

Exploring the Neural Correlates of Social Stereotyping

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Abstract

■ Judging people on the basis of cultural stereotypes is a ubiquitous facet of daily life, yet little is known about how this fundamental inferential strategy is implemented in the brain. Using fMRI, we measured neural activity while participants made judgments about the likely actor (i.e., person-focus) and location (i.e., place-focus) of a series of activities, some of which were associated with prevailing gender stereotypes. Results revealed that stereotyping was underpinned by

activity in areas associated with evaluative processing (e.g., ventral medial prefrontal cortex, amygdala) and the representation of action knowledge (e.g., supramarginal gyrus, middle temporal gyrus). In addition, activity accompanying stereotypic judgments was correlated with the strength of participants' explicit and implicit gender stereotypes. These findings elucidate how stereotyping fits within the neuroscience of person understanding. ■

INTRODUCTION

As consensual beliefs about individuals based on knowledge of the groups to which they belong, stereotypes are engrained in the very fabric of society (Kunda, 1999; Fiske, 1998; Hilton & von Hippel, 1996; Fiske & Neuberg, 1990). Acquired during early childhood and reinforced throughout adult life (Hill & Flom, 2007; Poulin-Dubois, Serbin, Eichstedt, Sen, & Beissel, 2002), stereotypes shape thought and action in innumerable ways. In a world of daunting interpersonal complexity, the primary benefit of stereotyping is that it offers apparent insights into the personalities and deeds of others without the cumbersome necessity of getting to know them (Macrae & Bodenhausen, 2000). For example, whereas women are thought to be nurturing and to be found cooking and gossiping, emotionally repressed men are believed to enjoy repairing cars and guzzling beer. While clearly simplifying the process of person understanding (hence, social interaction), stereotypical thinking is not without its problems. Through indiscriminate application, stereotyping promotes judgmental inaccuracy, societal inequality, and intergroup conflict (Fiske, 1998).

Recognizing the impact that stereotyping exerts on contemporary life, researchers have sought to identify the neural underpinnings of this core psychological process (e.g., Cunningham & Johnson, 2007; Eberhardt, 2005; Phelps & Thomas, 2003). In this respect, much of what is currently known about the neural circuitry supporting stereotyping has been garnered from studies exploring face processing, specifically the perception of outgroup members (Kim et al., 2006; Lieberman, Hariri, Jarcho,

Eisenberger, & Bookheimer, 2005; Wheeler & Fiske, 2005; Cunningham et al., 2004; Richeson et al., 2003; Golby, Gabrieli, Chiao, & Eberhardt, 2001; Hart et al., 2000; Phelps et al., 2000). Most interestingly, this work has revealed that the increased amygdala activity elicited by outgroup faces is correlated with the strength of people's evaluative race-based associations (Cunningham et al., 2004; Phelps et al., 2000). This effect is assumed to reflect a primary product of cultural socialization, beliefs about the emotional significance of racial groups. What research to date has not yet considered, however, are the neuroanatomical structures that subserve the expression of stereotypical thinking. That is, little is known about the neural structures that support the defining feature of the stereotyping process, the generation of culturally proscribed judgments about prominent social groups (Fiske, 1998). Accordingly, in the context of gender stereotyping, we explored this important issue in the current investigation.

Consideration of the neuroanatomy of social cognition has led to the identification of a putative social-cognition network in the brain (i.e., medial prefrontal cortex [MPFC], temporo-parietal junction [TPJ], superior temporal sulcus [STS], and amygdala), with components of this network supporting core aspects of person construal (e.g., Amodio & Frith, 2006; Frith & Frith, 2006; Adolphs, 2001, 2003; Brothers, 1990). There is preliminary evidence from neuroimaging and patient studies to suggest that the MPFC may play a prominent role in the stereotyping process. For example, judging a person about whom only knowledge of his political affiliation is available (i.e., a condition that should precipitate stereotyping) and completing implicit group-based associations (i.e., race and

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gender) in a stereotypic manner have both been shown to increase activity in the MPFC (Knutson, Mah, Manly, & Grafman, 2007; Mitchell, Macrae, & Banaji, 2006). Similarly, lesions to the MPFC have been associated with the diminished accessibility of implicit gender-based beliefs (Milne & Grafman, 2001). Taken together, these findings suggest that the MPFC may play a contributory role in the generation of stereotype-based judgments.

