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Politics on the Brain: An fMRI Investigation

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Abstract

We assessed political attitudes using the Implicit Association Test (IAT) in which participants were presented faces and names of well-known Democrat and Republican politicians along with positive and negative words while undergoing functional MRI. We found a significant behavioral IAT effect for the face, but not the name, condition. The fMRI face condition results indicated that ventromedial and anterior prefrontal cortices were activated during political attitude inducement. Amygdala and fusiform gyrus were activated during perceptual processing of familiar faces. Amygdala activation also was associated with measures of strength of emotion. Frontopolar activation was positively correlated with an implicit measure of bias and valence strength (how strongly the participants felt about the politicians), while strength of affiliation with political party was negatively correlated with lateral PFC, lending support to the idea that two distinct but interacting networks—one emphasizing rapid, stereotypic, and emotional associative knowledge and the other emphasizing more deliberative and factual knowledge—cooperate in the processing of politicians. Our findings of ventromedial PFC activation suggests that when processing the associative knowledge concerned with politicians, stereotypic knowledge is activated, but in addition, the anterior prefrontal activations indicate that more elaborative, reflective knowledge about the politician is activated.

Keywords

implicit association test; functional MRI; prefrontal cortex; politics; frontopolar PFC; social cognition

Introduction

Politics is a domain within social cognition where individuals use acquired knowledge to explicitly influence (via advocacy or voting) social decisions affecting large groups, not just themselves or significant others. Over time individuals may develop attitudes about different political figures and parties based on their experience. This political aspect of social behavior appears unique to humans and may be especially relevant to understanding the functions of the human prefrontal cortex. In this study, we investigated how decision-making involving political attitudes is reflected in patterns of prefrontal cortex brain activation.

Attitudes have been explored extensively using the IAT (Greenwald, McGhee, & Schwartz, 1998; Greenwald & Nosek, 2001) and the majority of studies have focused on attitudes toward gender and race. In the IAT, participants are presented two tasks; one requires categorization of words into two possible categories such as female or male; the other requires evaluation of words describing attributes such as weak or strong. The response keys are mapped in either a

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congruent or incongruent manner according to conventional stereotypes. For example, in the stereotype-congruent condition of the gender IAT, participants would press one response key if the words were female names or weak words (e.g., helpless, feeble), and another response key if the words were male names or strong words (e.g., brave, tough). In the stereotype-incongruent condition, participants would press one response key if the words were male names or weak words, and another response key if the words were female names or strong words. The typical finding is that participants respond faster to stereotype-congruent than stereotype-incongruent trials despite reporting that they were unaware of the purpose of the task. Greenwald and colleagues explored attitudes toward the candidates in the 2000 U.S. presidential primaries using a modified version of the IAT in which the faces and names of Bush and Gore were contrasted with pleasant and unpleasant words, such as “joy” and “love”, or “agony” and “terrible” (Greenwald, Nosek, & Banaji, 2003; Nosek, Banaji, & Greenwald, 2002). Their web-based behavioral study involved 8891 participants. The “Election 2000 IAT” yielded a similar attitudinal effect to that observed for the gender and race versions of the task, with faster responses to the congruent than incongruent trials.

There have been few studies exploring the neural substrate of social attitudes. For example, a recent neuropsychological study demonstrated that patients with lesions of the ventromedial prefrontal cortex showed impaired automatic priming of gender stereotypic knowledge relative to healthy controls and patients with prefrontal cortex lesions that did not involve ventromedial regions (Milne & Grafman, 2001). Many lesion studies have demonstrated the importance of the ventromedial PFC in responding to socially meaningful stimuli (Damasio, Tranel, & Damasio, 1990) and in interpreting non-verbal emotional expressions (Mah, Courtney Arnold, & Grafman, 2005). Neuroimaging studies have also demonstrated involvement of the amygdala in processing black and white faces, with activation showing habituation only when the faces were of a different race than the viewer (Hart, Whalen, Shin, McInerney, Fischer, & Rauch, 2000; Phelps, O'Connor, Cunningham, Funayama, Gatenby, Gore et al., 2000). Of direct relevance to the present study, Phelps and colleagues showed that activation of the amygdala and anterior cingulate gyrus in response to facial stimuli correlated with performance on a race version of the IAT performed outside of the MRI scanner. To our knowledge, there has been only one published study that addressed attitudes using the IAT performed during functional imaging (Chee, Sriram, Soon, & Lee, 2000). Chee and colleagues asked participants to perform a flower and insect version of the IAT while undergoing fMRI. Relative to a simple classification control task, incongruent trials (flowers = unpleasant; insects = pleasant) were associated with activation of left ventral prefrontal cortex, left dorsolateral prefrontal cortex (DLPFC), anterior cingulate, and superior parietal areas bilaterally.

In the present study, we assessed political attitudes using a modified version of the IAT in which participants were presented faces and names of well-known Democrat and Republican politicians. Faces are readily identifiable representations of social groups and as such may be associated with relatively automatic social evaluations (Phelps et al., 2000). Based on prefrontal connectivity patterns (Wood, 2003), we predicted that responses to both faces and names in the congruent and incongruent conditions would be associated with activation of a network including DLPFC, premotor, orbitofrontal, and left inferior prefrontal cortices. Relative to the control condition, the face congruent and incongruent conditions were expected to activate the amygdala, whereas the name condition was predicted to activate prefrontal regions, since the emotional response to names may not be as automatic as that for faces. The incongruent condition is likely to have inhibition and conflict processing components since the prepotent response must be inhibited and the conflict between the two possible responses resolved. Therefore, the incongruent, but not congruent, conditions were expected to activate the anterior cingulate and right inferior frontal gyrus as these have been implicated in tasks requiring inhibition and conflict resolution (Braver, Barch, Gray, Molfese, & Snyder, 2001; Garavan, Ross, & Stein, 1999; Konishi, Nakajima, Uchida, Kikyo, Kameyama, & Miyashita,

1999; Konishi, Nakajima, Uchida, Sekihara, & Miyashita, 1998; MacDonald, Cohen, Stenger, & Carter, 2000; Ruff, Woodward, Laurens, & Liddle, 2001).

