A neural basis for the effect of candidate appearance on election outcomes

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Election outcomes correlate with judgments based on a candidate's visual appearance, suggesting that the attributions viewers make based on appearance, so-called thin-slice judgments, influence voting. Yet, it is not known whether the effect of appearance on voting is more strongly influenced by positive or negative attributions, nor which neural mechanisms subserve this effect. We conducted two independent brain imaging studies to address this question. In Study 1, images of losing candidates elicited greater activation in the insula and ventral anterior cingulate than images of winning candidates. Winning candidates elicited no differential activation at all. This suggests that negative attributions from appearance exert greater influence on voting than do positive. We further tested this hypothesis in Study 2 by asking a separate group of participants to judge which unfamiliar candidate in a pair looked more attractive, competent, deceitful and threatening. When negative attribution processing was enhanced (specifically, under judgment of threat), images of losing candidates again elicited greater activation in the insula and ventral anterior cingulate. Together, these findings support the view that negative attributions play a critical role in mediating the effects of appearance on voter decisions, an effect that may be of special importance when other information is absent.

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We rapidly evaluate others based on their appearance, an effect that has been well demonstrated in social psychology (Hassin and Trope, 2000; Todorov and Uleman, 2003; Willis and Todorov, 2006) and not lost on political scientists (Rosenberg, 1986; Rosenberg et al., 1991). In fact, recent behavioral studies have shown that judgments about candidates' physical appearance correlate with real election outcomes (Todorov et al., 2005; Ballew and Todorov, 2007), suggesting that information derived from visual appearance alone (so-called thin-slice information) affects voting behavior. In particular, work done by Todorov and coworkers showed that competence judgments made about candidates who ran in 2006 gubernatorial elections picked out the winner at significantly above-chance levels (57 ± 6%, mean ± s.d.) (Ballew and Todorov, 2007). This replicated an earlier study, where the average association between an individual viewer's competence judgments and electoral victory ranged from 53 ± 10% to 59 ± 7% for various types

of political office (Todorov et al., 2005). Interestingly, participants made these judgments about politicians with whom they were unfamiliar, and after only very brief exposures to the images (100–2000 ms). These findings are quite remarkable given the amount of information about candidates to which a typical voter is exposed. For example, in the 2006 U.S. midterm elections, candidates and their interest groups spent over a billion dollars on advertising to inform voters of their party affiliation, record, policies and personal qualities (CNN, 2006). While some political scientists view such rich information as the primary driver of voter decisions (Popkin, 1991; Prior, 2005), there are other data suggesting that voters make use of much sparser information (Downs, 1957; Alvarez, 1997).

Given that mere appearance seems to influence voting behavior, this raises the question of what psychological and neural processes might mediate this effect. Here we investigate whether the effect of appearance on voting is more strongly influenced by positive or negative attributions (which might be either implicit or explicit; Galdi et al., 2008). Given the association between appearance-based judgments about competence (a putatively positive trait) and electoral victory (Todorov et al., 2005), one might expect that positive attributions from a politician's appearance dominate in influencing decisions by voters. Yet there are several reasons to hypothesize that negative attributions

also play a role. First, one would predict that thin-slice attributions play a larger role in influencing voters who have little knowledge of candidates, and there is strong evidence that, when voters know little about a candidate, perceived negative aspects of a candidate exert a stronger influence than positive aspects on voter turnout (Lau and Pomper, 2001; Martin, 2004; Stevens *et al.*, 2008), party defection, the number of self-reported reasons for voting for or against, and predicting overall positive and negative evaluations of a candidate (for a review, see Lau, 1982). Second, voters make implicit ingroup/outgroup distinctions about candidates (Iyengar and Simon, 2000), and negative information dominates the evaluation of outgroup members (Forgas and Fiedler, 1996). To the extent that candidates occupy a default outgroup position for voters lacking relevant information, as suggested by evidence showing that increasing a candidate's facial similarity to a voter significantly increases that voter's support (Bailenson *et al.*, 2006), negative attributions will dominate voter decisions. Third, negative motives play a significant role in voter decisions, particularly in so-called negative voting, in which a vote for Candidate A is really just a vote against Candidate B (Kernell, 1977; Fiorina and Shepsle, 1989).

There is, thus, reason to hypothesize that candidate appearance affects voting through processes that evaluate both positive as well as negative traits, and that may be both implicit and explicit. To test whether positive or negative attributions play a primary role, and to identify the neural regions involved, we conducted two fMRI studies using images of real political candidates. The first study asked participants to vote in the scanner and the second asked an independent group of participants to make both positive and negative trait judgments. In the first study, we would expect the particular brain structures activated during voting to provide insight into the relative influences of the above factors. Specifically, if voting is more influenced by positive attributions, we would expect vote winners to elicit greater activation of brain structures known to be involved in affective processing. Conversely, if negative attributions dominate, vote losers should elicit the greater activation in these structures. Following up on the results from this first study, our second study used explicit trait judgments (threat, deceitfulness, attractiveness, competence) to further investigate the relative contributions made by positive and negative attributions in linking candidate appearance to voter decisions. We expected that similar neural mechanisms would be revealed, further supporting the findings from the first study.