As stereotyping entails the coordinated operation of several distinct subprocesses, activity is likely to extend beyond the prefrontal cortex. In particular, consideration should be given to the content of stereotype-based judgments and how this may impact the associated neural circuitry (Martin, 2007). As a case in point, consider the various forms that gender stereotyping can take. Stereotyped judgments about the sexes typically tap knowledge pertaining to the appearance (e.g., *women wear skirts, men have short hair*), preferred activities (e.g., *women bake cakes, men play poker*), and likely personalities (e.g., *men are aggressive, untidy, and ambitious; women are timid, emotional, and patient*) of women and men (Crawford, Leynes, Mayhorn, & Bink, 2004). Given that semantic knowledge about objects (including people) is represented in a distributed network of domain-specific cortical areas (see Humphreys & Forde, 2001; Tyler & Moss, 2001), this then suggests that visual, action, and conceptual stereotypes should elicit activity in the relevant parts of this network (Martin, 2007). For example, whereas visual stereotyping (i.e., “visual form” knowledge) should be accompanied by activity in the ventral temporal cortex (e.g., Ishai, Ungerleider, Martin, & Haxby, 2000; O’Craven & Kanwisher, 2000), action stereotyping (i.e., “action” knowledge) should yield activity in regions within the posterior temporal and parietal cortices (Kellenbach, Brett, & Patterson, 2003; Damasio et al., 2001; Chao, Haxby, & Martin, 1999). As the current investigation explored the generation of action-related stereotypes, we expected to observe activity in these latter areas (Martin, 2007).

To elucidate the neural correlates of gender stereotyping, we used fMRI to measure brain activity while participants performed two versions of a simple judgment task. The task required participants to report the likely actor (i.e., person-focus) and origin (i.e., place-focus) of a series of everyday activities (e.g., *mowing the lawn, watching talk shows, taking photographs*), some of which were associated with prevailing gender stereotypes. On person-focus trials, participants reported if the behaviors were performed predominantly by men or women or were equally likely to be undertaken by both sexes. On place-focus trials, in contrast, participants indicated whether the behaviors were typically performed indoors or outdoors or were likely to occur in both locations. These tasks made it possible to establish if inferences about people differ from comparable judgments with a nonperson focus (i.e., person vs. place).

To investigate the neural substrates of gender stereotyping (i.e., person-focus trials), responses convergent with the cultural stereotypes of women and men were contrasted with person judgments that have no stereotypic implications (i.e., stereotypic vs. nonstereotypic). We anticipated that brain regions subserving person construal (i.e., MPFC), together with areas supporting the representation of action knowledge (e.g., posterior temporal cortex), would underpin the generation of stereotypical judgments.

Finally, we explored if patterning of the BOLD response during stereotyping was associated with pre-existing beliefs about the sexes. Previous research on race categorization has indicated that increased brain activity elicited by outgroup faces is correlated with the strength of people’s implicit but not with their explicit beliefs about outgroup members (Cunningham et al., 2004; Phelps et al., 2000). In the current study, both implicit and explicit measures of gender attitudes were therefore administered to establish if comparable effects emerge when the neural signature of stereotyping is under investigation. As such, participants were required to complete a gender-based Implicit Association Test (IAT; Rudman, Greenwald, & McGhee, 2001) and the Attitudes Toward Women Scale (AWS; Spence, Helmreich, & Stapp, 1973) outside the scanner. Whereas the gender IAT was administered to measure participants’ implicit evaluative associations, the AWS was used to assess the extent to which they explicitly endorse stereotyped beliefs about men and women.

METHODS

Participants

Twenty right-handed undergraduate students of the University of Aberdeen (7 men) aged between 18 and 32 years (mean age = 22.3 years) participated in the experiment in exchange for a picture of their brain. All participants were native English speakers, reported normal or corrected-to-normal vision, and had no history of neurological problems. Informed consent was obtained from all individuals and the study protocol was approved by the Grampian Local Research Ethics Committee.

Stimuli and fMRI Paradigm

The task in the fMRI scanner required participants to report the likely actor (i.e., person-focus) and origin (i.e., place-focus) of a series of behaviors. On person-focus trials, participants reported if the behaviors were performed predominantly by men or women or were equally likely to be undertaken by both sexes. On place-focus trials, in contrast, participants indicated whether the behaviors were typically performed indoors or outdoors or were likely to occur in both locations. For both tasks, participants were presented with phrases describing everyday activities and were instructed to base their

responses, not on the basis of their own personal views, but in terms of general societal beliefs. This is a standard methodology in social psychology to elicit stereotypical judgments (Devine, 1989). Responses were given by pressing one of three buttons on a button box with the index, middle, or ring finger of the right hand. Prior to the experiment proper, a pilot study was undertaken to select behaviors for the judgment task. Twenty undergraduates (6 men, mean age = 22.65 years, age range = 18–26 years) completed “person” and “place” judgments on a questionnaire comprising 170 phrases describing everyday activities (e.g., *maintaining the car, going horseback riding, using a cell phone*). Based on these ratings, 100 behaviors were selected for the imaging experiment. To be included in the experiment proper, 60% of participants had to make the same response to an item (e.g., *men maintain the car*). Equivalent numbers of stereotypic and neutral behaviors were selected.

