

Neural Bases of Motivated Reasoning: An fMRI Study of Emotional Constraints on Partisan Political Judgment in the 2004 U.S. Presidential Election

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Abstract

■ Research on political judgment and decision-making has converged with decades of research in clinical and social psychology suggesting the ubiquity of emotion-biased motivated reasoning. Motivated reasoning is a form of implicit emotion regulation in which the brain converges on judgments that minimize negative and maximize positive affect states associated with threat to or attainment of motives. To what extent motivated reasoning engages neural circuits involved in “cold” reasoning and conscious emotion regulation (e.g., suppression) is, however, unknown. We used functional neuroimaging to study the neural responses of 30 committed partisans during the U.S. Presidential election of 2004. We presented subjects with reasoning tasks involving judgments about in-

formation threatening to their own candidate, the opposing candidate, or neutral control targets. Motivated reasoning was associated with activations of the ventromedial prefrontal cortex, anterior cingulate cortex, posterior cingulate cortex, insular cortex, and lateral orbital cortex. As predicted, motivated reasoning was not associated with neural activity in regions previously linked to cold reasoning tasks and conscious (explicit) emotion regulation. The findings provide the first neuroimaging evidence for phenomena variously described as motivated reasoning, implicit emotion regulation, and psychological defense. They suggest that motivated reasoning is qualitatively distinct from reasoning when people do not have a strong emotional stake in the conclusions reached. ■

INTRODUCTION

In political science, cognitive science, economics, law, and business, the predominant models of judgment and decision-making today are “bounded rationality” models (Simon, 1990). These models suggest that people are rational within limits imposed by cognitive shortcuts and heuristics (Westen, Weinberger, & Bradley, in press; Gigerenzer & Selten, 2001; Kahneman & Tversky, 2000). In political science, a long-standing body of research on “partisan” biases in political judgment (e.g., Taber, Lodge, & Glathar, 2001; Campbell & Converse, 1960) points to another set of limits to rational judgment imposed by emotion-biased or motivated reasoning (i.e., reasoning biased to produce emotionally preferable conclusions; Kunda, 1990; Lord, Ross, & Lepper, 1979). Motivated reasoning can be viewed as a form of implicit affect regulation in which the brain converges on solutions that minimize negative and maximize positive affect states (Westen & Blagov, in press; Westen, 1985, 1994, 1998). Freud (1933) described such processes decades ago, using the term “defense” to denote the processes by which people can adjust their cognitions to

avoid aversive feelings such as anxiety and guilt. We use the term *motivated reasoning* here because of its widespread use (although, strictly speaking, *all* reasoning is typically motivated by emotions such as interest, excitement, anxiety, etc.; see Marcus, 2002; Westen, 1985).

Neural network models of motivated reasoning suggest that in affectively relevant situations, the brain equilibrates to solutions that simultaneously satisfy two sets of constraints: *cognitive constraints*, which maximize goodness of fit to the data, and *emotional constraints*, which maximize positive affect and minimize negative affect (Westen, Feit, Arkowitz, & Blagov, 2005; Thagard, 2003; Westen, 1998). Decision theorists have long argued that people gravitate toward decisions that maximize expected utility (or in emotional terms, that optimize current or anticipated affect; Simon, Krawczyk, & Holyoak, 2004; Mellers, 2000; Westen, 1985). Contemporary views of motivation similarly emphasize approach and avoidance systems motivated by positive and negative affect (Carver, 2001; Davidson, Jackson, & Kalin, 2000). The same processes of approach and avoidance, motivated by affect or anticipated affect, may apply to motivated reasoning, such that people will implicitly approach and avoid judgments based on their emotional associations.

A series of studies involving political crises in the United States spanning the past 8 years (the impeachment of Bill Clinton, the disputed presidential election of 2000, and the discovery of torture by the United States at Abu Ghraib prison in Iraq) supports this model (Westen et al., 2005). These studies, along with simulations using a connectionist network designed to address “hot cognition” (Thagard, 2003), suggest that political reasoning can be strongly influenced by the emotional consequences of drawing one conclusion or the other. Although research has begun to examine explicit (conscious) processes used to regulate emotion, notably suppression and distraction (Anderson et al., 2004; Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003; Ochsner, Bunge, Gross, & Gabrieli, 2002), no studies have yet examined the neural processes involved in motivated reasoning or implicit affect regulation. The present study is also among the first to explore the neural basis of any form of political decision-making.

In this study, conducted during the U.S. Presidential election of 2004, we observed the reasoning processes of committed partisans as they were presented with threatening information about their own candidate, the opposing candidate, and neutral control individuals. We hypothesized that reasoning about threatening information about one’s own candidate would activate regions likely to be involved in implicit emotion regulation, notably the ventromedial prefrontal cortex (VMPFC) and the anterior cingulate cortex (ACC), as well as regions reflecting elicitation of negative emotion (the insula, lateral orbital frontal cortex, and amygdala) (see, e.g., Ochsner & Gross, 2005).

METHODS

Participants

We recruited subjects ($n = 30$, 15 Democrats and 15 Republicans) by placing flyers at local political party offices, public places, and cars and houses with political endorsements (e.g., bumper stickers); posting information on Internet political discussion groups and local political and party listservs; and placing newspaper and radio advertisements. Recruitment materials requested right-handed men, ages 22–55 years, who were “committed Republicans or Democrats.” We conducted all screening and scanning from late August through early October 2004. Subjects received \$50 compensation.

Potential subjects were screened by phone using a magnetic resonance imaging (MRI) screener (to rule out safety risks, neurological conditions, etc.) and a political attitudes questionnaire, using items from the National Election Studies (NES, www.umich.edu/~nes) to measure partisanship. Using NES item wording, we asked about nature and strength of party affiliation; obtained ratings on their feelings toward George W. Bush, John

Kerry, Bill Clinton, Dick Cheney, the Democratic Party, and the Republican party using a 0–100 “feeling thermometer” (from *cold* to *warm*); obtained 4-point ratings of how often Bush and Kerry made them feel angry, hopeful, afraid, proud, and disgusted; and obtained 4-point ratings of the extent to which they saw the two candidates as moral, intelligent, dishonest, and out of touch with ordinary people. To be included subjects had to rate themselves as a *strong* Democrat or Republican and to endorse a difference between the two parties or the two candidates ≥ 30 points on the feeling thermometer.