RESULTS

Study 1: simulated voting

In the first study, participants voted in a simulated election. Participants viewed grayscale pictures of 100 pairs of unfamiliar real politicians, one Republican and one Democrat, who competed in the 2006 U.S. midterm elections (Figure 1A; see Methods for details). Participants saw the image of each of the two candidates in sequence, for only 1 s, separated by a blank screen, and after a delay were asked to cast their vote. All the data were collected before the 2006 election, ensuring that participants could not have been influenced in any way by the real election outcomes.
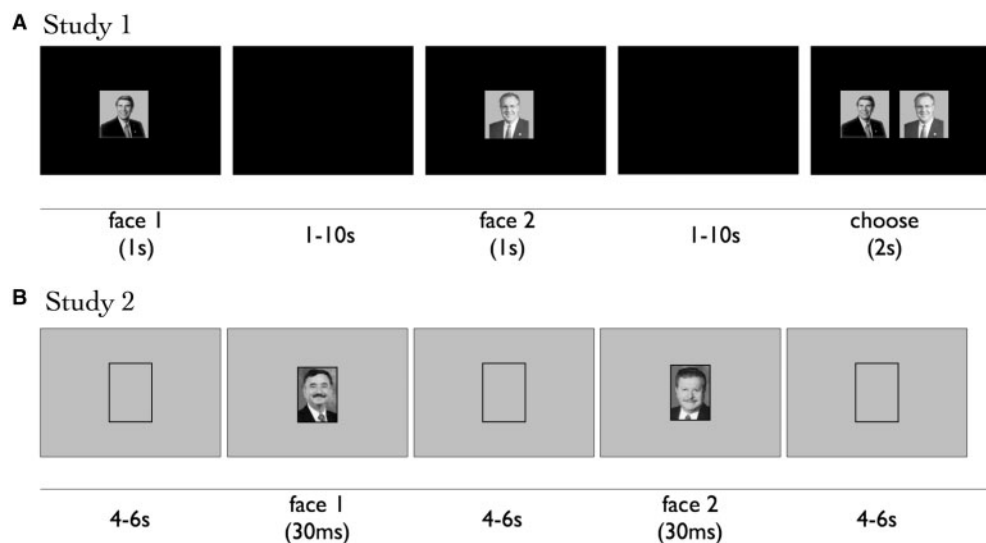

Fig. 1 Trial design of the two studies. Each experiment showed participants grayscale images of real politicians, one at a time, separated by a variable interstimulus interval. For both experiments, stimuli are depicted as they appeared on the screen. (A) Study 1: simulated voting study. Participants were shown grayscale images of each of the candidates, separately, for 1 s each. The images were separated from each other and from the decision period by a 1–10 s blank screen. (B) Study 2: social judgment study. Each trial consisted of two cycles of the alternating presentation of two images, separated by blank boxes that cued viewers to the subsequent location of the image. Participants were asked to indicate which of the two images looked more threatening, attractive, deceitful or competent (in four separate blocks) by pushing one of two buttons (whose location was indicated by a small black dot in the lower corner of the screen). Images were shown for 30 ms (unmasked). We analyzed data only from the first cycle (shown in the figure), but not from the second cycle, to ensure consistency with our first study and to maximize association with thin-slice processing.

In order to increase the sensitivity of our fMRI analyses, we limited our analyses to voxels within brain areas already known to be associated with the evaluation of facial appearance and affective processing. We produced region of interest (ROI) masks using the Automated Anatomical Labeling Toolbox for SPM (Tzourio-Mazoyer *et al.*, 2002). These ROIs are as follows: (i) the bilateral temporal lobes, including the fusiform gyrus (associated with gaze and face processing; Kanwisher and Yovel, 2006); (ii) the bilateral caudate (associated with positive evaluation of faces; Kim *et al.*, 2007); (iii) the bilateral putamen (associated with reward-based processing; O'Doherty *et al.*, 2004); (iv) the bilateral gyrus rectus (associated with positive evaluation of faces; Kim *et al.*, 2007); (v) the bilateral orbitofrontal cortex (associated with positive evaluation of faces; Gottfried *et al.*, 2003; Kim *et al.*, 2007); (vi) the bilateral insula [associated with perception of lack of trustworthiness (Winston *et al.*, 2002), and pain perception (Ploghaus *et al.*, 1999; Salomons *et al.*, 2007), but also with positive evaluation of faces (Kim *et al.*, 2007)]; (vii) the bilateral amygdala (associated mostly with negative facial attribution; Winston *et al.*, 2002); and (viii) the bilateral anterior cingulate (associated with social rejection; Eisenberger *et al.*, 2003; Somerville *et al.*, 2006). We report only those clusters surviving FWE correction at $P < 0.05$, as determined by Monte Carlo simulation using AlphaSim in AFNI (Xiong *et al.*, 1995; Cox, 1996) (see Supporting Information).

