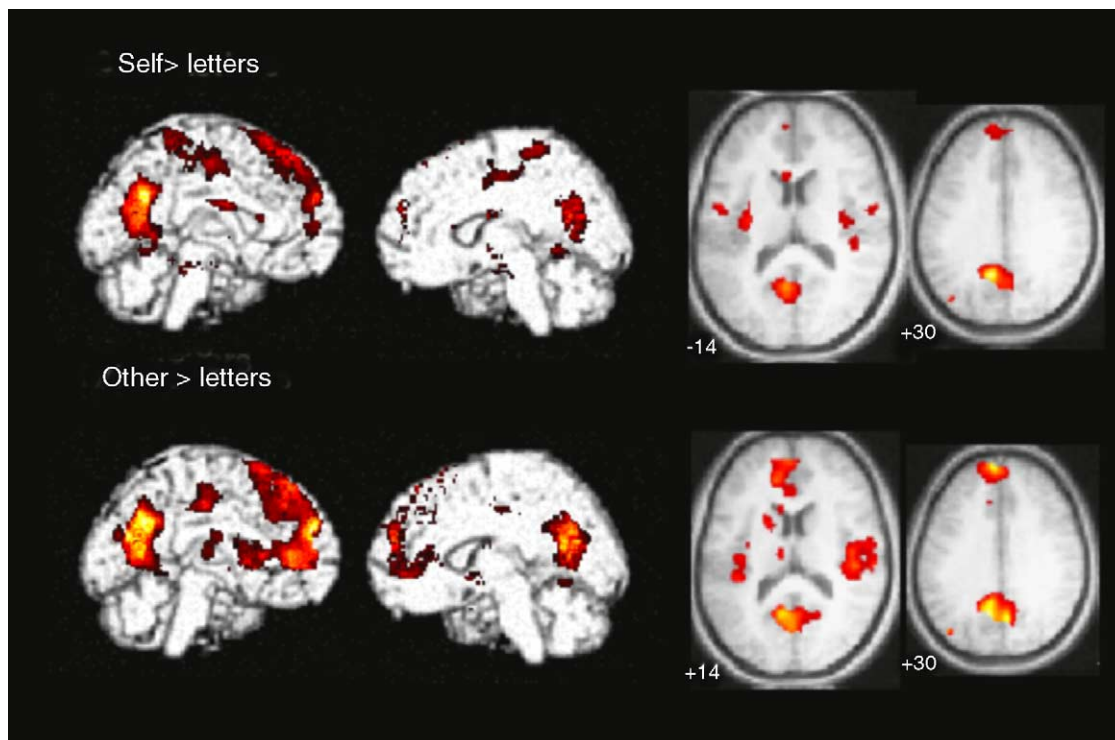


Fig. 1. Areas of activation in the self > letter and other > letter comparisons, rendered on the sagittal template of SPM 96 (left), and overlaid on axial slices taken from the average anatomical image of the participants (right) at $z = +14$ and $z = +30$.