Measures and Procedures

To simulate the constraint satisfaction processes that occur as citizens confront political information, we devised six sets of statements regarding each of the following targets: George Bush, John Kerry, and politically neutral male targets (e.g., Tom Hanks, Hank Aaron, William Styron). (We tried to generate well-known targets who were emotionally neutral but ultimately selected politically neutral but largely mildly positive targets because of the difficulty identifying well-known figures of any kind about whom people have no feelings.) Although many of the statements and quotations were edited or fictionalized, we maximized their believability by embedding them in actual quotes or descriptions of actual events. Subjects were given detailed instructions prior to scanning and a practice run to familiarize them with procedure prior to imaging trials.

Each statement set consisted of seven slides presenting verbal material, designed to present a clear contradiction between the target person’s words and actions and then to resolve that contradiction (Figure 1). Presentation duration of the slides ranged from 5 to 15 sec, depending on the length and demands of the material or task, and reflected pretesting on pilot subjects. Slide 1 (15 sec) presented an *initial statement*, typically a quote from the target individual. Slide 2 (12 sec) presented a *contradictory statement* suggesting that the target’s words and actions were inconsistent. Slide 3 (7 sec) asked subjects to consider whether the target’s “statements and actions are inconsistent with each other,” and Slide 4 (5 sec) asked them to rate the extent to which they agreed that the target’s words and deeds were contradictory, from 1 (*strongly disagree*) to 4 (*strongly agree*) by using a four-button pad. Slide 5 (12 sec) presented an *exculpatory statement* that logically explained away the inconsistency. Slide 6 (7 sec) then asked subjects to consider whether the target’s “statements and actions are not quite as inconsistent as they first appeared.” The seventh and final slide (5 sec) asked them once again to rate the extent to which they agreed with this statement, using the same 4-point scale.

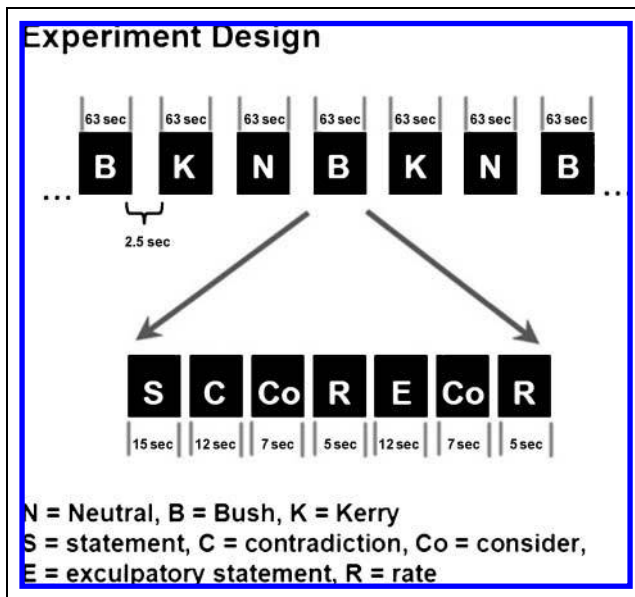


Figure 1. The structure of the experiment. The top part describes the sequence and length of statement sets, alternating among Bush, Kerry, and neutral targets. The bottom describes the sequence of phases within each set: initial statement, contradiction, first *consider* statement (asking subjects to consider the contradiction), initial rating of contradiction, exculpatory statement, second *consider* statement (asking subjects to reconsider the contradiction), and second rating of the contradiction in light of the exculpatory information.

(We refer to these seven phases of the experimental trials throughout as *statement*, *contradiction*, *Consider 1*, *Rate 1*, *exculpatory statement*, *Consider 2*, and *Rate 2*.)

The progression of statements provides a reasoning task in which subjects have to judge twice whether the information represents a contradiction. For example, for the practice statement set, Walter Cronkite was the target:

Initial statement: “I think my days in journalism are over. I’ve had a wonderful, full life, but when it’s time to retire, it’s time to retire. And it’s my time to retire.”—Walter Cronkite, 1981.

Contradictory statement: Twenty-one years later, Mr. Cronkite hosted a series on CBS.

Exculpatory statement: Mr. Cronkite had no intention of hosting any further shows, but a longtime friend at CBS asked him as a special favor to do a retrospective on TV journalism.

Statement sets regarding the two candidates had the same structure, except that the contradiction would be threatening to partisans on one side or the other (Table 1). We counterbalanced order of presentation of targets, such that half of subjects (stratified by party) were presented with a Bush statement set first and the other half with a Kerry statement set.

Table 1. Two Examples of Statement Sets

<i>Sample Statement Set—George W. Bush</i>	
Initial	“First of all, Ken Lay is a supporter of mine. I love the man. I got to know Ken Lay years ago, and he has given generously to my campaign. When I’m President, I plan to run the government like a CEO runs a country. Ken Lay and Enron are a model of how I’ll do that.”—Candidate George Bush, 2000
Contradictory	Mr. Bush now avoids any mention of Ken Lay and is critical of Enron when asked.
Exculpatory	People who know the President report that he feels betrayed by Ken Lay, and was genuinely shocked to find that Enron’s leadership had been corrupt.
<i>Sample Statement Set—John Kerry</i>	
Initial	During the 1996 campaign, Kerry told a Boston Globe reporter that the Social Security system should be overhauled. He said Congress should consider raising the retirement age and means-testing benefits. “I know it’s going to be unpopular,” he said. “But we have a generational responsibility to fix this problem.”
Contradictory	This year, on Meet the Press, Kerry pledged that he will never tax or cut benefits to seniors or raise the age for eligibility for Social Security.
Exculpatory	Economic experts now suggest that, in fact, the Social Security system will not run out of money until 2049, not 2020, as they had thought in 1996.