We analyzed the fMRI data for this first study by using the voting data provided by the participants in our experiment. We estimated a general linear model in which the appearance of an individual candidate's image was modulated by its vote share in the simulated election, a variable that we refer to as lab vote share (see Methods for details). We found that positive lab vote share elicited no significant activation in any ROIs. In fact, positive lab vote share did not result in any significant activation anywhere, even with a whole-brain analysis. In contrast, negative lab vote share (i.e. election loss) elicited robust, statistically significant activations in bilateral insula [222 voxels (48, −3, −9), $Z = 3.81$; 179 voxels (−45, 12, 9); $Z = 3.96$; Supporting Information Table S1; Figure 2A], and bilateral anterior cingulate cortex [239 voxels (3, 33, 9), $Z = 3.73$; Supporting Information Table S1; Figure 3A]. Thus, these regions are increasingly engaged by viewing candidates with larger margins of electoral loss.

The lack of any significant brain activations elicited by viewing winners in our simulated vote, coupled with the robust activations elicited by viewing losers, suggests that negative attributions from appearance may play a predominant role in mediating how appearance influences voting.

Study 2: candidate trait judgments

In our second study, we sought to further investigate the relative contributions to this effect made by positive and negative attributions (which might be either implicit or
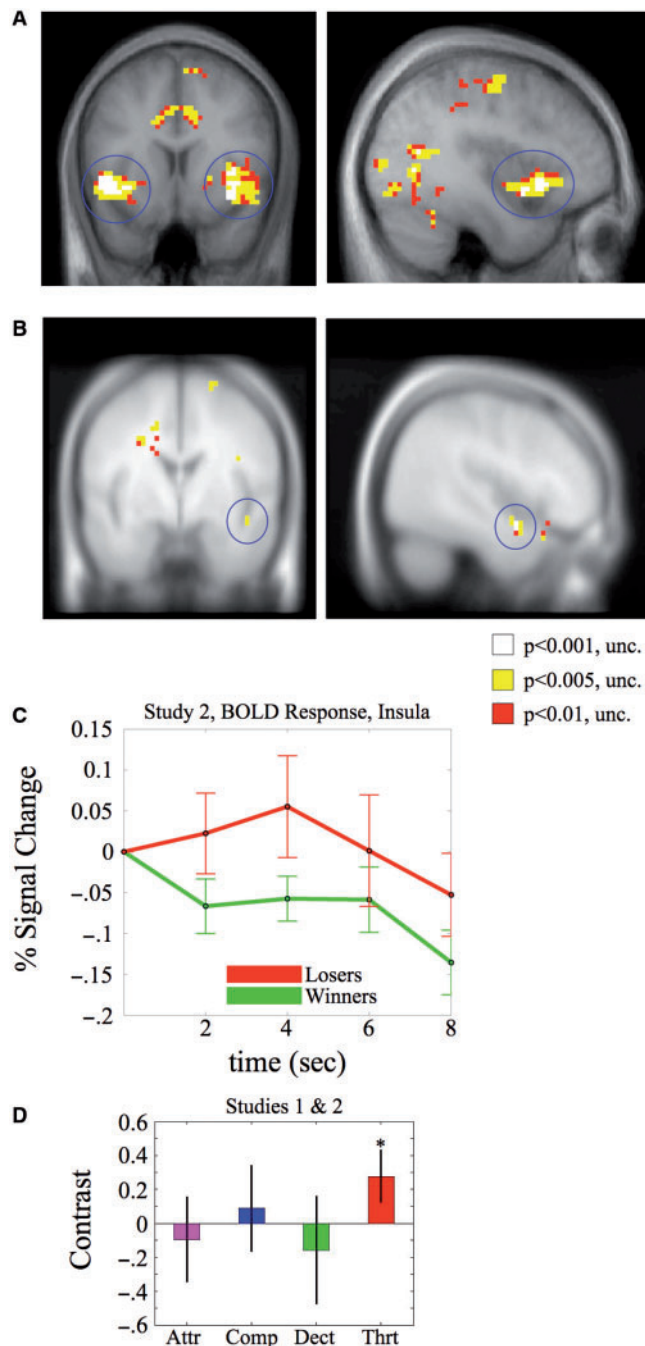