For both tasks (i.e., person and place), the same behaviors were presented in different random orders. The experiment was conducted in four blocks, with two blocks of trials for each type of judgment. Within each of these four functional runs, an event-related design was employed. Each functional run contained 50 trials of interest and an additional 30 rest trials. Rest trials consisted of a display of the default screen only (i.e., a display of the response options only). These trials were included to introduce “jitter” into the time series so that unique estimates of the hemodynamic responses for the trial types of interest could be computed (Ollinger, Shulman, & Corbetta, 2001). The order of the four functional runs was counterbalanced across participants in an A, B, B, A fashion. Stimuli (i.e., behavioral phrases) were presented for 2000 msec centrally on a computer screen and the stimulus onset asynchrony was 2500 msec. Participants’ responses and associated response latencies were recorded. Stimulus presentation was controlled using Presentation software (version 9.13, Neurobehavioral Systems, Albany, CA).

Attitude Measures

Following the imaging experiment (i.e., outside the scanner), participants completed a computer-based standardized IAT on gender (Rudman et al., 2001), and the short version of the AWS (Spence et al., 1973). The gender-IAT measures automatic category–attribute associations thought to underlie implicit gender beliefs (Greenwald & Banaji, 1995). The task requires respondents to map four categories of stimuli on two response buttons and operates under the assumption that well-associated concepts can more easily be mapped onto the same response key than less associated concepts.

In the current study, the IAT comprised a set of practice and test stimuli. The practice stimuli consisted of five male forenames, five female forenames, five power-meaning words, and five weak-meaning words. The test

stimuli consisted of 15 male forenames (e.g., *Brian, Scott, Peter*), 15 female forenames (e.g., *Susan, Laura, Karen*), 15 power-meaning words (e.g., *strong, solid, violent*), and 15 weak-meaning words (e.g., *delicate, quiet, frail*). Participants responded to forenames and words by pressing the “v” and “m” keys on a computer keyboard. The IAT was administered in seven blocks. First, participants were asked to distinguish male versus female practice names. They were then instructed to distinguish powerful and weak practice words. In Block 3, participants were asked to respond to the set of practice stimuli by pressing the “v” key for male names and strong words, and the “m” key for female names and weak words. In Block 4, Block 3 was repeated as a test block with the experimental stimuli described above. In Block 5, participants were again asked to distinguish powerful and weak practice words, with response key assignments reversed. In Block 6, participants were required to respond to the practice set of stimuli by pressing the “m” key for female names and strong words and the “v” key for male names and weak words. In Block 7, Block 6 was repeated as a test block. The IAT effect was computed by subtracting the mean response latency for performing the stereotype-compatible task (Block 4, female names + weak words, male names + strong words) from the stereotype-incompatible task (Block 7, female names + strong words, male names + weak words) and dividing the difference by the pooled standard deviation of latencies across both blocks (Greenwald, Nosek, & Banaji, 2003). Thus, the bigger the relative difference in response latencies, the stronger the implicit associations a person holds with regard to gender. The order in which participants performed the stereotype-compatible and incompatible tasks was counterbalanced across participants and stimuli were randomly presented within each block of trials.

The AWS consists of items reflecting traditional gender-role beliefs (e.g., “A woman should not expect to go to exactly the same places or to have quite the same freedom of action as a man”). Answers are given on 4-point scales ranging from 0 (*agree strongly*) to 3 (*disagree strongly*). A low average score is indicative of the possession of stereotyped beliefs about men and women. The AWS was administered as a paper-and-pencil questionnaire.

Image Acquisition and Analysis

Image acquisition was undertaken on a 1.5-Tesla whole-body scanner (GE Healthcare) with a standard head coil. Anatomical images were acquired using a high-resolution, 3-D spoiled gradient recalled echo sequence (SPGR; 124 sagittal slices, TE = 3.2 msec, TR = 8 msec, flip angle = 15°, voxel size = 1 × 1 × 1.6 mm). Functional images were collected in runs each comprising 80 volumes using a gradient spin-echo, echo-planar sequence sensitive to BOLD contrast (TR = 2500 msec,

T2* evolution time = 40 msec, flip angle = 90°, 3.75 × 3.75 in-plane resolution). For each volume, 30 axial slices, 5 mm slice thickness, 0 mm skip between slices were acquired allowing complete brain coverage.

