An fMRI study of self-reflection about body image: Sex differences

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ABSTRACT

Recent functional imaging studies suggest key involvement of medial prefrontal cortex (mPFC) in processes of self-evaluation. Additional behavioral evidence suggests significant sex differences in sensitivity both to social norms and to information about one's own body, particularly as it pertains to assessments of self-worth. Because these observed sex differences are hypothesized to arise from differences in cognitive representations of the self, brain activation differences in mPFC might likewise be expected while men and women process information about body image. In this study, 10 females and nine males viewed images of gender-matched bodies of either an overweight body type or a thin body type while undergoing functional MRI (fMRI) scanning. While viewing these images, participants were instructed to make evaluations of their own bodies in relation to the images displayed. Significant within-group contrasts in mPFC activation were observed for women only, with relatively higher activation for overweight images versus thin images. Men showed no significant mPFC activation while processing either type of image. These results are consistent with cognitive models of self-representation, particularly those developed within social and cultural theoretical frameworks, where body size is hypothesized to play a dominant role in schematic representations of self-worth for many women.

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1. Introduction

Recent PET and fMRI studies have examined cognitive processing and brain organization differences between men and women (Wallentin, 2009). Likewise, a considerable number of functional neuroimaging studies have examined the neurocognitive systems associated with self-referential information processing (for reviews see Mitchell, Banaji, & Macrae, 2005; Northoff et al., 2006). Finally, within the domain of self-referential processing, other functional neuroimaging studies, though relatively few, have examined neural systems related to body image representation (Friederich et al., 2007; Uher et al., 2005; Wagner, Ruf, Braus, & Schmidt, 2003). This latter topic of investigation – body image – appears relatively underdeveloped in cognitive neuroscience, both in the context of sex differences as well as self-referential processing. This is unfortunate in light of the theoretical importance of body image in many current psychological models of self-evaluation (Cash & Deagle, 3rd., 1997; Feingold & Mazzella, 1998; Furnham, Badmin, & Sneade, 2002; Morris, Goldsmith, Roll, & Smith, 2001; Pliner, Chaiken, & Flett, 1990; Spangler & Stice, 2001; Williamson, White, York-Crowe, & Stewart, 2004), particularly where

body image is hypothesized to play a different role in representations of self-worth for women than for men (Stice, Maxfield, & Wells, 2003). In this study, we build on previous functional imaging work in these three areas – sex differences, self-referential processing, and body image – in order to address current theoretical models of the representational link between body image and self-worth. We used an fMRI paradigm which contrasts self-referential thought about body image to evaluate predictions about activation differences between the sexes.

Recent fMRI paradigms have been developed in order to examine self-referential information processing. One common approach is to elicit conditions in which a subject actively engages in awareness of the self and/or the self's relationship to a third-person. Although several brain areas have been shown to be activated in these studies, the single brain region most consistently implicated in self-referential and self-evaluative thought is by far the medial prefrontal cortex (mPFC), particularly its anterior portions (D'Argembeau et al., 2007; Heatherton et al., 2006; Kelley et al., 2002; Mitchell et al., 2005; Ochsner et al., 2005; Vogeley et al., 2004; Yoshimura et al., 2009; Zysset, Huber, Ferstl, & Von Cramon, 2002).

One influential and representative study on the neural correlates of self-reflection, for example, is described by Zysset et al. (2002) in the context of memory retrieval. In this study, participants produced responses to statements that required three types of information retrieval: simple semantic memory ("December

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31st is New Year's Eve"), episodic memory ("I spent New Year's 2000 at home"), or evaluative statements ("I enjoy going to New Year's parties"). Compared to a baseline task, the episodic and evaluative tasks, but not the semantic task, both showed significant mPFC activation, with a greater anterior extent of activation for the evaluative task. Additionally, significant activation was found bilaterally in the precuneus, an area with strong direct corticocortical ties to the mPFC.

As stated above, within the domain of self-referential cognition, relatively few fMRI studies have investigated brain activity associated with cognitive representations of body image, and no self-referential studies have systematically examined differences between the sexes. The possibility that sex differences might exist in self-referential processing is suggested by evidence that males and females differ substantively in at least some cognitive social processing domains where self-representation plays a strong role. For example, females, particularly younger females, show more public self-consciousness than males (Gould, 1987). As for body image, particularly body size and fat composition, differences between the sexes in self-representation appear to be especially pronounced. For example, females have been shown to be more concerned than males with physical attractiveness, over-eating, body weight, and body image, where satisfaction with one's body has a significantly higher correlation with self-esteem for females than it does for males (Feingold and Mazzella,1998; Furnham et al., 2002; Pliner et al., 1990).