Fig. 2 Activation in the insula/parainsula correlates with election loss in both studies. (A) Study 1: activation during the simulated voting study in bilateral insula [blue circles; left insula (−45, 12, 9) and right insula (48, −3, −9)] was negatively correlated with lab vote share (greater for losers in the simulated election). (B) Study 2: activations elicited by images of candidates who lost real elections, for the contrast of loser > winner, under the condition of threat judgment. Shown are activations in the right insula, circled in blue. (C) Study 2: time course of activations for the peak voxel in the area of activation in the right insula, shown for real-electoral losers (red) and winners (green). Candidates who lost elicited an increase in activation in the right insula, while those who won actually elicited a decrease, consistent with our interpretation that this activation reflects negative attributions (means and s.e.m.). (D) Studies 1 and 2: group mean contrast estimates for loser > winner in real elections, under the four judgment conditions in Study 2, within a region in the right insula defined by the peak contrast in Study 1. Only the threat judgment (Thrt; red bar) shows significant effects (means and s.e.m.; * indicates $P < 0.05$).
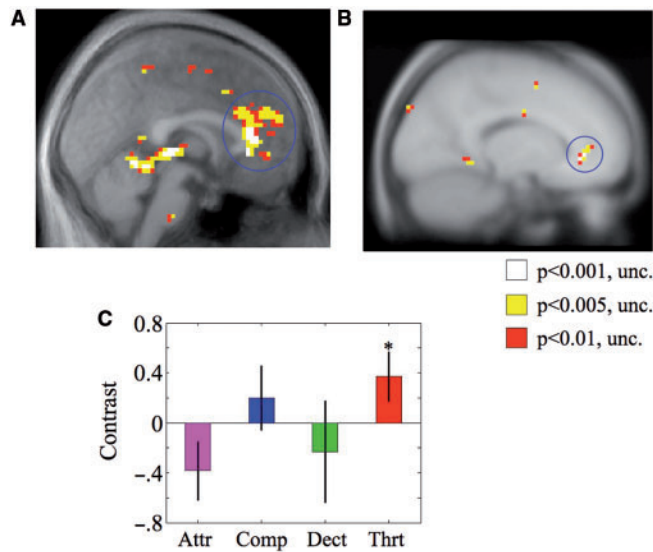
Fig. 3 Activation in ventral anterior cingulate cortex correlates with election loss in both studies. (A) Study 1: activation during the simulated voting study in bilateral anterior cingulate [blue circle; (3, 33, 9) and (−9, 21, 24)] was negatively correlated with lab vote share. (B) Study 2: activation elicited by images of candidates who lost real elections, for the contrast loser > winner (circled in blue), under the threat judgment condition. Activations are seen in the right ventral anterior cingulate. (C) Studies 1 and 2: group mean contrast estimates for loser > winner in real elections for the four judgment conditions in Study 2, within a region in the right anterior cingulate defined by the peak contrast in Study 1. Only the threat judgment (Thrt; red bar) shows significant effects (means and s.e.m. * indicates $P < 0.05$).

explicit), as well as the underlying neural structures we had found in the first study. In order to selectively enhance processing of one attribution over another, we asked participants to make overt judgments in the scanner. To best investigate the effects of candidate appearance alone, we maximized thin-slice conditions with a rapid stimulus presentation. We used a subset of the same images previously shown to elicit an association between real-electoral outcome and judgments of competence (Todorov *et al.*, 2005).

Study participants made social judgments based on the images of real, but unfamiliar, political candidates who ran against one another in the 2000, 2002 and 2004 U.S. Congressional elections, mainly in the House of Representatives. Participants made binary judgments about 30 pairs of candidates, one Republican and one Democrat (in randomized order), on two putatively positive traits, attractiveness (Attr) and competence (Comp), and two putatively negative traits, public deceitfulness (Dect) and personal threat (Thrt), in four separate scanning sessions (see Methods). Each trial consisted of a protocol that has been previously used to investigate face preferences (Kim *et al.*, 2007), in which the two images in a pair of candidates were presented sequentially, for only 30 ms each (unmasked), one alternating with the other, until the participant pushed a button to indicate which of the two faces showed more of the trait being judged (Figure 1B).

As one would expect if participants made meaningful judgments, positive trait judgments were positively

correlated (Attr and Comp, $r = 0.39$, $P = 0.002$), those for negative traits were positively correlated (Thrt and Dect, $r = 0.61$, $P < 0.0001$) and those between Comp and Thrt were negatively correlated (Comp and Thrt, $r = -0.39$, $P = 0.002$). No other statistically reliable relationships were seen in the behavioral data alone.

The relationship between our behavioral data regarding competence judgments and real-world electoral outcome was in line with the published findings we reviewed above (Todorov *et al.*, 2005; Ballew and Todorov, 2007): we found that our participants were above chance in judging winners of real elections as more competent [$55 \pm 9\%$, $t(15) = 2.15$, $P < 0.05$], with the same average individual accuracy as seen in the prior studies. When we examined the majority group competence judgments, comparing candidates who were characterized as competent by a majority of our participants with those who had won elections, the association trended positively [55%, $\chi^2(1) = 1.00$, $P > 0.1$, against an expected 50%] but did not reach statistical significance. This is likely due to our fMRI-scale sample size, as sample sizes of 40 or more are generally required to achieve reliability on this particular measure for competence judgments (Todorov *et al.*, 2005).

Consistent with the robust effect of election loss we found in our first study, a novel behavioral finding from the second study was that the strongest association between election outcome and trait judgments was seen for personal threat judgments. Majority group personal threat judgments corresponded to election loss 65% of the time [$\chi^2(1) = 9.00$, $P < 0.05$], and average individual accuracy was also above chance [$57 \pm 10\%$, $t(15) = 2.65$, $P < 0.05$]. In fact, the association between majority personal threat judgments and election outcome was stronger than that for competence [$\chi^2(1) = 4.04$, $P < 0.05$] and public deceitfulness [$\chi^2(1) = 9.00$, $P < 0.05$], although not reliably different from attractiveness [$\chi^2(1) = 2.01$, $P > 0.1$]. In addition, only the association between personal threat judgments and election loss survived in a multiple binomial regression model relating all four social judgments to the election outcomes (beta = 1.5, $P = 0.03$, $r^2 = 0.1$, $P = 0.01$).