fMRI Acquisition and Processing

The study was conducted on a 3-T Siemens Magnetom Trio whole-body MRI scanner in the Biomedical Imaging Technology Center at Emory Hospital. Brain imaging involved the acquisition of 30 axial slices of 3 mm thickness, acquired parallel to the AC–PC line with a matrix size of 64 × 64 over a field of view of 22 × 22 cm. Blood oxygenation level dependent (BOLD) contrast images were acquired (TE of 30 msec) using T2*-weighted gradient-echo, echo-planar pulse sequences with a TR of 2.5 sec for a total of 477 scans. In addition, a 3-D MP-RAGE sequence was collected at an isotropic resolution of 1 × 1 × 1 mm for 3-D anatomic analysis and visualization of task-related activations. Head movement was limited by padding and restraint. After reformatting the data into the ANALYZE image format, the images were resliced and corrected for motion by registration to the first functional image acquired for each subject by using a six-parameter transformation. Images were then spatially normalized to the Montreal Neurological Institute (MNI) template by applying a

12-parameter affine transformation followed by non-linear warping using basic functions. Images were smoothed by using a Gaussian kernel of 8-mm full width at half maximum to enhance signal-to-noise ratios and facilitate group comparisons. Differences in global BOLD signal were controlled by proportional scaling. Low-frequency noise was removed by using a high-pass filter, and an autoregressive model (SPM2) was used to account for serial correlations in the data.

fMRI Data Analysis

The data were analyzed by using a two-stage, random effects procedure. In the first stage, the BOLD response for each phase of the statement sets for each subject (initial statement, contradiction, Consider 1, Rate 1, exculpatory statement, Consider 2, Rate 2) was modeled with the standard canonical hemodynamic response function (cHRF). Parameter estimates of the cHRF were created via within-subject contrasts collapsed across trial phases. The resulting summary statistic images were then entered into a second-stage analysis that treated each subject as a random variable. Image analysis was conducted by using MATLAB and Statistical Parametric Mapping software (SPM2, Wellcome Department of Cognitive Neurology, www.fil.ion.ucl.ac.uk/spm). The data were analyzed in an event-related format, epochs within each set varying in duration based on duration of slide presentation, because we could not be certain precisely when subjects would begin to engage in motivated reasoning, to recognize a contradiction, and so forth. While making 4-point ratings, subjects were instructed to press a button on a 4-button MRI-compatible response pad. Unless otherwise indicated, all activations were assessed at a significance level of $p < .001$ (uncorrected) and an extent threshold of 5 contiguous voxels.

Planned Comparisons

We tested hypotheses using planned comparisons (contrast analysis), using all six statement sets per experimental condition (same party, other party, neutral target). Because the focus of this report is on partisans' responses to threatening information about their candidate (rather than on differences in neural processing between Democrats and Republicans), and because Democrats' neural and behavioral responses to Kerry contradictions resembled Republicans' responses to Bush contradictions, we aggregated the data across parties.¹ No subjects' data were excluded for data analysis. We tested three primary contrasts. The first compared neural responses in the *same-party* condition (i.e., Republicans evaluating Bush and Democrats evaluating Kerry) to responses in the neutral condition (i.e., the neutral targets) during the *contradiction* phase, when subjects were confronted with a cognitive contra-

dition. By subtracting responses to the neutral targets from the same-party targets, we controlled for cognitive processes involved while reasoning about a contradiction relatively free of emotional entailments, to isolate neural processes associated with emotional constraint satisfaction.

The second contrast made use of the structural similarity of the contradiction statement to the *exculpatory* statement. In both statements (each presented for 12 sec), subjects were presented with information that seemingly contradicted prior information (i.e., imposing new cognitive constraints requiring resolution). What differs is that the contradictory but not the exculpatory statement generates a conflict between conclusions that would be reached by weighing the evidence (cognitive constraints) and desired conclusions (emotional constraints). Hence, the contradiction but not the exculpatory statement should activate neural circuits involved in emotion-biased motivated reasoning. Thus, the second contrast focused on the same-party condition only, subtracting activations related to the exculpatory statement (reasoning without emotional conflict) from those associated with the contradiction statement (reasoning plus emotional conflict).

The third planned contrast, which is conceptually the most complex, tested the interaction between target (same-party vs. neutral) and phase (contradiction vs. exculpatory). In other words, this contrast describes activations that were significantly greater when subjects were processing negative versus exculpatory information for their preferred candidate versus a neutral target. The interaction subtracts neural activity for *neutral targets* from same-party targets (isolating conditions of emotional conflict, as in the first contrast) while partisans were processing information presenting during the contradiction phase minus the exculpatory phase.

RESULTS

Behavioral Ratings

Subjects' ratings during image acquisition of the extent to which targets' statements and actions were inconsistent provided strong evidence of motivated reasoning (Figure 2). As can be seen from Figure 2, mean ratings on the six Bush contradiction phases were 3.79 for Democrats versus 2.16 for Republicans, $t(27) = 12.82$, $p < .0001$, with small *SEs* (indicated by the error bars). Mean ratings on the six Kerry contradictions were 2.60 (± 0.15) for Democrats versus 3.55 (± 0.12) for Republicans, $t(27) = -5.25$, $p < .0001$. The patterns were similar (and statistically significant) for the post-exculpatory-phase ratings (i.e., partisans were substantially more likely to accept the exculpatory statements for their own candidate vs. the opposing candidate). Mean ratings on the six Bush exculpatory phases were