Preprocessing and analysis of the imaging data were performed using Statistical Parametric Mapping (SPM2, Wellcome Department of Cognitive Neurology, London, UK). First, functional data were time-corrected for differences in acquisition time between slices for each whole-brain volume and realigned to the first volume to minimize the effects of head movements on data analysis. Functional data were then transformed into a standard anatomical space (2 mm isotropic voxels) on the basis of the ICBM 152 brain template (MNI). Normalized data were then spatially smoothed (8 mm full-width-at-half-maximum) using a Gaussian kernel. Statistical analyses were performed using the general linear model. An event-related design was modeled using a canonical hemodynamic response function and its temporal derivative. The model also included regressors for additional covariates of no interest (a linear trend for the four blocks). This analysis was performed individually for each participant, and resulting contrast images were subsequently entered in a second-level analysis treating participants as a random effect. To minimize false-positive results, effects were considered statistically significant using a statistical criterion of 71 or more contiguous resampled voxels at a voxelwise threshold of $p < .001$. This cluster size was calculated on the basis of a Monte Carlo simulation (see Slotnick, Moo, Segal, & Hart, 2003) to enforce an a priori threshold of $p < .05$ (corrected for multiple comparisons). We also looked at the relation between activation in regions of interest identified from the contrast of stereotypic versus nonstereotypic judgments and the strength of participants' implicit and explicit gender beliefs. For each functionally defined region, we calculated the correlation between (i) the difference in BOLD response associated with stereotypic versus nonstereotypic trials, as indexed by the SPM parameter estimates associated with each trial type; and (ii) participants' IAT and AWS scores. In addition, given that this is one of the first fMRI studies to examine gender stereotyping, we also conducted regression analyses across the whole brain to explore whether brain activity during stereotypic compared to nonstereotypic person judgments was correlated with participants' gender beliefs as expressed on the IAT and AWS. Again, brain regions with 71 or more contiguous resampled voxels at a voxelwise threshold of $p < .001$ were considered statistically significant.

RESULTS

Behavioral Data

As the current experiment explored the neural correlates of stereotyping (i.e., culturally shared beliefs about

the attributes and behaviors associated with social groups), only judgments that matched consensual gender stereotypes were submitted to statistical analysis. That is, participants' responses had to match the gender stereotypes that were established in the pilot study. For example, if a participant reported that "playing poker is preferentially performed by women," this trial was excluded from analyses because it did not confirm the stereotype (i.e., "men typically play poker"). To ensure consistency, the same approach was adopted for responses on the place task (i.e., only judgments that matched consensual beliefs about the appropriate locations were analyzed). Applying this strategy, 11% ($SD = 5%$) of the person-categorical (i.e., gender stereotypic) trials and 9% ($SD = 3%$) of the place-categorical trials were excluded from the analysis, as were 20% ($SD = 13%$) of the person-both (i.e., gender nonstereotypic) and 19% ($SD = 10%$) of the place-both trials. To investigate whether the number of critical trials differed across tasks, participants' percentages of accurate responses were submitted to a 2 (task: person or place) × 2 (response: categorical or both) repeated measures analysis of variance (ANOVA). The only significant effect to emerge was a main effect of response [$F(1, 19) = 11.63, p < .05$], such that participants' judgments were more accurate (i.e., confirmed consensual beliefs) on trials with "categorical" (i.e., men/women or indoor/outdoor, $M = 90%$, $SD = 4%$) than "both" ($M = 81%$, $SD = 11%$) answers.

Participants' median response times on correct trials were submitted to an identical analysis. The results revealed a significant effect of task [$F(1, 19) = 33.25, p < .05$], indicating that person judgments ($M = 1107$ msec, $SD = 115$ msec) were faster than place judgments ($M = 1216$ msec, $SD = 116$ msec). There was also a main effect of response [$F(1, 19) = 92.04, p < .05$], such that "categorical" answers ($M = 1077$ msec, $SD = 98$ msec) were given faster than "both" answers ($M = 1245$ msec, $SD = 129$ msec). A Task × Response interaction was also observed [$F(1, 19) = 5.58, p < .05$]. Additional t tests revealed that reaction times were faster for "categorical" ($M = 1036$ msec, $SD = 118$ msec) than "both" judgments ($M = 1177$ msec, $SD = 136$ msec) on person trials [$t(19) = 5.81, p < .05$]. Comparable effects emerged on "categorical" ($M = 1118$ msec, $SD = 95$ msec) and "both" ($M = 1313$ msec, $SD = 144$ msec) judgments during place trials [$t(19) = 11.51, p < .05$].¹

Questionnaire Data

Participants' IAT scores ranged from -0.30 to 0.94 with a mean score of 0.40 ($SD = 0.33$), indicating that female names were more readily associated with weak words and male names with powerful words than vice versa. Scores on the AWS ranged from 26 to 43 with a mean value of 36.6 ($SD = 4.07$). The two attitude measures were correlated [$r(18) = -.43, p < .05$], such that the

Table 1. Peak Voxel and Number of Voxels for Brain Regions Obtained for Person Judgment and Place Judgment Trials ($p < .05$, Corrected)

<i>Region</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>Voxels</i>	<i>t</i>
<i>Person Judgment > Place Judgment</i>					
No significant activation					
<i>Place Judgment > Person Judgment</i>					
Precuneus	-28	-78	34	606	6.13
Middle temporal gyrus	-58	-56	-14	189	6.05
Inferior parietal lobe	-40	-54	40	111	5.26
Superior occipital lobe	36	-84	26	71	5.18
Middle frontal gyrus	-30	2	54	167	5.01
Fusiform gyrus	-48	-42	-18	141	4.64
Cerebellum	6	-54	0	71	4.56

t values reflect the statistical difference between the two conditions, as computed by SPM2. Coordinates refer to the MNI stereotaxic space.