As previously reported (Todorov *et al.*, 2005), the association between election outcome and attractiveness judgments was not statistically different from chance for the average individual [$46 \pm 10\%$, $t(15) = -1.46$, $P > 0.1$] or for majority group judgments [58% correspondence with election loss, $\chi^2(1) = 2.56$, $P > 0.1$]. Judgments of public deceitfulness across individuals [$49 \pm 9\%$, $t(15) = -0.34$, $P > 0.1$] and group majority judgments [50%, $(\chi^2(1) = 0$, $P > 0.1$] also did not differ from chance in associating with election outcome.

Our behavioral findings from the second study are, thus, consistent with what we inferred from our first study: there appears to be a primary role for negative attributions in mediating the effect of candidate appearance on election outcome. Interestingly, this may be especially the case for

attributions that affect one's personal welfare (i.e. the personal threat judgments viewers made). Given these behavioral findings, and given that our first study revealed no activations for winners, we focus subsequent imaging ana-
5 lyses on the condition of personal threat (see Supporting Information for more detail). This allows us to determine if loser-elicited activations seen in our first study are also seen here for candidates who lost real elections, under conditions where we aimed to most enhance negative attri-
10 bution (i.e. in judging personal threat from a smiling politician).

   We analyzed the fMRI data from our second study by estimating a general linear model in which separate regressors were formed for the first onset of images based on
15 whether those candidates had won or lost in real elections and on whether those candidates were the majority choice with respect to reflecting a particular trait (see Methods for details). We contrasted the parameter estimates obtained in response to the pictures of candidates who had won and
20 those who had lost real elections. We report significant activations surviving FWE-corrected thresholding at $P < 0.05$ (see Supporting Information).

   Again consistent with Study 1, we found no significant activations in our regions of interest for candidates who
25 won real elections (see Supporting Information for complete details). Instead, we found that candidates who lost real elections, compared to those who won, elicited greater activation in the insula/parainsula [18 voxels (45, 0, −15), $t = 4.80$; Figure 2B and C; Table S2B.] and in the ventral
30 anterior cingulate cortex [24 voxels (15, 39, 0); $t = 4.02$; (9,45,6), $t = 3.90$; Figure 3B; Table S2B.]. These locations are within the regions we found for Study 1 and further support the idea that negative attribution is primary in mediating the effects of candidate appearance on voter deci-
35 sions, and itself is mediated by a network of structures that include the insula/parainsula and ventral anterior cingulate regions. Further evidence for this interpretation comes from the observation that losers elicited an increase in activation in the insula, while winners elicited a decrease (Figure 2C).
40   To link our two studies directly, we first chose a region in the right insula from Study 1 (with simulated voting) and queried this region [a 10 mm radius sphere centered on the peak voxel (48, −3, −9)] with respect to the contrast effects seen in Study 2 (with real voting). Consistent with Study 1,
45 we found in Study 2 that the contrast of loser > winner, under the condition of threat judgment, resulted in a significantly enhanced activation in this region [$t(15) = 1.87$, $P < 0.05$; Figure 2D]. However, we found no significant effect under any of the other judgment conditions
50 ($P > 0.1$). Similarly, we chose a region in the right anterior cingulate from Study 1 and queried this region [a 10 mm radius sphere centered on the peak voxel (3, 33, 9)] with respect to the contrast effects seen in Study 2. Again, we found that the contrast of loser > winner resulted in a sig-
55 nificantly enhanced activation in the region, for threat

judgment only [$t(15) = 1.98$, $P < 0.05$; Figure 3C; all other conditions, $P > 0.1$, except for attractiveness, which shows a near-significant effect of winner > loser, $t(15) = 1.71$, $P = 0.054$]. Thus, brain regions identified in Study 1 showing a differential sensitivity for images of election losers, com- 60 pared to winners, show this same sensitivity in Study 2 under conditions in which negative attributions are putatively enhanced, and this time for real election outcomes. This is further evidence that negative attributions are primary in mediating the effect of appearance on voting. 65

   While analyses in Study 2 focused primarily on the threat judgment condition, it is important to note that we observed activations under the other three conditions also (see Supporting Information for details). The direction of the significant election contrasts (loser > winner, or winner > 70 loser) was in line with what one would expect given the valence of the social judgment condition. Thus, both threat and deceit conditions produced activations primarily for loser > winner, whereas attractiveness and competence conditions produced activations primarily for winner > loser. 75 We interpret these data to show that either positive or negative attributions can be enhanced with a sufficiently valenced social judgment context, while negative attributions are primary under the context of voting, particularly when there is a lack of other information about the candidates. 80