In addition to our main goal of elucidating the neural correlates of political attitudes using the IAT, we wished to explore the effects of social and emotional factors such as the perceived powerfulness of the politicians (“pecking order”), the strength of emotions regarding politicians (“valence strength”) and political party (“affiliation strength”), along with the influence of the implicit measure of political bias on patterns of neural activation. We expected that stronger emotions would be associated with greater activation during attitude-incongruent minus attitude-congruent conditions.

Materials and Methods

Basic Experimental Design

The experimental task had a Stimulus (2: faces, names) x Congruence (2: attitude-congruent, attitude-incongruent) repeated measures design. The control condition required participants simply to classify the stimuli as faces/names or words. In a practice phase prior to scanning, participants were familiarized with the pictures, names, and political parties of the politicians by viewing printed photos of each of the politicians with the politician’s name and party printed below the photo. Participants were allowed to view the pictures as long as they wanted. They were also familiarized with the task by classifying the experimental stimuli (faces or names) as Democrat or Republican, and words as pleasant or unpleasant). They then practiced the experimental tasks using stimuli that were unique to the practice phase. For the fMRI experiment, the response measures were median response times for each subject for each condition and changes in the BOLD response in each condition. Linear contrasts were performed to compare brain activation in each experimental condition with the appropriate control condition (i.e., experimental face condition-control face condition, and experimental name condition-control name condition).

Participants

Participants were 30 right-handed, native English-speakers aged 21-40 years (12 women; 21 White, 7 African-American, 2 other) who reported no history of psychiatric or neurological problems. One subject was excluded due to a 26% error rate, and data from five participants were excluded due to loss of data resulting from technical problems, resulting in data from 24 participants for analysis. All participants were screened for handedness using the Edinburgh handedness inventory (Oldfield, 1971) and for political affiliation using several measures prior to participation in the study. Political affiliation was assessed by obtaining each subject’s (1) self-reported political orientation on a scale of 1 to 7 (where 1 is extremely liberal and 7 is extremely conservative, Wyer, Budesheim, Shavitt, Riggle, Melton, & Kuklinski, 1991), and (2) political party preference on a scale of 1 to 7 (where 1 is strongly Democratic and 7 is strongly Republican, Wyer et al., 1991). Individuals who on this pre-screening rated their orientation and preference as 3 or lower, or 5 or higher were called back to participate in the study. Fifteen participants of 24 gave a self-rating of liberal on the orientation scale, while nine rated themselves as conservative. Fourteen participants rated their political party preferences as Democrat, ten as Republican. In addition, the subject rated his or her mother’s and father’s political party preferences.

Stimuli and Presentation Conditions

Stimuli were faces and names of well-known Democrat and Republican politicians (see Appendix) and single words. The face stimuli were 36 photographs (half of Democrats and half of Republicans) downloaded from the Internet. The names were of the same politicians. The faces of two Republicans and two Democrats were African-American, while the remaining

faces were White. The photographs were converted to grayscale using Adobe Photoshop. The sets of Democrat and Republican faces were equated for how many showed someone speaking, how many had a neutral or smiling facial expression, and how many pictures showed American flags. (In order to equate the number of pictures involving the American flag, the image of John Kerry had a flag inserted on the left side of the photograph). The word stimuli were 36 pleasant and 36 unpleasant words. Half of the pleasant and half of the unpleasant words were randomly assigned to the face conditions and the other halves of each type to the name conditions. The assignment of each set of words to the face or name conditions was counterbalanced across participants. Univariate analyses of variance showed the sets of pleasant and unpleasant words of the sets did not significantly differ in frequency, $F_s(3,68) < 1.40$, *ns*, or number of letters, $F_s(3,68) \leq 1.94$, *ns*.

The fMRI experiment consisted of 6 runs. The order of presentation of runs was counterbalanced across participants using a Latin Square design. Each stimulus was presented once in each condition; assignment of each stimulus to a block within the run was counterbalanced across conditions, such that each stimulus occurred in each block across the experiment; assignment of stimuli to a run was randomized with the constraint that repetition of a stimulus was separated by one intervening run. Each run contained 3 blocks of attitude-congruent trials, 3 blocks of attitude-incongruent trials, and 3 blocks of control trials—classification of trials as attitude-congruent or -incongruent will be determined by the subject's own political affiliation (see Table 1). The order of presentation of blocks was counterbalanced across runs for each subject, using a repeated Latin Square. Each block contained 8 trials—two faces (a Democrat and a Republican), two names (a Democrat and a Republican), and four words (two pleasant, two unpleasant—one of each type for the face and one of each type for the name condition). The trials in each block were presented in a fixed randomized order. Each block was preceded by 1s of blank screen followed by 3s of instruction concerning the task for the next block followed by 2s of blank screen.

Stimulus presentation within each block was event-related and jittered, with trials randomly assigned to one of four stimulus presentation times (3, 4.33, 5.67, 7s). Each presentation time included a 250ms blank inter-trial interval. Random assignment of jitter length to events was constrained by the need to ensure similar distribution of the trial lengths across the tasks. Jittering the stimulus presentation around a mean length increases the number of time-points over which the hemodynamic response is sampled and ensures sufficient sampling points to allow estimation of the shape and duration of the hemodynamic response (Dale, 1999; Dale & Buckner, 1997; Miezin, Maccotta, Ollinger, Petersen, & Buckner, 2000).