Table 1
Areas of activation in between task comparisons

	BA	<i>k</i>	<i>x</i>	<i>y</i>	<i>z</i>
Self > other					
L paracentral lobule, precuneus, posterior cingulate	5, 7, 23	1447	−22	−25	53
			−30	−10	28
R paracentral lobule, precuneus, posterior cingulate	5, 7	486	18	−39	65
			14	−30	55
Other > self					
L superior and middle frontal gyri	6, 8	794	−26	20	52
			−34	20	51
B posterior cingulate and precuneus	31, 7	609	16	−61	18
			−12	−50	45
Other > letter					
L Superior and middle frontal gyri, caudate nucleus	10, 6, 8	4589	−2	53	18
			−28	20	49
B posterior cingulate and precuneus	31	2258	−6	−67	25
			4	−61	29
R insula		1160	46	−22	18
			59	−23	16
L cingulate, paracentral lobule, insula	6, 24	298	−8	−17	40
			−10	−15	50
Self > letter					
L cingulate and precuneus	23, 31	1467	−12	−55	29
			−4	−57	16
L superior frontal gyrus	6, 8	1223	−10	24	60
			−10	43	48
R insula		691	42	−26	20
			46	−9	23
L cingulate and paracentral lobule	6	589	−14	−11	47
			−20	−36	64
R cingulate and paracentral lobule	6, 24	334	12	−13	45
			18	−38	65
L insula		473	−32	−12	10
			−26	−6	−3
Letter > self					
L inferior and superior parietal lobules	7, 40	2916	−42	−45	39
			−26	−72	44
R inferior and superior parietal lobules	7, 40	2878	42	−46	43
			32	−65	53
R inferior and middle frontal gyri	9, 6	3859	42	40	29
			26	5	59
R middle temporal and fusiform gyri	21, 37	518	38	−55	−9
			55	−47	1
L inferior frontal gyrus	44, 6	586	−54	3	20
			−44	0	44
Letter > other					
R inferior and superior parietal lobules	7, 40	4911	30	−58	47
			36	−52	52
L inferior parietal lobule	7, 40	4623	−26	−71	48
			−40	−45	37
R inferior and middle frontal gyri	44, 9	3684	42	40	27
			53	9	31
R posterior cingulate	29, 30	379	14	−32	16
			10	−38	20

Note: All clusters reached a corrected significance level of $P = 0.005$, and an extent threshold of 20 voxels. For each cluster, coordinates are given for the maximally activated voxel and one local maxima. *k*: number of voxels in cluster. BA: Brodmann's areas. *x*, *y*, *z*: Talairach coordinates were calculated from MNI coordinates using the method given by Matthew Brett at <http://www.mrc-cbu.cam.ac.uk/Imaging/mnispac.html>.

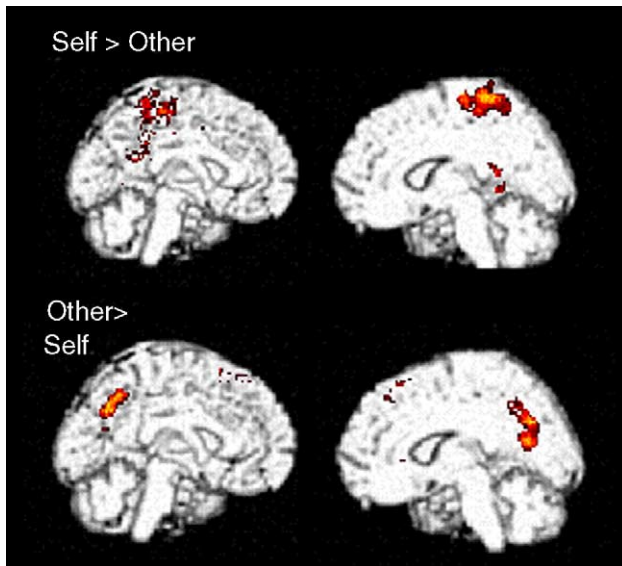


Fig. 2. Areas of activation in the self > other and other > self comparisons, rendered on the sagittal template of SPM 96.

self comparison. Areas of the right inferior temporal and fusiform gyri were active in both comparisons, but reached significance only in the letter > self condition. Finally, there was a cluster of activation in the posterior cingulate (BA 29) which reached significance only in the letter > other comparison.

4. Discussion

Judging whether one likes a food was predicted to recruit a network of cortical areas involved in representation of mental states (medial prefrontal areas), representation of bodily state (secondary somatosensory areas in the medial parietal lobe and the insula), and representation of food taste and preference (orbitofrontal areas). These predictions were born out by the data, with the exception of the orbitofrontal cortex, which could not be imaged successfully due to susceptibility artifacts. Judging whether another person likes a food led to overlapping activations with the self task in medial prefrontal, insula, and posterior medial parietal areas. The two tasks differed in cortical recruitment in medial parietal areas. There was activity only in the self condition in superior medial parietal areas including the posterior cingulate and anterior precuneus, which contrasted with greater activity for other than self in more inferior areas of the precuneus and left lateral frontal areas.