DISCUSSION

The activation patterns in the insula and anterior cingulate are similar between our two studies, especially considering that they (i) involved different groups of participants, (ii) used different images of political candidates, (iii) used 85 different tasks, and (iv) used different measures of electoral outcome (i.e. simulated and real). In both studies, the activations were elicited by images of candidates who had lost in an election, simulated or real, consistent with the notion that the activations reflect processing in negative attribution. 90 Taken together, the studies suggest that elicitation of negative emotional processes may predominate in mediating the connection between candidate appearance and voting behavior. This interpretation of the data is based on several observations. First, winners of our simulated election elicited no 95 activations in any brain region, while losers elicited robust activation in both the insula and ventral anterior cingulate. While both of these regions have been shown to be sensitive to positive as well as negative aspects of appearance, under various conditions, our interpretation is that here they were 100 responding to negative aspects since they were strongly activated by candidates who lost. This is consistent with literature associating the insula/parainsula (Coan et al., 2006; Lamm et al., 2007) and the ventral anterior cingulate (Eisenberger et al., 2003; Somerville et al., 2006) with the 105 processing of negatively valenced emotions in social situations. The insula is an area known to mediate interoceptive processing and feelings (Craig, 2002), such as sensations of pain or internal discomfort (Singer et al., 2004; Coan et al.,

2006), and the right ventral anterior cingulate is implicated in panic attacks (Eser *et al.*, in press), fear (Williams *et al.*, 2006; Bryant *et al.*, 2007) and uncontrollable pain (Salomons *et al.*, 2007). These regions, including the parainsula (Stefanacci and Amaral, 2002), are also known to connect strongly with the amygdala (Amaral *et al.*, 1992), a structure known to play a key role in negative affect associated with faces. Second, judgments of personal threat were most robustly correlated with election outcomes. Finally, under conditions likely to enhance negative attributions (i.e. examining faces for personal threat), we again saw that candidates who won elections elicited no activations in our regions of interest, while those who lost elections elicited greater activation in the insula and ventral anterior cingulate.

These findings are all the more surprising given that nearly all of our politicians were smiling (92% in Study 1; 100% in Study 2) and none showed any overt negative facial expressions. To our knowledge, this is the first demonstration that images with expressions that are overtly positive can nonetheless drive brain activations related to negative evaluations. It is also the first demonstration of a link between voter decisions and brain activations in people making social judgments.

It is important to qualify the findings in this paper in several ways. First, although the weight of our findings suggests a preferential role for negative attributions from candidate appearance, we did see some areas associated with positive emotional processing in Study 2. However, the behavioral judgments under these conditions (competence and attractiveness; cf. Supporting Information) were not as robustly correlated with real electoral outcomes. Thus, we do not wish to rule out that positive attributions may contribute to the effect of appearance on voter decision making, but this effect may be small compared to the effect of negative attributions. It is also possible that positive attributions are simply more variable across individuals than negative attributions, thus diluting their group effect. Nevertheless, our findings support a model in which the contribution made by negative attributions predominates when voters make decisions based on limited information, in line with findings from political science (Lau and Pomper, 2001; Martin, 2004; Stevens *et al.*, 2008).

A fundamental question in politics is the extent to which voters' decisions are driven by positive motives, which induce them to vote for candidates that they like, or by negative ones, which induce them to vote for the candidate that they do *not* dislike (i.e. negative voting). As detailed above, there is evidence that negative motives play a role, if not an exclusive one, in voters' decisions (Kernell, 1977; Lau, 1985; Fiorina and Shepsle, 1989). The results from our two studies suggest that political 'intangibles', such as a candidate's appearance, might also work primarily via negative motives. This raises a final question about the nature of those intangibles: what is it about a person's appearance that signals negative traits and influences election loss?

Future studies with considerably larger stimulus sets, and with experimental manipulations of facial features, will be required to address this question.

METHODS

Study 1: simulated vote

Participants. Twenty-four participants (seven female, aged 18–38) participated in the study. Participants had no history of neurological or psychiatric illness and were not on psychotropic medications. Participants had no previous knowledge of any of the political candidates whose images were used in the study, and reported no recognition of any of the politicians. All procedures were approved by the Institutional Review Board at the California Institute of Technology, and participant consent was obtained according to the Declaration of Helsinki.

Stimuli. Stimuli consisted of 200 grayscale images of political candidates who ran in the real 2006 U.S. midterm elections for either the Senate (60 images), the House of Representatives (74 images), or Governor (66 images). The stimuli were collected from the candidates' campaign Web sites and other Internet sources. An electoral pair consisted of two images of candidates, one Republican and one Democrat, who ran against one another in the real election. Due to the racial and gender composition of the candidates, 70 of the 100 pairs were of male politicians, and 88 of 100 pairs involved two Caucasian politicians. An independent observer classified 92% of the images as 'smiling'. In 57% of the pairs, both candidates were frontal facing; in the rest at least one was facing to the side. Except for transforming color images into a gray scale, the stimuli were not modified. Images were presented using video goggles (Resonance Technologies Inc.; http://www.mrivideo.com). The stimulus presentation and response recording was controlled by Cogent 2000 (Wellcome Department of Imaging Neuroscience; http://www.vislab.ucl.ac.uk/Cogent/index.html).

The study was conducted in the month before the 2006 election. An effort was made to avoid pairs in which one of the candidates (e.g. Hillary Clinton) had national prominence or participated in a California election, and familiarity ratings collected from all of the participants after the scanning task verified the stimuli were unfamiliar. On a scale of 1 (completely unfamiliar) to 7 (very familiar), the mean rating was 1.65 (s.d. = 1.03) for the Democratic candidates and 1.62 (s.d. = 0.98) for the Republican candidates.