Across the experiment, there were 72 trials (360s) for each of the six conditions, giving 120 images per condition (using a TR of 3s). The 12s T1 equilibration period at the beginning of each run included the instructions for the first block and the 3s blank screen that followed the instructions.

Procedure

Prior to participation in the study, subject gave informed consent to a protocol that had been approved by the NINDS Institutional Review Board, in accordance with the Declaration of Helsinki (BMJ 1991; 302, 1194).

High-resolution anatomical images were acquired for the purposes of data presentation with a 1.5 Tesla GE scanner (Milwaukee, Wisconsin) using a 3D SPGR sequence to obtain 124 contiguous slices (slice thickness = 1.5mm, in-plane resolution = .9375 x .9375 mm²). Functional images were acquired using a 2D gradient echo, EPI sequence to obtain 34 contiguous slices (TR = 3s, TE = 40ms, flip angle = 90°, FOV = 24cm, slice thickness = 4mm, in-plane resolution = 3.75x3.75mm²). Head motion was restricted using a head strap and foam

pads placed around the subject's head. Visual stimuli were back-projected onto a screen viewed in a mirror attached to the head coil. Stimulus presentation was carried out using SuperLab Pro for Macintosh (Abboud, 1989-1997). No error feedback was given.

On completion of the fMRI study, participants were asked to complete several ratings:

Voting decision-participants rated the faces and names on a 1-7 scale as to whether they would vote for the politician if that politician was running for President, where 1 indicated that the subject would not vote for the politician under any circumstances and 7 indicated that they would vote for the politician without hesitation. Each subject's computed political affiliation was defined as the party containing more candidates for whom they were likely to vote.

Emotional response-participants rated all of the stimuli on a 1-7 scale, where 1 indicated an extremely positive response to the face, name, or word, and 7 indicated an extremely negative response. Valence strength for faces was defined as the difference from neutral for a subject's mean valence rating for the Democratic politician's faces plus the difference from neutral for the subject's mean valence rating for the Republican politicians' faces on a scale from 1 to 7 (where 1 = extremely positive and 7 = extremely negative).

Pecking order-participants rated the faces and names on a 1-7 scale according to the rank of the politician within their own political party, where 1 indicated that the politician is/was the most powerful member of the party and 7 indicated that the politician plays/played a minor role in the party.

Some of the ratings were used in parametric analyses of the fMRI data that were carried out to supplement the subtractive contrasts.

Data Analysis

Means of participants' median RTs and error rates were computed and compared across conditions. Computation of the IAT effect for Greenwald's D scores was carried out according to an improved algorithm (Greenwald, Nosek, & Banaji, 2003). The D score divides the difference between the incongruent and congruent response times by the standard deviation of the individual's response times. This removes the effect of an individual's latency variability from the measure. Analysis of the behavioral data was performed using SPSS (version 11.0 for Macintosh). A repeated-measures ANOVA with within-subject factors of stimulus type and attitude-congruency was carried out on the median RT in the experimental conditions. Also, to determine if having a change in preferred political party affected response times, a repeated measures ANOVA with a within-subject factor of attitude congruency (2: congruent, incongruent), and a between-subject factor of whether or not a subject's preferred political party differed depending on the method used to determine it, was carried out on response times in the face experimental condition.

fMRI data processing was carried out using SPM2 (K. Friston, 2003) running in Matlab. The functional images were realigned to the first image acquired and a mean functional image created (K. J. Friston, Ashburner, Frith, Poline, Heather, & Frackowiak, 1995). The mean functional images were normalized to the Montreal Neurological Institute (MNI) brain template and the resulting transformation matrix applied to the functional images. The functional images were resampled into 4 mm cubic voxels during the normalization process. Finally, data were smoothed with a 8mm FWHM isotropic Gaussian kernel (K. J. Friston, Holmes, Poline, Grasby, Williams, Frackowiak et al., 1995).

The trials for each condition and participant were modeled using a boxcar function convolved with the hemodynamic response. Data were globally scaled at the individual subject level of

analysis to allow comparison of images from different individuals at the group level of analysis. In addition, the data were temporally smoothed using a 4s FWHM Gaussian filter to remove effects due to physiological noise. Linear statistical contrasts for each comparison of interest were used to estimate effect sizes for each participant. In addition to subtractions between conditions, exploratory parametric analyses were carried out to explore the relationship between brain activation and the participants' emotional responses, and other ratings of the political stimuli. The estimates of effect sizes from the subtraction and parametric individual subject analyses were entered into second-level random effects analyses. Random effects analyses take inter-subject variability into account and eliminate the possibility of one participant skewing the results. These analyses also allow inferences to be made regarding the population in general rather than the specific participants in the experiment (K. J. Friston, Holmes, & Worsley, 1999). One-sample t-tests were used to determine the voxel-wise t-statistics for each condition. In addition, a multiple regression analysis was performed on the conjunction of the faces congruent & incongruent conditions (each relative to their control condition) with the faces IAT D scores. The correction for multiple comparisons for the a priori predicted activation in the frontal lobe and anterior temporal lobe was carried out using an uncorrected p value of .02 and a cluster size threshold of 20; this corresponds to a per-voxel false-positive probability of less than .000001 (Forman, Cohen, Fitzgerald, Eddy, Mintun, & Noll, 1995). This method of dealing with multiple comparisons has been utilized by our group (Knutson, Wood, & Grafman, 2004; Wood, Romero, Makale, & Grafman, 2003) as well as other researchers (Konishi, Nakajima, Uchida, Sekihara, & Miyashita, 1998; Poldrack, Wagner, Prull, Desmond, Glover, & Gabrieli, 1999; Wagner, Pare-Blagoev, Clark, & Poldrack, 2001). For conjunction and correlational analyses, the same p value and threshold were used for the frontal lobe, fusiform gyrus, and anterior temporal lobe, except for region of interest (ROI) analyses that used an uncorrected p value of 0.02 with no cluster threshold. For the whole-brain analyses, correction for multiple comparisons was carried out using the false discovery rate (FDR) approach (Benjamini & Yekutieli, 2001; Yekutieli & Benjamini, 1999). The MNI coordinates were transformed into Talairach stereotactic space (Duncan, Seitz, Kolodny, Bor, Herzog, Ahmed et al., 2000; Talairach & Tournoux, 1988) and approximate Brodmann areas of the activations were determined using MEDx's Talairach Database (Sensor Systems, version 3.43) to establish the nearest gray matter to the peak of activation according to the VOTL database (Lancaster, Woldorff, Parsons, Liotti, Freitas, Rainey et al., 2000).