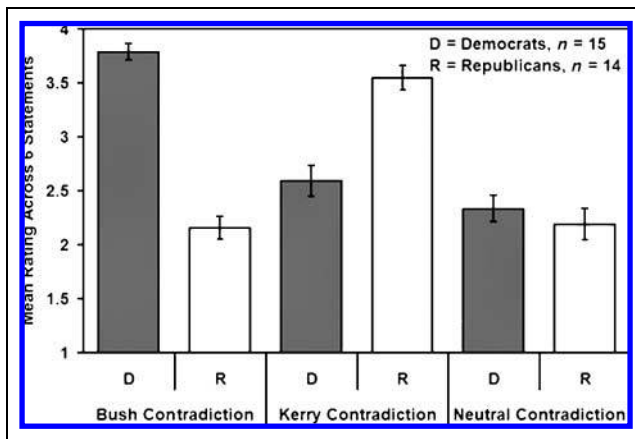


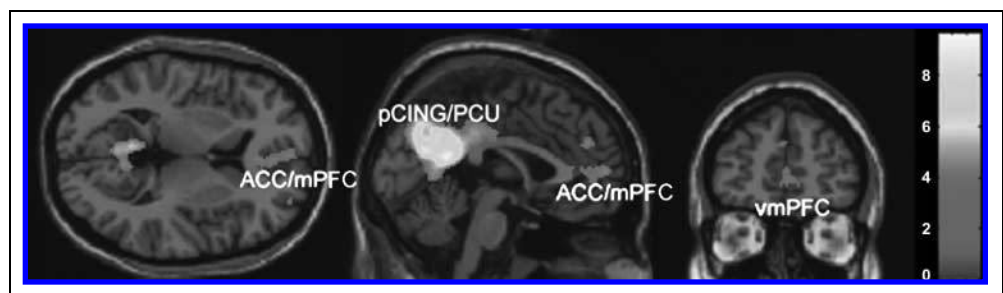
Figure 2. Subjects' ratings of perceived contradictions in statements by Bush, Kerry, and neutral figures (higher ratings indicate greater perceived contradictions). Democrats and Republicans reasoned to distinctly different conclusions about their preferred candidates, with mirror-image responses: Democrats readily identified the contradictions in Bush's statements but not Kerry's, whereas Republicans readily identified the contradictions in Kerry's statements but not Bush's.² As can be seen from the SEM bars, the distributions of responses were nonoverlapping, demonstrating powerful effects of motivated reasoning. In contrast, Democrats and Republicans reasoned similarly about the contradictions of politically neutral figures.

1.71 (± 0.14) for Democrats versus 3.50 (± 0.04) for Republicans, $t(27) = -11.69$, $p < .0001$. Mean ratings on the six Kerry exculpatory statements were 3.11 (± 0.16) for Democrats versus 1.82 (± 0.12) for Republicans, $t(27) = 6.64$, $p < .0001$. As predicted, Democrats and Republicans did not differ in their ratings of the neutral targets.

Processing the Contradiction: Same-party Candidate > Neutral Target

The first contrast subtracted neutral targets from same-party targets during the contradiction phase (e.g., Republicans evaluating Bush contradictions vs. contradictions involving Hank Aaron). As can be seen in Figure 3,

Figure 3. Three orthogonal views (axial, sagittal, coronal; at $x = 0$, $y = 50$, $z = 6$) of the areas of activation that differed when subjects were confronted with contradictory (threatening) information regarding their own party's candidate versus a neutral target person. ACC = anterior cingulate; mPFC = medial prefrontal cortex; pCING = posterior cingulate; PCU = precuneus; vmPFC = ventromedial prefrontal cortex.

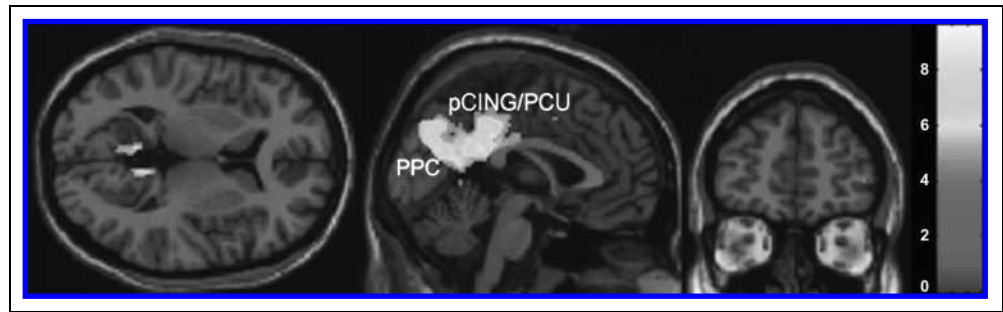


processing emotionally threatening information about one's preferred candidate relative to a neutral target activated distributed sites in the medial PFC, including a large cluster of activation that included the ventral ("affective") subdivision of the ACC (centered at 4, 42, 10; size = 323 voxels; $Z = 3.86$), as well as the more rostral ("cognitive") subdivision (Bush, Luu, & Posner, 2000), and extending into the ventromedial PFC, a region associated with affective processing and emotional influences on reasoning (Miller, Taber, Gabbard, & Hurley, 2005; Davidson, 2002; Hamann, Ely, Hoffman, & Kilts, 2002; Hamann & Mao, 2002). A superior medial prefrontal region (at 2, 46, 28; size = 66 voxels; $Z = 3.71$) was also activated. The other notable finding was a large area of activation in the posterior cingulate cortex (along with coextensive regions of the precuneus and inferior parietal cortex, at 2, -52, 18; size = 3340 voxels; $Z = 6.40$), associated in prior studies with neural processing related to social emotions, moral evaluations, and judgments of forgivability (Cunningham, Raye, & Johnson, 2004; Farrow et al., 2001; Greene, Sommerville, Nystrom, Darley, & Cohen, 2001).

To rule out the alternative hypothesis that these activations might simply reflect general emotion processing, we ran a secondary contrast subtracting responses to neutral targets from those to *other-party* targets (i.e., Democrats evaluating Bush, Republicans evaluating Kerry) during the same contradiction phase. This contrast produced a single, large area of activation centered in the posterior cingulate and extending to the precuneus and posterior parietal cortex (Figure 4) (at 4, -42, 26; size = 3598 voxels; $Z = 5.46$). Thus, evaluating a contradiction with strong moral overtones led to activation of the posterior cingulate cortex and precuneus for both same-party and other-party candidates. However, only when the contradiction created conflict between data and desire (i.e., when unbiased reasoning would produce judgments with negative emotional consequences) did we observe a large activation of the ACC and medial PFC.