Procedure. Participants were instructed that they would be asked to vote for real political candidates who were running against each other in the upcoming midterm election. In particular, they were asked to decide who they would be more likely to vote for given that the only information that they had about the politicians were their portraits.

Each trial consisted of three events (Figure 1A). First, a picture of one of the candidates was centrally presented for 1 s. Second, after a blank screen of length 1–10 s (uniform distribution), the picture of the other candidate in the pair

was presented for 1 s. Third, after another blank screen of length 1–10 s, the pictures of both candidates were presented side by side. At this point, participants were asked to cast their vote by pressing either the left or the right button. They had a maximum of 2 s to make a decision. Participants made a response within this time frame in 100% of the trials. Trials were separated by a 1–10 s blank screen. The order of presentation of the candidates as well as their position in the final screen was fully randomized between participants.

Neuroimaging data acquisition. Imaging data were collected on a Siemens 3.0-T Trio MRI scanner. Whole-brain, high-resolution $(1 \times 1 \times 1 \, \text{mm}^3)$ T1-weighted images were collected for each participant and coregistered with the mean functional, T2*-weighted images. For the fMRI data, we collected gradient-echo T2*-weighted echoplanar images with blood oxygenation level-dependent contrast using an interleaved, ascending image sequence (parameters: TR = 2.75 s, TE = 30 ms, field of view = 192 mm, 44 slices at 3 mm thick, 64×64 voxels, resulting in a voxel size of $3 \times 3 \times 3 \, \text{mm}^3$). We used a tilted acquisition, at $30°$ relative to the anterior commissure–posterior commissure line in order to achieve good signal in both the orbitofrontal cortex and subcortical regions. In addition, we used an eight-channel phased array coil that yields a 40% signal increase in OFC over the standard head coil.

Neuroimaging data analysis. All data analysis was performed using SPM5. We discarded the first five EPI images to allow for signal equilibration, applied slice-timing correction (centered at TR/2), realigned all volumes, spatially normalized a standard EPI template with a resampled isotropic voxel size of $3 \times 3 \times 3 \, \text{mm}^3$, spatially smoothed the data using a Gaussian kernel with FWHM of 8 mm and applied intensity normalization and high-pass temporal filtering (filter width 128 s).

We constructed regressors corresponding to the onsets of the images and additionally used six motion regressors. We used the lab vote share as a parametric modulator of the image onset regressor. The lab vote share is the fraction of our participant group who voted for the politician, and the negative lab vote share is simply this fraction subtracted from 1. In our first analysis, we used the positive lab vote share as a parametric modulator, and in our second analysis, we used the negative lab vote share as a parametric modulator. We applied linear contrasts within each participant, and took this to the random effects level using *t*-tests. To select statistically significant clusters, we applied an FWE-corrected threshold of $P < 0.05$ (see Supporting Information for details).

Study 2: trait judgments

Participants. Twenty-two Caucasian women (aged 20–35) participated in the study (note: none of these individuals participated in Study 1). At the time of the experiment, they were registered to vote and had voted in one or more of the following national elections: 2000, 2002 and/or 2004.

Participants had no history of neurological or psychiatric illness and were not on psychoactive medications. Participants had no prior knowledge of any of the political candidates whose images were used in the study and reported no recognition of any of the politicians. Neuroimaging data from six participants were rejected due to excessive motion. The behavioral data of the 16 participants included in the study did not differ significantly from those of six participants rejected for excessive motion. All procedures were approved by the Institutional Review Board at the California Institute of Technology.

Stimuli. Stimuli consisted of 60 grayscale images of smiling political candidates who ran in real U.S. elections for the House of Representatives or Senate in either 2000, 2002 or 2004 (30 pairs of opponents). The stimuli comprised a subset of those used in the 2005 study by Todorov *et al.* (2005), and were selected by three of the experimenters so that both images in an electoral pair (i) were frontal facing, (ii) were of the same gender and ethnicity and (iii) had clear, approximately central presentation of faces that were of approximately the same size. An electoral pair consisted of two images of candidates, one Republican and one Democrat, who actually ran against one another in a real election. Due to the racial/ethnic and gender composition of the original image library, all stimuli were of Caucasian politicians, and 8 of the 30 pairs were of female politicians. Stimuli were preprocessed to normalize overall image intensity while maintaining good image quality, across all 60 images. All images were presented centrally, via an LCD projector and a rear-projection screen, onto a mirror attached to the MRI head coil, approximately 10 inches from a participant's eyes. Stimuli subtended approximately $8°$ of visual angle. Stimulus control and response recording used the Psychophysics Toolbox v2.54 (Brainard, 1997; Pelli, 1997) in Matlab (the Mathworks, Natick, MA). A pilot behavioral study confirmed that the social judgments made about our selected stimuli were representative of the entire set of face stimuli from which they were drawn (the entire set used by Todorov *et al.* (2005).