stronger participants' implicit gender bias (i.e., the higher the relative difference between compatible and incompatible trials), the more stereotypic their explicit beliefs about the sexes (i.e., the lower their score on the AWS; see also Rudman et al., 2001).

fMRI Data

Our first set of analyses compared judgments completed under a person-focus with those obtained under a place-focus (see Table 1). The contrast (place-focus > person-focus) yielded differences in several regions, including the left middle frontal gyrus (BA 6), the left inferior parietal lobe (BA 40), the right superior occipital lobe (BA 19), the left posterior middle temporal gyrus (BA 21/37), the left precuneus (BA 17/19), and the left fusiform gyrus (BA 37). The reverse contrast (person-focus > place-focus) did not reveal any significant differences in activation. Interestingly, when analysis was restricted to categorical trials (i.e., trials eliciting a male/female or indoor/outdoor response), the contrast of person > place revealed activity in regions that have previously been implicated in social thought, notably the dorsal MPFC (BA 8 and 9), the left TPJ (BA 39), and the right superior frontal gyrus (SFG, BA 6).

In our second analysis, we targeted brain regions that differentiated between stereotypic and nonstereotypic (i.e., both) person judgments (see Table 2). The contrast person-stereotypic > person-both revealed activation in several areas, including the ventral MPFC [vMPFC] (BA 10), the left middle temporal gyrus (MTG, BA 37), the left supramarginal gyrus (SMG, BA 40), the left putamen, the right precuneus (BA 7), the right amygdala and the left amygdala extending into the parahippocampal, and

the superior temporal gyri (STG, BA 20/21; see Figure 1). The reverse contrast (person-both > person-stereotypic) revealed no significant differences in brain activation.

To establish if the effects observed for person-stereotypic judgments (stereotypic > both) were modulated by stereotypicality rather than differences in the cognitive processes underlying "categorical" versus "both" judgments, we extracted the mean parameter estimates for the comparable place judgments (i.e., categorical vs. both) and submitted these together with the person parameter estimates to a 2 (task: person or place) \times 2 (response: categorical or both) repeated measures ANOVA. Analyses were restricted to the areas of theoretical interest depicted in Figure 1 (i.e., vMPFC, MTG, SMG, bilateral amygdalae). In each region, a Task \times Response interaction was observed [all $F_s(1, 19) > 11.26, p < .05$], although this effect was only marginally significant in the right amygdala [$F(1, 19) = 3.75, p < .07$]. Additional *t* tests confirmed that, with respect to person trials, activity in all of the regions was greater when stereotypic-person than both-person judgments were reported [all $t_s(19) > 4.85, p < .05$; see Figure 1]. Importantly, quite different effects emerged during place trials. Whereas in the vMPFC and in the left and right amygdala no differences in activity were observed as a function of the judgments reported [all $t_s(19) < 1.84, ns$], in the MTG and STG, "both" judgments yielded a larger BOLD response than "categorical" judgments [both $t_s(19) > 2.45, p < .05$; see Figure 1]. Taken together, these findings speak against the possibility that the stereotyping effects observed herein reflect

Table 2. Peak Voxel and Number of Voxels for Brain Regions Obtained for Person-stereotypic and Person-both Trials ($p < .05$, Corrected)

<i>Region</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>Voxels</i>	<i>t</i>
<i>Person-stereotypic > Person-both</i>					
vMPFC	-4	54	6	112	4.59
MTG	-62	-60	8	156	6.67
SMG	-58	-48	30	86	5.06
Putamen	-24	12	2	84	4.46
Precuneus	10	-58	56	562	6.63
Amygdala	-24	-6	-24	525	6.34
	32	0	-26	120	5.22
Midbrain	-2	-28	-12	825	7.81
Cerebellum	-12	-62	-12	138	5.17
<i>Person-both > Person-stereotypic</i>					
No significant activation					

t values reflect the statistical difference between the two conditions, as computed by SPM2. Coordinates refer to the MNI stereotaxic space.