We had predicted that processing emotionally threatening information about one's preferred candidate relative

Figure 4. Three orthogonal views (axial, sagittal, coronal; at $x = 0, y = 50, z = 6$) of the areas of activation that differed when subjects were confronted with contradictory (threatening) information regarding the opposing party's candidate versus a neutral target person. pCING = posterior cingulate; PCU = precuneus; PPC = posterior parietal cortex.



to a neutral target would activate the amygdala, but we did not observe amygdala activation in our primary contrasts. Because the amygdala has been characterized as often exhibiting a transient, rapidly habituating response to emotional stimuli (Breiter et al., 1996), we examined whether amygdala activation might be present only during the earlier part of the session, focusing again on the contradiction phase. For each condition (same-party, other-party, and neutral target), we separately contrasted the responses observed in the first half of the session with those in the latter half (i.e., the contradiction phase of the first three statement sets for each target vs. the last three) to assess whether habituation of amygdala response occurred across the session.

For this exploratory analysis, we set a statistical significance threshold of $p < .005$ and an extent threshold of five contiguous voxels, given the lower power of these contrasts. Supporting the habituation hypothesis, for the same-party condition, we observed greater amygdala activation during the first half of the session relative to the second half, in the left amygdala (at $-22, -4, -12$; size = 13 voxels; $Z = 3.19$). This effect was also observed for the other-party condition, also in the left amygdala (at $-22, -4, -22$; size = 8 voxels; $Z = 2.84$), perhaps reflecting arousal associated with the detection of a contradiction associated with a disliked opponent (i.e., *schadenfreude*). More importantly, this habituation effect was absent for the neutral-target condition, in line with the hypothesized weak emotional response to

contradictory statements associated with a relatively neutral individual.

Same-party Condition: Contradictory > Exculpatory Information

Our second primary contrast subtracted processing during the exculpatory phase from the contradiction phase for same-party conditions only. This allowed us to examine two phases in which subjects had to make judgments about new information that contradicted prior information, isolating processes involved when the emotionally desired conclusion did not coincide with the conclusion likely to be drawn based on unbiased assessment of the data (Figure 5). The contrast analysis showed activations in the left lateral inferior frontal cortex (at $-28, 24, -24$; size = 31 voxels; $Z = 4.51$) and left insula (not shown: at $-36, -18, 18$; size = 190 voxels; $Z = 4.47$), both consistent with processing of negative affect (Wright, He, Shapira, Goodman, & Liu, 2004). Also seen were activations in the inferior orbital frontal cortex (gyrus rectus) bilaterally (at $-2, 42, -24$; size = 230 voxels; $Z = 4.15$), indicative of emotion processing (Ballmaier et al., 2004; Kilts, Egan, Glideon, Ely, & Hoffman, 2002; O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001; Bechara, Damasio, & Damasio, 2000) as well as the precuneus (suggesting evaluative judgments, as above) (at $-6, -56, 18$; size = 278 voxels; $Z = 3.98$). Because the orbitofrontal cortex has been proposed to be crucially involved in emotional in-

Figure 5. Partisans' neural responses to the contradiction versus exculpatory statements regarding their party's candidate. It presents three orthogonal views (axial, sagittal, coronal; axial, sagittal, coronal; at $x = 0, y = 34, z = -22$) of the neural regions showing greater activation while partisans were reading emotionally threatening information (contradiction phase) relative to nonthreatening (exculpatory phase) information. PHG = parahippocampal gyrus; IOFC = lateral orbitofrontal cortex; mOFC = medial orbitofrontal cortex; PCU = precuneus.

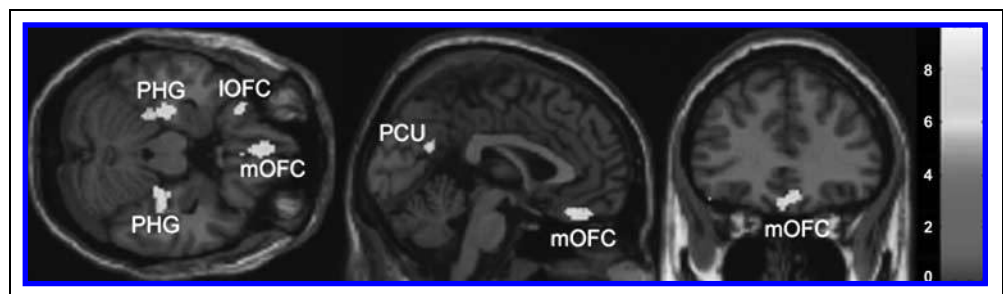
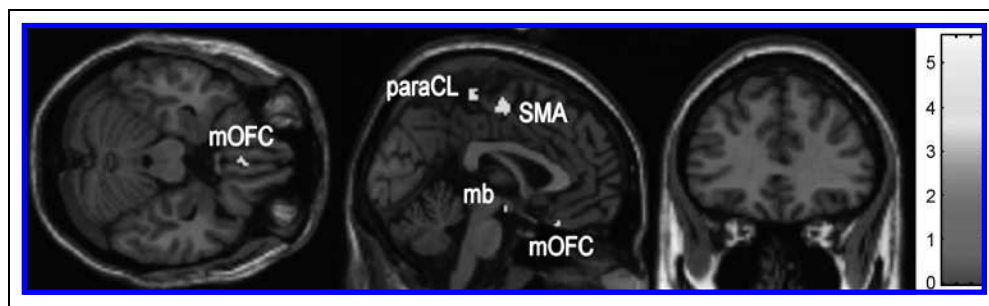


Figure 6. Three orthogonal views (at the same axial, sagittal, and coronal levels as in Figure 5 for comparison; at $x = 0, y = 34, z = -22$) of the neural regions that were significantly more active when subjects were processing threatening versus exculpatory information for neutral targets. mOFC = medial orbitofrontal cortex; paraCL = paracentral lobule; SMA = supplementary motor area; mb = mammillary bodies.