Results

Behavioral Data—There was a significant main effect of attitude congruency, $F(1,23) = 5.3$, $p = .03$, due to participants responding faster in the congruent condition than the incongruent condition, with a mean RT for the congruent condition = 1312ms, and for the incongruent condition = 1365ms. There was no main effect of stimulus type, $F(1,23) < 0.5$, *ns*, with a mean RT for faces = 1350ms, and for names = 1328ms. See Figure 1.

Paired-sample t-tests on mean RTs for congruent and incongruent faces and names conditions separately showed a significant difference only for faces, $t(23) = -2.23$, $p = .036$, not names, $t(23) = -1.84$, *ns*, due to the greater variability in the names RT data. Similarly, a one-sample t-test on Greenwald's D measures (Greenwald, Nosek, & Banaji, 2003) showed the D measure for faces (mean = 0.13) was significant, $t(23) = 4.25$, $p < .001$, but D for names (mean = 0.08) was not, $t(23) = 1.78$. The D measure for faces and the difference in RT between incongruent and congruent face tasks were significantly correlated, $r = .46$, $p = .03$. As the behavioral results for names were not significant, only results from the face conditions will be discussed further.

The implicit attitude measure for the face condition (defined as the difference in RT between the incongruent and congruent conditions) was not significantly correlated with the subject's explicit rating of his or her political party preference on the prescreening questionnaire, $r = -$.

07, *ns*. In addition, D scores (another implicit measure) were not significantly correlated with political party preference, $r < -.01$, *ns*. In our study, we found that seven of 24 participants had explicit measures (self-reported political party preference taken prior to the study) that did not agree with the political party containing the most candidates for whom they were likely to vote (the computed political affiliation which was determined from the voting decision ratings taken after the study). Fifteen out of 24 participants had a computed political affiliation of Democrat, and nine Republican. As we believe the computed political affiliation (with its multiple measures) was a more valid measure of their political attitudes than the self-reported political party preference (a single measure), we used the computed political affiliation to determine which conditions were considered congruent or incongruent for each subject. There was a somewhat higher correlation between this explicit measure and the RT difference implicit measure ($r = .16$, *ns*), and a significant correlation between this explicit measure and the D scores ($r = .50$, $p = .01$). There were no main or interaction effects on median RT for changing political affiliation ($F_s(1,22) < 0.32$, *ns*). Similarly, a one-way ANOVA on Greenwald's D for faces for changing political affiliation showed no effect ($F(1,22) = 0.24$, *ns*).

Post-hoc analysis revealed that participants' party affiliation (on a Democrat to Republican scale) and political orientation (on a liberal to conservation scale) were both correlated with the father's political party preference, $r = .52$, $p = .01$, and $r = .48$, $p = .02$, and to each other, $r = .83$, $p < .00$.

A paired t-test was performed to compare attitude-congruency effects on mean errors in the face experimental conditions. There was a significant effect of attitude congruency, with significantly fewer errors in the congruent versus incongruent condition, $t(1,23) = -3.11$, $p = .005$ (see Figure 2).

Neither political party preference nor gender significantly affected RT ($F_s(1,22) = 2.9$ and 2.4 , *ns*).

fMRI Results—We first examined correlations between activation in the fusiform gyri and amygdala with performance on the face trials of the control task (characterized by median RTs), with valence strength, and with affiliation strength. Activity in the left amygdala was correlated with RTs, valence strength, and affiliation strength ($p_s < .01$). There were also significant correlations between activation in various regions within the left and right fusiform gyri and RTs, valence strength, and affiliation strength. In other words, just asking participants to categorize politicians' faces elicited significant and frequent activations in both the amygdala and fusiform gyri that were not only associated with speed of response but also with measures of emotion and simple categorization.

We next performed a subtraction analysis of the two key conditions, congruent-incongruent, and incongruent-congruent. Note that each experimental condition contained mixed trials of the object (faces) and word stimuli (pleasant or unpleasant).

Subtraction Analyses

The faces congruent condition (relative to the faces incongruent condition; see Figure 3 and Table 2) revealed a large cluster of activation extending into left inferior frontal gyrus (Brodmann's area [BA] 47), right precentral gyrus (BA 6), and right amygdala. The faces congruent condition (relative to control; see Table 2) revealed activation of bilateral inferior frontal gyrus (BA 47), left middle frontal gyrus (BA 9), and left cingulate gyrus (BA 32) extending into medial frontal gyrus (BA 6). Thus, the IAT Political Faces congruency condition elicits activation in anterior dorsal, ventrolateral and ventromedial prefrontal cortex along with premotor cortex.