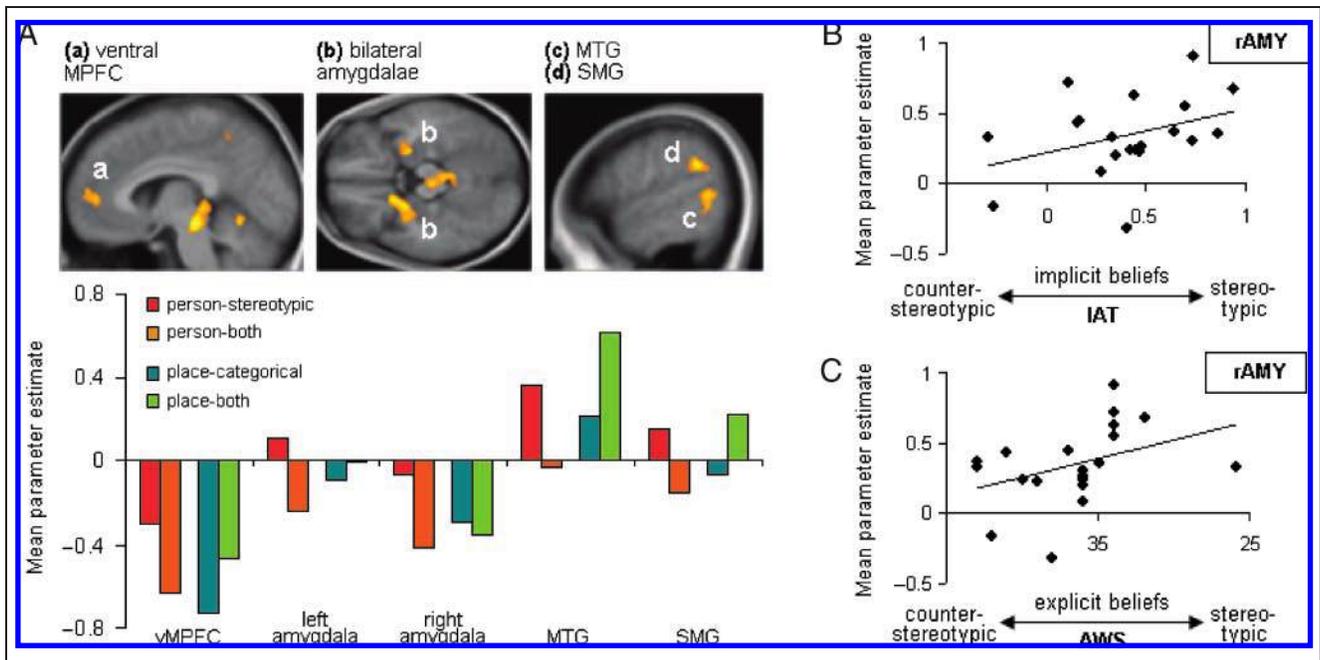


Figure 1. (A) Brain regions displaying greater activity during stereotypic than nonstereotypic trials: (a) vMPFC, (b) amygdalae, (c), MTG, (d) SMG. (B) Relationship between BOLD response in the right amygdala obtained for stereotypic > nonstereotypic trials and implicit gender beliefs. (C) Relationship between BOLD response in the right amygdala obtained for stereotypic > nonstereotypic trials and explicit gender beliefs.

differences in the cognitive operations supporting “categorical” and “both” judgments.

To investigate the relation between participants’ explicit and implicit beliefs about the sexes and the brain activity that accompanied person-based judgments, we examined the correlation between the BOLD response in the areas noted above and scores on the IAT and AWS. These correlational analyses revealed that the more stereotypic participants’ explicit beliefs about the sexes (i.e., as assessed by the AWS), the greater the activity in the right amygdala during the generation of “stereotypic” than “both” judgments [$r(18) = -.38, p < .05$; see Figure 1]. A comparable, though marginal, effect was also observed for participants’ implicit gender associations (i.e., as indexed by the IAT), such that the stronger these associations, the greater the activation in the right amygdala during “stereotypic” than “both” judgments [$r(18) = .37, p < .06$; see Figure 1]. Additional whole-brain regression analyses did not reveal any further significant correlations between the IAT and AWS scores and the BOLD response.

Finally, to identify the regions supporting place judgments, the BOLD signal during trials eliciting a “categorical” response and those eliciting a “both” response were compared (see Table 3). The contrast place-categorical > place-both did not reveal any significant differences in activation. The opposite contrast (place-both > place-categorical) yielded activity in a number of regions, including the left SFG (BA 6/8), the bilateral inferior frontal gyrus (IFG, BA 47), the right angular gyrus

(BA 39), and the left fusiform gyrus extending into the precuneus and the cuneus (BA 19/18).

DISCUSSION

In the current study, participants judged a series of everyday activities under either a person-based (i.e., who

Table 3. Peak Voxel and Number of Voxels for Brain Regions Obtained for Place-categorical and Place-both Trials ($p < .05$, Corrected)

Region	x	y	z	Voxels	t
<i>Place-categorical > Place-both</i>					
No significant activation					
<i>Place-both > Place-categorical</i>					
SFG	-6	20	68	2985	8.81
IFG	-50	30	-14	2274	7.75
	36	32	-14	184	5.21
Angular gyrus	52	-68	32	77	4.40
Fusiform gyrus	-40	-66	-16	4271	7.83
Cerebellum	40	-74	-38	1182	6.83
Thalamus	-8	-34	4	106	6.00

t values reflect the statistical difference between the two conditions, as computed by SPM2. Coordinates refer to the MNI stereotaxic space.

predominantly performs the action?) or place-based (i.e., where is the action typically performed?) focus. Critically, some of the activities were stereotypic with respect to prevailing cultural beliefs about the sexes. Although analysis of the imaging results revealed limited effects of judgment-focus on brain activity, gender stereotyping was associated with activation in regions that subserve the representation of action knowledge (e.g., left MTG, left SMG) and evaluative processing (e.g., amygdala, vMPFC). These results are noteworthy for a number of reasons. When participants are required to generate action words, answer questions about tools, or retrieve action knowledge, activity is reliably observed in the left hemisphere in the MTG and in the SMG (Assmus, Giessing, Weiss, & Fink, 2007; Tranel, Martin, Damasio, Grabowski, & Hichwa, 2005; Kellenbach et al., 2003; Damasio et al., 2001; Grezes & Decety, 2001; Chao et al., 1999). Comparable results were obtained in the current investigation in a task context in which participants generated action-based stereotypic judgments. What this suggests is that action knowledge may comprise not only the movements associated with particular activities or objects (Martin, 2007) but also information pertaining to the actor who is most likely to perform the activity in question. That is, action representations contain person-related knowledge.