fluences on reasoning (Damasio, 1994), we examined whether this orbitofrontal activation was specific to the same-party condition by performing the same contradictory > exculpatory contrast with the neutral target condition. Only a single, small activation was observed in the orbitofrontal cortex, in the gyrus rectus (at 2, 28, -24; size = 17 voxels; $Z = 3.60$), consistent with the lower hypothesized involvement of emotion processing in this condition (Figure 6). The only other prominent activations for the same-party condition contrasts were bilateral activations in the parahippocampal gyrus and extending to the hippocampus (at 36, -34, 18; size = 126 voxels; $Z = 4.03$ and -26, -26, -18; size = 190; $Z = 4.47$), perhaps indicative of efforts to generate solutions (rationalizations) based on memory retrieval. As in the first primary contrast, in this second primary contrast we observed no differential activation of the dorsolateral PFC (DLPFC), suggesting that motivated reasoning did not differentially engage regions previously linked with conscious attempts to reason, suppress information, or regulate affect.

Testing the Interaction: Contradictory > Exculpatory Information for Same-party > Neutral Target

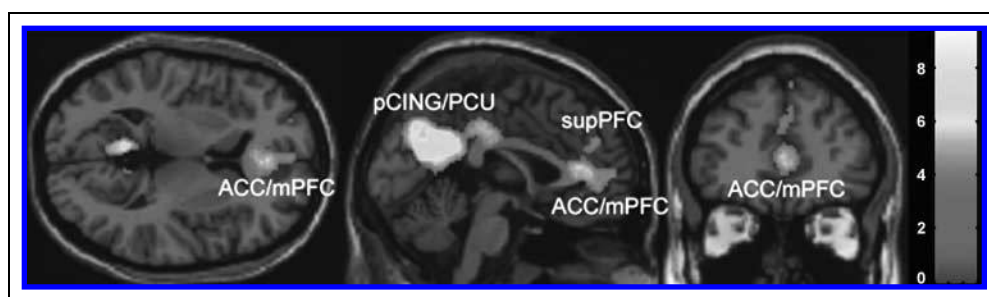
The third primary contrast (Figure 7) tested the interaction between target (same-party vs. neutral) and phase

(contradiction vs. exculpatory). Consistent with the expectation that same-party contradictions would elicit negative affect, the contrast yielded activations in the right lateral orbital frontal cortex (not shown: maximum at 38, 52, -8; size = 130 voxels; $Z = 4.16$). Also consistent with affect processing and regulation were multiple activations throughout the ACC, medial and orbital PFC (at 2, 40, 10; size = 952; $Z = 4.74$), and left superior frontal gyrus (at -24, 56, 12; size 90; $Z = 4.11$) associated in previous studies with moral reasoning and evaluation of self-generated information (Farrow et al., 2001). The contrast also showed large activations in the posterior cingulate/precuneus (at -8, -50, 8; size = 3114; $Z = 6.27$).

Postdecision Judgment: Consider1 > Consider2 for Same-party Targets

We performed a fourth, more exploratory analysis to isolate the neural information processing related to equilibrated, emotionally constrained solutions (i.e., solutions biased by emotional considerations). We hypothesized that neural processing indices of negative affect would be diminished or absent following motivated reasoning (because the function of motivated reasoning is hypothesized to be the elimination of the aversive affect states associated with threatening information). An inherent limitation of the study design was

Figure 7. Three orthogonal views (axial, sagittal, coronal; at $x = 0, y = 44, z = 6$) of the neural regions that were significantly more active when subjects were processing threatening versus exculpatory information for their party's candidate versus a neutral target. ACC = anterior cingulate; mPFC = medial prefrontal cortex; pCING = posterior cingulate; PCU = precuneus; supPFC = superior prefrontal cortex.



that we could not be sure precisely when subjects had reached conclusions over the course of exposure to the contradiction and instruction to consider it. However, given that the structure of the task was identical across all 18 statement sets, and subjects had 15 sec to read the initial statement and 12 sec to think about the contradiction for each statement set, we expected that most would have equilibrated to solutions (including emotionally biased solutions) by the time they reached the Consider 1 phase (or at the latest during the Rate 1 phase). We thus subtracted neural activity during the second Consider 2 phase (after subjects had 12 sec to consider the exculpatory information) from the first Consider 1 phase (after having had 12 sec to think about the contradiction) for same-party targets. This allowed us to isolate the neural responses associated with the cognitive *products* of emotional constraint satisfaction (i.e., the neural response to having generated a solution that resolved a cognitive–emotional conflict).

The contrast yielded a large activation in the ventral striatum (Figure 8) (at 2, 0, 2; size = 982 voxels; $Z = 4.58$), centered on the right caudate and extending to the left caudate, bilateral putamen, and pallidum. Activity in the ventral striatum, particularly the caudate nucleus, has been observed in paradigms in which contingencies exist between behavior and reward, as in reinforcement-based learning (Delgado, Miller, Inati, & Phelps, 2005). Given that subjects would be expected to experience some relief after resolving the uncertainty associated with a cognitive–emotional conflict, this suggests a possible reinforcement mechanism for motivated judgments. Caudate responses to positive and negative feedback have been shown to be modulated by prior social and moral beliefs regarding a partner in an interactive social trust paradigm (Delgado, Frank, & Phelps, 2005), suggesting that neural reinforcement mechanisms for motivated judgments may be influenced by affective social biases. Additional activations were observed near the ventral ACC (at 14, 48, -4; size = 86 voxels; $Z = 4.31$), suggesting continued neural processing related to affect regulation, as well as activation of left parietal regions (not shown, largest cluster at -46, -60, 54; size = 17 voxels; $Z = 4.07$) indicative of