The faces incongruent condition (relative to the faces congruent condition; see Figure 4 and Table 2) revealed activation of left inferior frontal gyrus (BA 10). The faces incongruent condition (relative to control; see Figure 4 and Table 2) revealed activation in left inferior frontal gyrus (BA 47) and left middle frontal gyrus (BA 9) extending into left inferior frontal gyrus (BA 45), along with right middle frontal gyrus (BA 46 and 9), and right cingulate gyrus (BA 32) extending into left middle and superior frontal gyrus (BA 6). Whole brain analysis using an FDR-corrected significance threshold ($p = .05$) revealed left superior parietal lobe (BA 7) activation. Thus the IAT Political Faces incongruent condition primarily elicits widespread anterior medial and lateral prefrontal cortex activation along with premotor cortex activation.

Correlational Analyses

Simple regression (correlation) analyses were performed to identify those regions whose activation co-varied across participants with the individuals' face IAT effect (as measured by the D score) for the corresponding imaging analysis contrasts. The faces IAT D score (in correlation with the faces congruent minus incongruent condition) was not associated with any activation but since the D score is derived from an equation that includes pooling the variance across congruent *and* incongruent conditions, this finding was not unexpected; for this reason, we next performed a multiple regression analysis of the activations resulting from the faces congruent & incongruent (each relative to their control condition) conjunction with the faces IAT D scores. The results showed a significant positive correlation with the right superior frontal gyrus (BA 10), and negative correlations with the right superior medial frontal gyri (BA 8) and precentral gyrus (BA 4) extending into inferior frontal gyrus (BA 9) (see Table 3). To summarize, the activation in the medial frontopolar region (BA 10) increased as the RT difference between congruent and incongruent tasks increased, further demonstrating this area's importance in facilitating implicit political associations as well as confirming its involvement in complex cognitive evaluations (Koechlin, Basso, Pietrini, Panzer, & Grafman, 1999).

Politician pecking order correlational analyses

Correlational analyses also were performed to identify those regions whose activation co-varied across participants with the individual's pecking order judgment score (see table 4). Pecking order measures the perceived powerfulness of the politicians. Pecking order and the faces congruent (relative to control) condition were *positively* associated with activation in left cingulate gyrus (BA 32) extending into left medial frontal gyrus (BA 9), and *negatively* with activation in right cingulate gyrus (BA 32) extending into right medial frontal gyrus (BA 10).

Valence strength correlational analyses

Correlational analyses were next performed to identify those regions whose activation co-varied across participants with their valence strength score (see table 4). The valence strength and the faces congruent (relative to control) condition were positively associated with activation in the left superior frontal gyrus (BA 10) and medial frontal gyrus (BA 11), right precentral gyrus (BA 6) and middle frontal gyrus (BA 8). No negative associations were found. Thus the correlation of strength of feelings toward the politicians and the face congruency condition was positively correlated with activation in the frontopolar cortex, as well as more posterior frontal lobe regions.

In addition, correlational analyses were performed to identify voxels in the amygdala and BA 10 whose activation co-varied across participants with the individual's valence strength. ROIs of the amygdala and BA 10 were created using WFU PickAtlas (Maldjian, Laurienti, Burdette, & Kraft, 2003) and used as explicit masks for the correlations. The valence strength and the faces congruent (relative to control) condition were not *positively* correlated with activation in

any voxel in the amygdala. This condition was *negatively* correlated with activation in left amygdala (an inferior lateral portion, $t(1, 22) = -2.47$, $p = .011$).

In BA 10, valence strength and the faces congruent condition were correlated with activation both positively, in left middle frontal gyrus, $t(1, 22) = 4.09$, $p < .000$, and negatively, in right superior frontal gyrus, $t(1, 22) = -2.54$, $p = .009$.

Affiliation strength correlational analyses

Correlational analyses also were performed to identify those regions whose activation co-varied across participants with the individual's affiliation strength (see table 4). Affiliation strength is defined as the difference from neutral for the individual's political party preference taken prior to the study; that is, someone who rated him- or herself as extremely Democratic (or extremely Republican) would score 3 for affiliation strength. Someone who rated him- or herself as less extreme would score a 1 or 2.

The affiliation strength was not *positively* associated with any activation in the faces congruent condition (relative to control), but was *negatively* associated with activation of the right inferior and middle frontal gyrus (BA 9 extending into BA 6). Thus, lateral prefrontal cortex activation was mostly negatively associated with the participants' rated affiliation strength, showing less activation with greater affiliation strength.

Discussion

The lack of significant correlations for each of the two implicit measures (RT differences and D scores) with the explicit measure of self-reported political party preference is not unexpected, as this explicit measure was somewhat unreliable (seven participants had differing self-reported political party preferences and computed political party affiliations). We did find higher correlations for the two implicit measures with the explicit measure of computed political party affiliation, with a significant correlation of .5 between D scores and computed political party affiliation. Our results are in line with previous research which shows a wide variation in correlations between explicit and implicit attitudes using the IAT, with a modest mean effect size of .19 (uncorrected) reported in the meta-analysis by Hofmann et al. (Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005). As Greenwald and colleagues (Greenwald & Nosek, 2001) state "there is not yet an established interpretation of the cause of variability in correlations between implicit and explicit attitude measures." They suggest that participants may be trying to give a better impression of themselves when they complete the explicit measure, or they may have poor introspection of their own views, resulting in less valid explicit measures.

This study demonstrates that many sectors of the prefrontal cortex, including anteropolar regions, are activated during a task inducing implicit priming of political attitudes. Some areas, including premotor, left inferior frontal gyrus, cingulate gyrus, and fusiform gyrus regions were activated under more than one condition, suggesting these areas are more involved in lower-level attitude processing tasks common across the study conditions. Some regions, such as the amygdala and fusiform gyrus, were activated in the control condition reinforcing their role in the perceptual processing of familiar faces. These areas are consistently activated in studies of face processing and recognition (faces: Kanwisher, McDermott, & Chun, 1997; words: Kronbichler, Hutzler, Wimmer, Mair, Staffen, & Ladurner, 2004). Amygdala activation is automatic and stimulus-driven whenever a face is presented and the degree of its activation should reflect the relevance of a stimulus (Sander, Grafman, & Zalla, 2003), as was revealed in the amygdala activation positively associated with affiliation strength and valence strength. Similarly, fusiform face area (FFA) activation is automatic when a task requires face processing and recognition (Schultz, 2005).