Of course, modulation in regions associated with the representation of action knowledge may simply reflect the manner in which stereotyping was probed in the current inquiry. Aside from information characterizing the favored activities of the sexes, cultural stereotypes also furnish details of the likely appearance and personalities of men and women (Fiske, 1998). Given that semantic knowledge is represented in a distributed network of domain-specific cortical areas (Martin, 2007; Humphreys & Forde, 2001; Tyler & Moss, 2001), this suggests that if appearance-based or personality-related forms of stereotyping were to be assessed, then activity would emerge in the relevant components of this network. For example, visual stereotyping should yield activity in areas within the ventral temporal cortex (Ishai et al., 2000; O'Craven & Kanwisher, 2000), whereas probing of gender-stereotypic personality traits should elicit activation in the anterior STG (Zahn et al., 2007). One useful task for future research will be to explore these possibilities.

Together with activation in regions supporting the representation of action knowledge, stereotyping was also accompanied by activity in areas associated with evaluative processing, notably the amygdala and the vMPFC (Bechara, Damasio, Damasio, & Lee, 1999). Furthermore, activity in the right amygdala was correlated with the strength of participants' explicit and implicit gender beliefs. An extensive literature has documented the critical role played by the amygdala in evaluative processing, particularly in the social domain (Bar-On, Tranel, Denburg, & Bechara, 2003; Zald, 2003; Phan,

Wager, Taylor, & Liberzon, 2002). In the context of stereotyping, however, the precise functional significance of amygdala activity remains open to debate (Knutson et al., 2007; Cunningham et al., 2004; Phelps et al., 2000). Although activity in this structure has been observed in tasks demanding the overt categorization of male and female faces (e.g., Fischer et al., 2004; Phillips et al., 2001; DuBois et al., 1999), this effect likely reflects an evaluative component of person construal, rather than stereotyping per se. As Knutson et al. (2007) have reported, "further research is needed before stating that performing gender stereotypic tasks activates the amygdala, as amygdala activation to gender stereotyping has not been previously reported in the literature" (p. 926). In this respect, the current findings provide direct evidence for an association between amygdala activity and gender stereotyping. In addition, they extend previous research on race processing which has demonstrated a relationship between people's race-related IAT scores and activity in the amygdala during the perception of Black and White faces (Cunningham et al., 2004; Phelps et al., 2000). Specifically, the current results reveal that amygdala activity may also subserve the generation of group-based stereotypic judgments, albeit in the context of gender stereotyping. What this suggests is that responding stereotypically may be an inherently evaluative process (Wilson, Lindsey, & Schooler, 2000), especially for individuals who hold strong stereotypic beliefs about the sexes.

In contrast to previous studies on race categorization (Cunningham et al., 2004; Phelps et al., 2000), amygdala activity during gender stereotyping was not only correlated with the strength of participants' implicit attitudes but also their explicit beliefs about the sexes. So why might these differences between race and gender stereotyping arise? One possibility is that the strength of the relationship between neural activity and various attitude measures may depend on the particular social group under consideration (i.e., race versus sex). That is, perhaps activity in the amygdala during race-based processing correlates only with the strength of implicit race attitudes, whereas activity in the amygdala during gender-based processing correlates with the strength of implicit and explicit gender attitudes. It seems more likely, however, that these differences may be traced to the manner in which racial and gender-related attitudes have been explored in the literature to date. Whereas the current study required participants to draw explicit stereotypic inferences about the sexes, imaging investigations of race-based processing typically entail the perceptual categorization of outgroup faces (Cunningham et al., 2004; Phelps et al., 2000). These basic task differences (i.e., stereotype generation vs. face construal), we suspect, may account for the discrepant findings. Accumulating evidence has indicated that categorization is a necessary but not sufficient condition for the emergence of stereotyping (Blair, Judd, Sadler, & Jenkins,

2002; Lepore & Brown, 1999; Kawakami, Dion, & Dovidio, 1998; Wittenbrink, Judd, & Park, 1997; Gilbert & Hixon, 1991). What this suggests is that previous work on race processing may have failed to trigger stereotypical thinking, hence, the absence of a significant correlation between amygdala activity and participants' explicit racial beliefs (Cunningham et al., 2004; Phelps et al., 2000). This possibility merits further empirical attention.