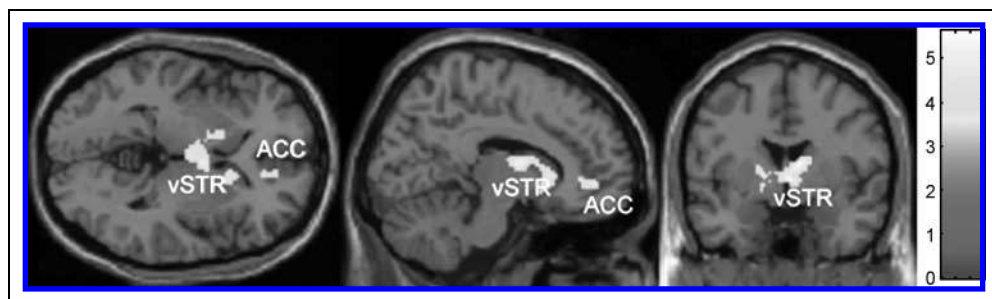
effortful processing (perhaps reflecting efforts to bolster rationalizations in support of motivated reasoning; see Ditto, Munro, Apanovitch, Scepanisky, & Lockhart, 2003). The association of equilibrated decisions with (negative) reinforcement was further represented in diminished activations in the lateral orbital frontal and insular cortex, sites related to negative affect.

We ran two secondary contrasts to clarify further the functional inferences from this fourth contrast. First, we compared the two *consider* phases for the *neutral* targets. This contrast yielded few significant activations, all located outside of the regions implicated in motivated reasoning (e.g., small areas of visual cortex), suggesting the absence of the reinforcement mechanisms hypothesized to underlie the results obtained for same-party targets. Second, to test our conjecture that subjects had already equilibrated to a conclusion by the time they were asked to consider the contradiction, we contrasted neural activity during the second (postexculpatory) *rating* phase from the first (postcontradiction) *rating* phase for the same-party condition. These phases occurred immediately after the consider phases for which we found substantial reinforcement effects. This contrast yielded spatially large activations in the left DLPFC (at -54, 0, 44; size 437; $Z = 5.02$) and a small activation in the orbital frontal cortex (maximum at -4, 44, -20; size = 20 voxels; $Z = 3.37$). The DLPFC activations could reflect either the tendency toward effortful cognitive processing (overgeneration of cognition) observed in behavioral studies of motivated cognition, which likely follows in rapid succession an implicit judgment (i.e., to “shore up” the defensive cognition), or the fact that the postexculpatory ratings required minimal processing because cognitive and affective constraints were congruent.

Task-related Deactivations in the Resting Circuit

Our primary hypotheses concerned differential levels of activation between the experimental conditions and phases, independent of the relation between these levels and those of the resting baseline or no-task periods. However, because of interest in task-related

Figure 8. Three orthogonal views (axial, sagittal, coronal; at $x = 12, y = 0, z = 0$) of regions significantly more active when partisans had presumably equilibrated to solutions regarding their party's candidate (i.e., when they were asked to consider the initial contradiction) than when asked to consider the contradiction again following the exculpatory information. Neural regions previously active suggesting negative affect processing are no longer active. However, the ventral striatum shows a large region of activation, suggesting reward or reinforcement. vSTR = ventral striatum; ACC = anterior cingulate.



deactivations during active experimental tasks relative to low-level resting or baseline conditions (as reviewed in Gusnard & Raichle, 2001), we conducted a descriptive analysis to characterize regions of task-related deactivation for the contradictory and exculpatory phases in the neutral-target condition. The neutral condition was selected because of its primary role as a control condition in the between-condition contrasts. The main deactivation effects relative to the modeled signal baseline (i.e., a contrast weight of -1 for the main effect) for the contradictory and exculpatory phases were separately assessed for the neutral-target condition, using a threshold of $p < .05$, corrected for multiple comparisons, and an extent threshold of 10 contiguous voxels. Matching prior findings of a resting circuit involving primarily medial structures (Gusnard & Raichle, 2001), we observed two primary regions of medial task-related deactivation, including a large anterior cluster spanning the ACC and medial orbitofrontal gyrus (maximum at 2, 46, -8 ; size = 933 voxels; $Z = 6.90$; $p < .000$; and maximum at 2, 46, -4 ; size = 742 voxels; $Z = 7.21$; $p < .000$, for *both* the contradictory and exculpatory phases, respectively) and a posterior cluster spanning the middle and posterior cingulate and precuneus (with maxima at 10, -38 , 44; size = 1,378 voxels; $Z = 7.53$; $p < .000$; and at 4, -44 , 48; size = 1319 voxels; $Z = 6.97$; $p < .000$, once again for both the contradictory and exculpatory phases, respectively).

DISCUSSION

This is, we believe, the first study to describe the neural correlates of motivated reasoning (and the closely related constructs of implicit affect regulation, psychological defense, confirmatory biases, and forms of cognitive dissonance involving cognitive–evaluative discrepancies; see Westen, 1985, 1994). It is also, we believe, the first study describing the neural correlates of political judgment and decision-making.

Consistent with prior studies of partisan biases and motivated reasoning, when confronted with information about their candidate that would logically lead them to an emotionally aversive conclusion, partisans arrived at an alternative conclusion. This process was not associated with differential activation of the DLPFC, as in studies of “cold” reasoning and explicit emotion regulation (suppression). Rather, it was associated with activations in the lateral and medial orbital PFC, ACC, insula, and the posterior cingulate and contiguous precuneus and parietal cortex. Neural information processing related to motivated reasoning appears to be qualitatively different from reasoning in the absence of a strong emotional stake in the conclusions reached.

These findings support the role of a network of functionally integrated brain areas in motivated rea-

soning. Activations of the left insula, lateral orbital frontal cortex, and VMPFC have been associated with experiences of punishment, pain, and negative affect (Hamann, 2003; O’Doherty et al., 2001). The role of the VMPFC in cognitive–affective interactions is well established (Damasio, 1994) and was hypothesized a priori in this study to be centrally involved in implicit appraisal and reappraisal of emotionally threatening information. Activation of the left ventral lateral frontal cortex may also be implicated in affect regulation. Previous studies of (explicit) emotion regulation (Anderson et al., 2004; Hariri et al., 2003; Ochsner et al., 2002) observed activation of the lateral ventral PFC when subjects were cognitively suppressing responses to negative emotional stimuli; this in turn was associated with decreased amygdala response.