IAT Effect

Whereas the mean results for names was similar to those for faces, the greater variability of the names data reduced their statistical significance; therefore, participants demonstrated a significant IAT effect for attitude-congruent mappings compared to attitude-incongruent mappings for faces only, using response time difference as well as the “D” statistic (Greenwald, Nosek, & Banaji, 2003). The overall mean response time in our study (1228 ms) was slower than that found in Chee et al.’s IAT study (~800 ms), indicating that the associative knowledge being accessed in our study was likely more complex. This observation suggests that a critical determinant of the pattern of brain activity when performing the IAT is the content of the IAT material itself, although the increased task switching costs in the present study due to switching between congruent and incongruent tasks within each run as opposed to having separate congruent and incongruent runs as in the Chee study might have partially contributed to the complexity and increased overall RT.

Activation Associated with Attitude-Congruent and -Incongruent Conditions

Attitude Congruent Activations

Face congruent condition activations were present when the subtraction involved either the face incongruent or face control conditions. For the face incongruent subtraction, we found a large area of activation that extended into the right precentral gyrus, left inferior frontal gyrus, and right amygdala. For the face control subtraction, we found left precentral gyrus, left cingulate gyrus, left middle frontal gyrus, and bilateral inferior frontal gyri activation. This indicates that attitude congruent (i.e., associative) activations regarding political figures involve a distributed network of frontal cortical structures that includes ventromedial PFC. We have previously argued that the ventromedial PFC plays an important role in storing an aspect of the stereotypic associative knowledge induced by IAT content (e.g., see Milne & Grafman, 2001).

Attitude Incongruent Activations

Face incongruent activations were present when the subtraction involved either the face congruent or face control conditions. For the face congruent subtraction, we found selective activation in the left anterior inferior frontal gyrus. For the face control subtraction, we found left inferior and bilateral lateral prefrontal cortex activation along with right anterior cingulate, left precentral, and left superior parietal lobe activations. These areas also were activated during a flower and insect IAT study (Chee, Sriram, Soon, & Lee, 2000). Cognitive-incongruent tasks often invoke cingulate gyrus and premotor activation due to conflict resolution and inhibition (Braver, Barch, Gray, Molfese, & Snyder, 2001; Garavan, Ross, & Stein, 1999; Konishi, Nakajima, Uchida, Kameyama, Nakahara, Sekihara et al., 1998; Konishi et al., 1999; MacDonald, Cohen, Stenger, & Carter, 2000; Ruff, Woodward, Laurens, & Liddle, 2001). Consistent with this, the cingulate gyrus activation for our study’s incongruent condition (cluster size 256; $t = 6.42$) was more extensive than for the congruent condition (cluster size 48; $t = 3.08$). A review of primate and human studies investigating the role of the medial frontal cortex in cognitive control shows the posterior medial frontal cortex, particularly the rostral cingulate zone (the human homologue of the monkey’s rostral cingulate motor area), is frequently engaged during response conflict and decision uncertainty (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Those activations cluster primarily in the transition zone between the cingulate, paracingulate, association, and premotor cortices. Our findings of activation in BA 6 and 32 for the incongruent tasks are consistent with these findings (as were our IAT score correlation analysis results).

There was only a small area of DLPFC activation for congruent conditions, while it was activated bilaterally for incongruent (minus control) conditions. Patients with damage to the

left DLPFC have been found to have difficulty performing the Stroop task, and there is consensus that DLPFC plays an important role in the top-down control of behavior, (MacDonald, Cohen, Stenger, & Carter, 2000) partly via an attention mechanism, in situations requiring supervision. In the present study, DLPFC activation may have been induced in response to the unusual associations being formed in the incongruent condition.

It was expected that face congruent and incongruent conditions in comparison with control conditions would activate the amygdala, but amygdala activation was not found in any non-ROI subtraction analyses, except the congruent-incongruent contrast. It is possible that the high cognitive demand of the tasks did not allow for much emotion processing in the brief time allowed (Bush, Luu, & Posner, 2000). The lack of amygdala activation is consistent with a study (Phelps et al., 2000) where amygdala activation was found for unfamiliar black faces, but not for familiar black faces (both black and white faces in the present study were well-known), and a lesion study that demonstrated the amygdala is not critical during performance of the IAT (Phelps, Cannistraci, & Cunningham, 2003). Also, amygdala activation has been found to habituate quickly (Wright, Fischer, Whalen, McInerney, Shin, & Rauch, 2001), and this may have led to lowered amygdala activation in our study since participants had exposure to the politicians and words used in this study during the practice sessions as well as through previous media exposure. Similarly, Chee's flower and insect IAT study also did not show amygdala involvement (Chee, Sriram, Soon, & Lee, 2000).

The D statistic is the current gold standard for claiming an IAT effect exists in an experiment. Since the D measure takes into account the variation in response times across congruent and incongruent conditions, the activations we found associated with the D measure were correlational in nature. The faces D measure was positively associated with activation in anterior frontopolar cortex and negatively associated with activation in right BA 4, 8, and 9 for the faces C&I conjunction. The frontopolar region is associated with social judgments (Moll, Eslinger, & Oliveira-Souza, 2001; Moll, Zahn, de Oliveira-Souza, Krueger, & Grafman, 2005), inhibitory processing (Fuster, 1989), integrating emotions during decision-making (Bechara, Damasio, & Damasio, 2000), multitasking (Koechlin, Basso, Pietrini, Panzer, & Grafman, 1999), making choices in incompletely specified situations (Elliott, Dolan, & Frith, 2000), and selecting between stimulus-independent and stimulus-oriented cognitive processes (Gilbert, Frith, & Burgess, 2005).