4.1. Mental state representation in medial frontal cortex

Medial prefrontal areas are commonly activated in tasks that involve mentalizing, both when making judgments about the minds of other persons (Frith & Frith, 1999;

Gallagher & Frith, 2003), and when evaluating one's own mental state (Frith & Frith, 1999; Vogeley & Fink, 2003). Damasio (1999) argued that the anterior cingulate represents the relation between self and external stimuli, and Frith and Frith (1999) argued that medial frontal areas represent mental states that are used as the basis for judgments about the self and others. Activation of this area in both the other > letter and the self > letter comparisons is consistent with this large body of literature. Some previous studies have found greater medial prefrontal activity during self-related than other person-related processing (Kelley et al., 2002; Vogeley et al., 2001), but there was no significant difference in this area in the self > other or other > self comparisons. Recently, Gusnard et al. (2001; Gusnard & Raichle, 2001) have argued that the medial prefrontal area can be functionally divided into two parts, a more dorsal area which is active when attention is directed towards the self in relation to an external stimulus, and a more ventral area which is active when attention is directed internally and which is commonly active during rest conditions. The location of activation in the present study fell in the dorsal area, which is consistent with the demands of the task to focus on the relationship of the self to the externally presented word stimuli.

4.2. Representation of bodily states in medial parietal cortex

In the present study, there were two separate areas of medial parietal activity, the first of which extended through the central aspects of the cingulate gyrus and the paracentral lobule. This area was active only in self processing, in comparison with both the letter and other task. The paracentral lobule is one of the secondary somatosensory areas that Damasio (1999) postulates represents the body in the protosef. The present study implies that this area subserves functions that are only used for self-relevant processing and are not recruited when making decisions about other persons.

The second medial parietal area was more posterior and inferior, extending through the cuneus, precuneus, and posterior cingulate. This area was active in both the self and other tasks in comparison with the letter task, but was more strongly active in the other than the self task. The precuneus and posterior cingulate is commonly activated when participants perform tasks involving mental state processing of both the self (Craig et al., 1999; Fink et al., 1996; Johnson et al., 2002; Kelley et al., 2002; Kircher et al., 2002; Kircher et al., 2000; Kircher et al., 2001) and other persons (Craig et al., 1999; Friston et al., 1995b; Gallagher et al., 2000; Kelley et al., 2002). The greater activity in this area for other than self is consistent with Ruby and Decety (2001) findings of greater activity in this area when imagining an other person performing an action than when imagining oneself performing the same action. However, Fink et al. (1996) found a somewhat more inferior area was

more active during recall of one's own memories than recall of another person's memories.

The precuneus/posterior cingulate is often more active in "rest" or low level undemanding baseline tasks. Medial parietal areas have high tonic levels of activity. This tonic activity is attenuated during goal-directed cognitive processing, as well as sleep, coma, and general anesthesia (Binder et al., 1999; Gusnard & Raichle, 2001). According to Damasio, these areas help subserve "core consciousness" and represent the self in relationship with the outside world (Damasio, 1999). Similarly, Gusnard and Raichle (2001) argue that these areas are important for monitoring the external world, particularly in the visual modality, and also play a role in emotional states. However, the roles of these areas are not well understood. It should be noted that the precuneus is often active in explicit memory tasks (Fletcher, Shallice, Frith, & Frackowiak, 1996), regardless of visual demands (Krause et al., 1999), and thus may indicate greater episodic memory demands when making decisions about another person versus oneself.