Procedure. Participants were instructed that they would be asked to make judgments about real political candidates who ran against one another in real elections. They were told that they would only be given the images of the politicians to inform their judgments. Image order was counterbalanced across participants. Participants made judgments about candidates' attractiveness (Attr), competence (Comp), public deceitfulness (Dect) and personal threat (Thrt) in four separate scanning sessions. For threat judgments, participants were asked which candidate in a pair looked more likely to act in a physically threatening manner toward them (i.e. personal threat). For attractiveness judgments, participants were asked which candidate looked more physically attractive to them (i.e. personal attractiveness). For competence judgments, participants were asked which candidate looked more competent to hold national congressional office.

For public deceitfulness, participants were asked which candidate looked more likely to lie to the voters (i.e. public deceit). Each session took approximately 9 min to complete. Of 16 participants, six made personal threat decisions prior to making other decisions, while the remainder made personal threat decisions after making decisions about other attributes. There were no effects of block order.

Each trial in a decision block consisted of the sequential presentation of two images in an electoral pair, image A then image B, until a participant entered a decision about the pair via a button press (Figure 1B). This follows a protocol we have used successfully in prior studies of face preference (Kim et al., 2007). An A/B cycle on a given trial proceeded as follows: (i) central presentation of a fixation rectangle that surrounded the area in which an image was to appear; (ii) after 4–6 s, a 30 ms display of image A surrounded by the fixation box, accompanied by a small black dot in the lower left corner (indicating that this was image A); and (iii) after 3–4 s, a 30 ms display of image B surrounded by the fixation box, accompanied by a small black dot in the lower right corner (indicating that this was image B). Cycles were separated by 4–6 s and continued until a participant entered a button press or until 30 s had elapsed, whichever came first (no participant ever took the 30 s). Participants were asked to attend overtly to the space inside the rectangle in preparation for a candidate image. We used eyetracking (MRI-compatible Long-Range Optics Model, Applied Science Laboratories, Bedford, MA) to ensure that participants were looking at the stimuli. Trials that required just one A/B cycle for participants to make their judgment are referred to as one-cycle trials, those that required two cycles are two-cycle trials, and so on.

Behavioral data analysis. Participants primarily took two cycles to decide [76 ± 2% of trials were two-cycle trials (mean ± s.d. across 16 participants, all judgment conditions)]. There was not enough data from other types of trials to conduct a full random effects analysis, so only data from two-cycle trials were examined.

Correlations between social judgments. For each candidate and for each judgment, we first calculated the judgment share, which was just the proportion of participants who decided that candidate was more threatening, attractive, competent or deceitful. Using these values, we calculated Pearson correlation coefficients between the different social judgments that participants made.

Correspondence between social judgments and electoral outcome. We conducted two types of analyses, as done for previous studies (Todorov et al., 2005). To determine average individual association between judgments and real electoral outcome, we calculated the percent agreement between each participant's social judgments and electoral outcome, and then averaged across participants. A simple t-test allowed us to determine whether the mean individual association differed significantly from chance (50%). To determine the association between majority group judgment and real electoral outcome, we first counted which politician in a pair had the most participants naming them as attractive, competent, deceitful and threatening. We then calculated the percent agreement between this social judgment outcome and the signed electoral outcome (for instance, agreement between who was judged to look more competent and real-world election winning; or who was judged to look more threatening and real-world election losing). A χ^2 test finally determined whether majority associations were different from chance (50%).

Neuroimaging data acquisition. This was as for Study 1, except that $TR = 2$ s, and each EPI image had 34 slices at 4 mm thick.

Neuroimaging data analysis. All data preprocessing was done in SPM2 and analyses were conducted with SPM5 (Wellcome Department of Imaging Neuroscience, London, UK; http://www.fil.ion.ucl.ac.uk/spm/) (Friston et al., 2005). Preprocessing was identical to Study 1, except that we used a spatial smoothing filter of 6 mm FWHM.

We combined all four judgment conditions in one design matrix and proceeded in three steps. In the first step, we estimated a general linear model with AR(1). Second, we calculated first-level contrasts of group chosen (GC) vs group unchosen (GU) for each of the four judgment choices, and real-world election winner (RW) vs loser (RL), again for each of the four judgment conditions, as well as interactions between conditions. Finally, for each of these first-level contrasts, we calculated a second-level random effects contrast using a one sample t-test. To select statistically significant clusters, we applied an FWE-corrected threshold of $P < 0.05$ (see Supporting Information for details). Our analysis focused on the first cycle of the 2-cycle trials. We did this for two reasons: to maintain consistency with our first study and to maximize thin-slice conditions.

To examine second-level effects in Study 2 using activation ROIs from Study 1, we used the RFXPLOT toolbox for SPM5 (http://rfxplot.sourceforge.net/). We formed a mask to select all voxels inside a sphere (10 mm radius) for a given ROI from Study 1 [right insula: around (48, −3, −9); right anterior cingulate: around (3, 33, 9)]. We applied this mask to the individual first-level contrast images from participants in Study 2, selecting all voxels inside the mask (both sub- and suprathreshold) and calculated a mean ROI contrast for each participant. We used t-tests to determine whether the group mean contrasts were significantly different from zero.

SUPPLEMENTARY DATA

Supplementary data are available at SCAN online.

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