Stimulus Feature Effects in the Congruent Condition: Politician Pecking Order, Valence and Affiliation Strength

Politician pecking order (1 = high power, 7 = low power) was positively correlated with left cingulate activation and negatively correlated with right cingulate activation. One possible interpretation of this finding is that highly powerful politicians may be considered less approachable than less powerful politicians, consistent with the hemispheric asymmetry and valence model of emotions (Davidson, Jackson, & Kalin, 2000; Demaree, Everhart, Youngstrom, & Harrison, 2005) and the dominance/submission lateralization model (Demaree, Everhart, Youngstrom, & Harrison, 2005). Valence strength, a measure of strength of feelings toward the politicians, was positively correlated with the frontopolar region, consistent with its role in integrating emotions during decision-making (Bechara, Damasio, & Damasio, 2000). Valence strength was also positively correlated with ventromedial cortex, an important region for emotional processing (Britton, Taylor, Sudheimer, & Liberzon, 2006; Kawasaki, Adolphs, Oya, Kovach, Damasio, Kaufman et al., 2005; Ongur & Price, 2000). Deppe et al. found increased activation in ventromedial PFC during decision-making between a favorite brand item and a non-favorite brand item due to increased emotion-processing and self-reflection; they speculated that their results can possibly be expanded to other objects or persons, including politicians (Deppe, Schwindt, Kugel, Plassmann, & Kenning, 2005).

Affiliation strength was negatively associated with face-congruency-related activations (right BA 6 and 9), thus stronger self-reported party affiliation leads to lower PFC activity. This is also broadly consistent with Deppe et al.'s findings (see also Bechara, Damasio, Tranel, & Damasio, 1997) that, for more emotion-driven responses, relatively less activation is found in lateral PFC (including BA 6 and 9), although they found more inactivation on the left than on the right. They reasoned that there were two separate but interacting types of networks involved—an *emotional* network involving ventromedial PFC, and a *reasoning* network that included more lateral PFC regions. When emotional input was required for adequate decision-making, the reasoning network's role would be relatively diminished.

In summary, this study confirmed Greenwald's results (Greenwald, Nosek, & Banaji, 2003) that political attitudes (as exemplified by the association between a politician's face and an affective word) can induce an IAT effect. The present study also showed that the overall RTs as well as the difference in median RTs between congruent and incongruent tasks are affected by the nature of the IAT material and task design, as the median RT for political attitudes in the present study was much slower than that of Chee et al.'s IAT study.

Not surprisingly, when a person simply views and makes a simple decision about the face of a known politician, brain structures associated with face recognition (e.g., the fusiform gyrus) and emotional processing (e.g., the amygdala) are engaged. When a person is further induced to access political knowledge about that politician, it is likely that brain structures subserving the simple associations underlying attitudes and those structures integrating emotions during decision-making (ventromedial prefrontal cortex and anterior prefrontal cortex) are engaged. The particular pattern of activation of all of these brain regions will depend on the precise task demands and depth of knowledge and feelings about that politician. When a person's stored knowledge about a politician is incongruent with the task demands, additional brain structures (e.g., anterior cingulate) will be activated. Any task that induces a person to process stimuli that will evoke stored emotional, semantic, and social information is likely to generally activate a set of frontal lobe regions irrespective of the content of the task (in our case political attitudes and knowledge).

The results of our study indicate that a large number of brain areas—primarily in the frontal lobes—play an especially important role in the mediation of political knowledge. Our findings of ventromedial PFC activation suggests that when processing the associative knowledge concerned with politicians, stereotypic knowledge of the politician is activated but in addition to stereotypic knowledge, the anterior prefrontal activations we also reported indicate that more elaborative and reflective knowledge about the politician is simultaneously activated. In our study, frontopolar activation was positively correlated with an implicit measure of bias (D scores), and valence strength (a measure of how strongly the participants felt about the politicians), while affiliation strength (a measure of strength of affiliation with the Democrat/Republican party) was negatively correlated with lateral PFC, lending support to the idea that at least two distinct but interacting networks—one emphasizing rapid, stereotypic, and emotional associative knowledge and the other emphasizing more deliberative and factual knowledge—cooperate in the processing of politicians. The implication of our novel findings is that the pattern of brain activation (and thus the neural networks relied upon) will depend on the context in which the politician is presented.

Whether there exist brain regions subserving domain-specific social knowledge (e.g., contrasting knowledge about politicians versus baseball players) remains to be seen, although there is some evidence that knowledge of self can be dissociated from knowledge of others and is differentially stored in the brain (Keenan, Nelson, O'Connor, & Pascual-Leone, 2001; Keenan, Wheeler, Gallup, & Pascual-Leone, 2000). The study of political preference, knowledge, and decision-making should be helpful in identifying brain areas activated in

common by many kinds of social tasks versus those brain sectors selectively activated when a social task involves attitudes and explicit beliefs about politicians and others with whom we have strong associations. It is likely that the examination of the latter will lead to the discovery of uniquely human brain processes.

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Appendix

Politicians used in the faces and names conditions

Democrats	Republicans
Hillary Clinton	Connie Morella
Bill Bradley	Dan Quayle
Gray Davis	George H. W. Bush
John Kennedy	Dwight Eisenhower
Ted Kennedy	Dick Cheney
Harry Truman	Henry Kissinger
Robert Kennedy	Jeb Bush
Lyndon Johnson	Trent Lott
Janet Reno	Elizabeth Dole
Madeleine Albright	Christine Todd Whitman
Carol Moseley Braun	Condoleezza Rice
Jesse Jackson	Ronald Reagan
Bill Clinton	John Ashcroft
Tom Daschle	John McCain
John Kerry	Gerald Ford
Jimmy Carter	Donald Rumsfeld
Joe Lieberman	Colin Powell
Al Gore	Bill Frist

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Figure 1.
Mean median response times in each condition.