Interestingly, although increased amygdala activity during stereotypic responding was observed bilaterally, only activity in the right amygdala correlated with participants' gender attitudes. It has been suggested that although both amygdalae can signal the emotional significance of a stimulus (Phelps, 2006; Zald, 2003), the respective patterns of activation may depend on why a stimulus is emotionally salient. In particular, it has been proposed that activity in the right amygdala is moderated by stimuli that have acquired emotional significance through learning rather than based on some innate propensity (Dolan & Morris, 2000). Elsewhere, it has been suggested that although both amygdalae can signal the learned emotional significance of material, the manner in which learning takes place modulates reactivity in these structures. Specifically, whereas the right amygdala appears to depend on the acquisition of emotional meaning through experience, the left amygdala reflects learning through instruction (Phelps et al., 2001). Given the experiential nature of gender-role socialization, this viewpoint may account for the current observation that the strength of people's gender beliefs was correlated with activity in the right but not in the left amygdala. A useful task for future research will be to specify the precise relationship between the manner in which stereotypes are acquired (e.g., instance vs. abstraction-based) and hemispheric differences in amygdala activity.

Complementing the reported amygdala activity, activation was also observed in the vMPFC during stereotyping. Both the animal and imaging literatures offer evidence that the vMPFC provides important regulatory input to the amygdala during emotional processing (e.g., Goel & Dolan, 2003; Kim, Somerville, Johnstone, Alexander, & Whalen, 2003; Milad & Quirk, 2002; Bechara et al., 1999; Damasio, 1997; Morgan, Romanski, & LeDoux, 1993). It is unsurprising therefore that the vMPFC is also implicated in the generation of stereotypical judgments. Elsewhere, activity in this region has been reported when people read stereotypic information about foreigners (Saxe & Wexler, 2005) or complete associations that confirm implicit racial and gender-based beliefs (Knutson et al., 2007). Furthermore, compared to healthy volunteers or patients with damage to the dorsolateral prefrontal cortex, individuals with lesions in the vMPFC display reduced levels of stereotyping when their implicit attitudes are assessed (Milne & Grafman, 2001). One possibility is that damage to the vMPFC blunts access to the evaluative component of stereotypical beliefs. What is

evident in the current paradigm is that gender stereotyping activates regions commonly associated with emotional reasoning (Goel & Dolan, 2003; Davidson, Jackson, & Kalin, 2000), a finding that underscores the evaluative nature of stereotypical thinking.

In the current study, increased activity in both the MPFC and the right amygdala during stereotypic compared to nonstereotypic judgments was the result of differences in the magnitude of deactivations relative to baseline (see Figure 1A). Although such a patterning of the BOLD response is commonplace in the MPFC, responses in the amygdala less frequently take this form. Studies examining why certain brain regions consistently deactivate in the presence of an active processing task suggest that the MPFC plays a prominent role in default cognitive operations, such as stimulus-independent thought (see Mason et al., 2007; Gusnard & Raichle, 2001). Quite why deactivations occur in the amygdala, however, is less certain. In the current investigation, whereas the right amygdala showed decreased activity relative to baseline during nonstereotypic person and all place judgments, activity during stereotypic-person judgments was at baseline. Recent data suggest that during cognitively demanding tasks that do not necessitate the emotional processing of stimuli, active suppression of amygdala activity can occur (Pessoa, Padmala, & Morland, 2005). Given this finding, the nonemotional character of both nonstereotypic and place judgments may account for the observed deactivations in the right amygdala in the current investigation. Additional research will be required to explore the viability of this viewpoint.

Conclusion

Notwithstanding the significant influence that stereotyping exerts on behavior, limited research has explored the neural correlates of this core social-cognitive process. Responding to this empirical lacuna, the current investigation considered the neural substrates of gender stereotyping. As a strategy to infer the likely deeds of others, stereotypic judgments were accompanied by activity in regions supporting the representation of action knowledge and evaluative processing. As such, the current results capture the cognitive and emotional components of stereotypical thinking (Fiske, 1998). In addition, the neural circuitry underpinning stereotyping was modulated by the strength of people's implicit and explicit gender-related beliefs. Thus, although most persons are capable of generating stereotypic judgments (Devine, 1989), activity in the neural circuitry supporting these responses is sensitive to the strength with which gender-based beliefs are endorsed in everyday life. These findings elucidate how stereotyping fits within the neuroscience of person understanding (Amodio & Frith, 2006; Frith & Frith, 2006; Adolphs, 2001, 2003).

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Note

1. To verify that male and female participants report the same gender stereotypes, accuracy scores and median response times on stereotypic-person trials were contrasted as a function of the sex of participants. No significant differences emerged in these analyses [accuracy: men = 89.2% ($SD = 4.8\%$), women = 89.0% ($SD = 5.2\%$), $t(18) < 1$, ns ; response times: men = 1072 msec ($SD = 152$ msec), women = 1017 msec ($SD = 97$ msec), $t(18) < 1$, ns].

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