Consistent with previous studies that have characterized the amygdala as frequently exhibiting a rapidly habituating response to stimuli, we observed left amygdala activation during the phase where maximal emotional response was predicted (i.e., the contradiction phase), but only during the first half of the experiment. This amygdala activation was observed in the two conditions where strong emotional response was expected to occur during the contradiction phase (the same-party and other party conditions) but did not occur in the neutral-target condition where a lesser emotional response was expected.

The dorsomedial frontal cortex is associated with such processes as self-reference (D’Argembeau et al., 2005; Fossati et al., 2003) and sympathy (Decety & Chaminade, 2003), which are congruent with the hypothesized processes by which partisans reason to emotionally biased conclusions about a candidate with whom they are presumably identified. Interestingly, the pattern of activity associated with implicit affect regulation in this study differs in an important respect from the pattern seen when subjects *consciously* attempt to regulate their affects by reappraising negative stimuli (Ochsner et al., 2002) in the increased rather than decreased activation observed in medial orbitofrontal circuits and in the absence of differential DLPFC activation as subjects are altering their cognitions. Of relevance, recent research (Dunbar & Fugelsang, 2005) on the neural correlates of evaluation of information inconsistent with prior beliefs (but not emotionally threatening) yielded activations in the ACC and precuneus but in the DLPFC rather than the VMPFC, suggesting the difference between cognitive constraint satisfaction in the absence of strong emotional constraints and conflicts between cognitive and emotional constraints.

The activation of the ACC, particularly its ventral affective subdivision, is consistent with distress-related to error detection (Bush et al., 2000) and motivational/emotional error detection, correction, and response (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Activation of the ACC is associated more generally

with modulation of activity in other brain regions (e.g., turning on cognitive activity, toning down affective activity; Bush, 2004; Bush et al., 2000) and often predicts *subsequent* activation of the DLPFC, as the person corrects a mistaken response (Ridderinkhof et al., 2004). This may be relevant to our finding of an increase in activity of the DLPFC once subjects had apparently drawn emotionally biased conclusions.

The activation in the posterior cingulate, precuneus, and adjacent parietal cortex in motivated reasoning fits well with studies showing activation in this region when people are judging forgivability of an action (Farrow et al., 2001) and making emotionally laden moral judgments (Greene et al., 2001). These brain regions are also involved in emotion processing, emotional memory, and evaluative processing more generally (Cunningham et al., 2004; Maddock, Garrett, & Buonocore, 2003; Paradiso et al., 1999). The posterior cingulate also appears to be involved in judgments about one's own and others' feeling states (Ochsner et al., 2004) and has been reported in one study to be activated by threat words (Maddock et al., 2003; Maddock & Buonocore, 1997). The posterior cingulate was activated in the present study while subjects were judging the culpability of both their own and the opposite party's candidate; however, the combination of a robust posterior cingulate activation with a large ACC activation distinguished processing of emotionally aversive information (i.e., threats to one's own candidate).

The large activation of the ventral striatum that followed subjects' processing of threatening information likely reflects reward or relief engendered by "successful" equilibration to an emotionally stable judgment. The combination of reduced negative affect (absence of activity in the insula and lateral orbital cortex) and increased positive affect or reward (ventral striatum activation) once subjects had ample time to reach biased conclusions suggests why motivated judgments may be so difficult to change (i.e., they are doubly reinforcing). These findings lend some support to a speculation made a number of years ago that the phenomenon described for a century in the clinical literature as psychological defense (e.g., denial, rationalization, motivated distortion) involves the operant conditioning of mental processes, such that people are reinforced by escape from negative (and perhaps elicitation of positive) affect (see Westen & Blagov, in press; Westen, 1985). Of potential relevance, several researchers have found avoidance and escape conditioning to be associated with dopamine release in the nucleus accumbens and dorsal striatum in other animals (Rada, Mark, & Hoebel, 1998; Salamone, Cousins, & Snyder, 1997).

Limitations

The study has several limitations. First, because this is the first study to examine the neural correlates of both

motivated reasoning and political decision-making, we chose to conduct whole-brain versus targeted region-of-interest analyses. Second, because of data suggesting some differences in the processing of emotion in men and women (Canli, Desmond, Zhao, & Gabrieli, 2002), we only studied men and hence cannot generalize to women without future investigation. Third, because of the complexity of the task and the fact that partisans are likely to recognize and respond to an emotionally significant contradiction of the sort presented here at different temporal rates, we could not be certain precisely when subjects began to engage in motivated reasoning. Future research should attempt to parse the timeline for defensive responding more clearly and "window" data analyses accordingly to distinguish initial emotional reactions to threatening information, equilibration to motivated solutions, response to resolution of the conflict (e.g., reward), and subsequent cognitive activity (e.g., explicit rationalization). Fourth, because of limitations of time imposed by the U.S. presidential election cycle and the difficulty in identifying people without any partisan leanings, particularly in the midst of a polarized election (Abramowitz, 2004), we examined only committed partisans and used politically neutral within- rather than between-subject controls. Future studies involving larger subject samples should examine the continuum of partisan feelings studied in research using NES data (i.e., from strong Democrat to strong Republican). Finally, we tested motivated reasoning in only one domain (politics). We chose this domain because of 50 years of research documenting emotionally biased decision-making and because it allowed us to identify subjects who would likely show defensive responses to the same stimuli. Nevertheless, future research should examine the neural correlates of motivated reasoning in other domains.

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Notes

1. Elsewhere, we will address any neural differences between Democrats and Republicans as they responded to these statements or to photographs of political, nonpolitical social, and emotional stimuli presented after the tasks described here.
2. Republicans showed a small but significant tendency to reason to more biased conclusions regarding Bush than Democrats did toward Kerry, $t(27) = -2.47, p = .020$.

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