Figure 2.
Mean errors in the face condition.

Figure 3.

Axial, coronal, and sagittal planes showing activation associated with attitude-congruent conditions minus attitude-incongruent conditions for faces (blue), and attitude-congruent conditions minus control conditions for faces (yellow), where $p = .02$ uncorrected and extent threshold = 20 voxels. Green shows areas of overlap. Left = right. Note that attitude-congruency is determined on the basis of the each subject's political views.

Figure 4.

Two axial planes and one sagittal plane showing activation associated with attitude-incongruent conditions minus attitude-congruent conditions for faces (blue), and attitude-incongruent conditions minus face control conditions (yellow), where $p = .02$ uncorrected and extent threshold = 20 voxels. Green shows areas of overlap. Left = right. Note that attitude-incongruency is determined on the basis of the each subject's political views.

Table 1

Condition-response mappings in the experiment.

Condition	KEY 1	KEY 2
Congruent condition for Democrat participants OR Incongruent condition for Republican participants	Democrat faces AND Pleasant words	Republican faces AND Unpleasant words
Congruent condition for Republican participants OR Incongruent condition for Democrat participants	Republican faces AND Pleasant words	Democrat faces AND Unpleasant words
Control condition for face task	Faces	Words

Table 2

Anatomical localization of the activation associated with the basic fMRI data analyses for faces ($p = .02$ uncorrected, and extent threshold = 20, $B = \text{Bilateral}$, $BA = \text{Brodmann's Area}$, $R = \text{Right}$, $L = \text{Left}$; * indicates FDR-corrected $p < .05$).

Anatomical localization of the peak of the cluster	Cluster size	Talairach coordinates x y z	t-score	p-value
Faces: Attitude Congruent-Attitude Incongruent B cluster of activation extending into L inferior frontal gyrus, BA 47, and R amygdala	946	-20 11 -17	4.59	<.001
R claustrum extending into R precentral gyrus, BA 6	121	48 -3 22	3.37	=.001
Faces: Attitude-Congruent - Control				
R inferior frontal gyrus, BA 47	29	36 23 -8	4.17	<.001
L inferior frontal gyrus, BA 47	23	-32 27 -8	3.99	<.001
L dorsolateral PFC, BA 9	26	-51 17 25	3.60	=.001
L cingulate gyrus, BA 32, extending into L medial frontal gyrus, BA 6	48	-8 21 39	3.08	=.003
Faces: Attitude Incongruent - Attitude Congruent				
L inferior frontal gyrus, BA 10	25	-44 47 -2	4.01	<.001
Faces: Attitude-Incongruent - Control				
R cingulate gyrus, BA 32, extending into L middle and superior frontal gyri, BA 6	256	4 18 43	6.42	<.001 *
L superior parietal lobule, BA 7	171	-28 -64 47	4.75	<.001 *
L inferior frontal gyrus, BA 47	22	-32 27 -5	3.88	<.001
L middle frontal gyrus, BA 9, extending into L inferior frontal gyrus, BA 45	116	-51 13 32	3.72	=.001
R middle frontal gyrus, BA 46, extending into BA 9	20	51 28 24	3.08	=.003

Anatomical localization of the activation associated with the faces congruent and incongruent (each relative to their control condition) conjunction correlated with the faces IAT D scores ($p = .02$ uncorrected, and extent threshold $= 20$, BA = Brodmann's Area, R = Right).

Table 3

Anatomical localization of the peak of the cluster	Cluster size	Talairach coordinates		z	t-score	p-value
		x	y			
Positive Correlation						
R superior frontal gyrus, BA 10	47	8	70	0	3.73	<.001
Negative Correlation						
R superior frontal gyrus, BA 8	45	8	26	50	3.42	=.001
R precentral gyrus, BA 4, extending into inferior frontal gyrus, BA 9	48	59	-7	22	3.28	=.001

Table 4

Anatomical localization of the activation associated with the faces congruent (relative to control) fMRI data analyses correlated with pecking order, valence strength, and affiliation strength ($p = .02$ uncorrected, and extent threshold = 20, BA = Brodmann's Area, R = Right, L = Left). Pecking order is a rating of powerfulness of a politician. Valence strength is a measure of strength of feelings toward the politicians. Affiliation strength is a measure of strength of Democrat/Republican affiliation.

Anatomical localization of the peak of the cluster	Cluster size	Talairach coordinates x y z	t-score	p-value
Positive Correlation with pecking order L cingulate gyrus, BA 32, extending into L medial frontal gyrus, BA 9	30	0 32 24	3.26	=.002
Negative Correlation with pecking order R cingulate gyrus, BA 32, extending into R medial frontal gyrus, BA 10	30	8 27 -8	3.55	=.001
Positive Correlation with valence strength				
R precentral gyrus, BA 6	30	63 5 14	3.84	<.000
L superior frontal gyrus, BA 10	36	-16 67 19	3.16	=.002
R middle frontal gyrus, BA 8	27	32 25 43	2.98	=.003
L medial frontal gyrus, BA 11	23	-8 50 -16	2.61	=.008
Negative Correlation with valence strength				
none				
Positive Correlation with affiliation strength				
none				
Negative Correlation with affiliation strength				
R inferior frontal gyrus, BA 9, extending into middle frontal gyrus, BA 6	59	59 9 29	4.05	<.001