Given previous findings that females generally appear more invested in body image than males, particularly with respect to weight, and that body size appears to play a more dominant role in cognitive representations of self image and self-worth, it is possible that females might show stronger activation in mPFC when engaged in self-reflection about their bodies, particularly when the content of self-reflection concerns the prospect of being overweight, in comparison to socially desirable norms for thinness (Bessenoff & Snow, 2006; Harrison, 2003). Moreover, given evidence that females also tend to show more sensitivity to social judgment than males (Davison & McCabe, 2006), this strength of self-reflective activity about body size might be further increased when it is elicited by *self-reflexive* thought – that is – in the context of a third-person opinion, where both self-reflective and self-reflexive processes appear to elicit activation within similar regions of the mPFC (D'Argembeau et al., 2007; Ochsner et al., 2005). The following experiment was designed to address this hypothesis, employing a paradigm with some similarities to that of Uher et al. (2005). In this experiment, men and women viewed virtual model images of thin individuals (close to the social ideal) versus overweight individuals (far from the social ideal) while undergoing fMRI scanning. In addition, subjects were instructed to consider a third-person opinion, in which the subjects' own body shape is alleged to resemble those in the images.

2. Method

2.1. Participants

Ten female and 9 male participants (ages 18–30) were native English speakers, with at least one year of college education, and were determined to be dominantly right-handed. The self-declared ethnicity of all participants was Caucasian, except for one Hispanic female. Participants were free of any history of psychological or neurological disorder, as determined by a screening questionnaire, as well as significant eating disorder, as determined by the Eating Disorder Diagnostic Scale (EDDS; Stice, Telch, & Rizvi, 2000). In particular, all participants scored very low on the weight/body-concern subsection of the EDDS, where on a scale of 0–6, females

$(M = .1, SD = .30)$ scored slightly higher than males $(M = .03, SD = .16)$, but with no significant difference between groups $(t[74] = 1.26, p = .21)$. All participants fell within the normal body mass index range (i.e. 19–25) with no significant sex differences $(t[18] < 1)$. Participants gave informed consent by signing an Institutional Review Board-approved form.

2.2. Materials

Test materials consisted of full-body images of women or men of two types – *thin* and *fat* (see Fig. 1). These respective labels are intended as experimental condition names only and do not attempt to capture formal categorizations of body shape. Computer generated virtual models for both fat and thin conditions were used to create a variety of appearances (e.g. varying skin tone, hair color and style). These variations were intended to create stimuli diversity for the sake of participant interest, thus helping to maintain attention toward the task, and also to control, through randomization, possible effects of any participants identifying systematically more strongly with any particular arrangement of appearance traits. A total of 42 stimuli were created for each condition. The control condition stimuli were derived from test stimuli using an image scrambling procedure.

2.3. Procedure

During functional scanning, participants viewed stimuli on a back-projection screen via angled mirrors. Stimuli were grouped in epochs of seven sequential images of the same stimulus type (thin, fat, control) at a rate of 2 s per image. Each 14 s presentation epoch was followed by a 6 s inter trial interval, for a total block of 20 s. Each condition block was presented six times, using a Latin Square design, for a total scanning time of 6 min. Prior to entering the scanner, participants were told that they would see images of virtual models dressed in underclothing or swimwear. Upon viewing each image, they were instructed to "Imagine that someone is comparing your body to the body of the woman/man you see in the picture. That is, imagine someone is saying 'your body looks like hers/his'". Participants viewed images from their own sex only. For the control condition, subjects were instructed to simply attend to the images.

2.4. Imaging acquisition and analysis

All MRI sequences were acquired in a single scanning session using a 1.5-T GE magnetic resonance scanner. Functional images were acquired at 23 contiguous axial locations using an EPI blood oxygen level-dependent (BOLD) sequence with the following critical parameters: TR = 2000; TE = 40 ms Flip Angle = 90; slice thickness = 5 mm; in-plane voxel resolution = 3.75 × 3.75; and a 64 × 64 matrix of individual sample points, producing a total of 64 × 64 × 23 voxels for entire brain coverage. Pre-processing and statistical analyses were performed using MRIcro and SPM5 software packages. Pre-processing procedures included acquisition time realignment, using sync interpolation, followed by motion correction with EPI distortion unwarping. No head movement exceeded 1 mm translation or 1° rotation displacement. After motion/distortion correction, all functional volumes were spatially normalized and resampled using the Montreal Neurological Institute (MNI) templates implemented in SPM5 and spatially smoothed with an 8 mm FWHM Gaussian kernel in order to increase signal-to-noise ratio and to reduce the effects of moderate interindividual variability in brain anatomy. Following functional scanning, high resolution 3D SPGR and T_2 axial FLAIR structural images were acquired. These images revealed no detectable brain