4.3. Representation of bodily states in insular cortex

Insula activity was found in both the self and other tasks in comparison with baseline. Insula activity has been associated with processing self related episodic memories (Fink et al., 1996) and processing the face of one's self or one's partner in comparison to an unknown face (Kircher et al., 2000). These previous studies have generally found greater insula activity for self-related processing, which is consistent with Damasio's view that the insula is one of the secondary somatosensory areas associated with the protoself. The insula is also commonly active in tasks that involve agency: Ruby and Decety (2001) found it to be more active when imagining oneself performing an action than another person, and Farrer and Frith (Farrer et al., 2003; Farrer & Frith, 2002) found it to be more active when interpreting a situation as being controlled by oneself than another person. It is not clear why the insula should be equally active in both the self and the other conditions of this study in comparison with the letter task. It is possible that because the self task was performed significantly faster than other there could have been less overall task related activation during the self task.

4.4. Lateral frontal cortex activations

The other task activated lateral left frontal regions in comparison with both the self and letter tasks. It is unclear why the two tasks differed in their reliance on this brain area. The other task was more difficult for participants than the self task (as indicated by the longer reaction times for other decisions). It is possible that the other task involved processes of attribution or probability judgment, functions that are subserved by the left frontal cortex (Blackwood et al., 2000; Parsons & Osherson, 2000).

Right dorsolateral prefrontal and bilateral parietal areas were more active in the letter task than in the self and others tasks. These areas are often active in spatial working memory tasks (Smith & Jonides, 1997), which is consistent with the high working memory demands of the letter task. In the letter task participants must scan the word, decide for each letter whether it is a vowel or not, maintain a running count of the number of vowels, and update this running total every time another vowel is identified. Then they must decide if the total is greater than two or not, and press the appropriate response button. This task was more time consuming than the self and others task.

There was no right lateral prefrontal activation associated with self processing, which has been found in numerous studies (see (Keenan, Wheeler, Gallup, & Pascual-Leone, 2000) for review). Tasks that find right lateral prefrontal activity generally require access to episodic memories about the self, whereas tasks which examine agency or trait judgments tend to find more right posterior activity (but see Craik et al., 1999). These findings may relate to Damasio's differentiation of the autobiographical self and the protoself.

4.5. Study limitations

One potential limitation of this study was in the choice of the baseline task. The letter counting task was selected to be comparable to the non-semantic tasks used in other studies (Craik et al., 1999; Kelley et al., 2002). As a result the self and other tasks differed from the letter task not just in making reference to a person, but also in general semantic processing. To examine the possibility that the common activations found in the self > letter and other > letter comparisons may be due to general semantic processing, we examined data collected in our laboratory for a different study (Seger & Schmidt, *in press*) in which participants viewed food names and made self judgments, other person judgments about their significant other or a stranger, and semantic judgments (deciding whether the food was normally served heated). The clusters of activation in the self > semantic comparison were very similar to those found in the self > letter comparison in the present experiment. There were significant ($P < 0.01$, corrected) clusters of activity in the bilateral medial frontal lobes and left and right insula. In addition, there was sub-threshold activation in the bilateral precuneus and paracentral lobules. The other conditions differed from the present study, but the significant other > semantic and stranger > semantic comparisons activated areas similar to this study's other > self comparison: posterior medial parietal areas, medial prefrontal areas, and bilateral insula.

Another limitation is that the tasks differed in difficulty: the self task was performed significantly faster than the other task. It is possible that areas that were more active in self than other conditions in other studies, such as the medial frontal lobes and bilateral insula, but did not differ significantly in the present study may not have been detectable due to lower blood flow due to less time on task in the self condition. In

addition, the other task probably involved more guessing by the participants than the self task, as they were unlikely to know all the food preferences of the reference person.

4.6. Conclusion

Food preference judgments for ones self and another person activated common brain areas in the medial frontal lobes and medial parietal lobes. These areas have been implicated in processing of mental states in both self and other person judgments. However, self related and other person related judgments differed in the medial parietal areas recruited, with self related judgments activating the paracentral lobule and anterior precuneus and other related judgments activating the posterior cingulate and precuneus. Thus, the neural networks underlying self processing and other person processing have some common elements and some independent elements. These results are inconsistent with philosophical and psychological theories that postulate that self judgments are made in exactly the same way as other person judgments, but they do allow for sharing of some processing stages.

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