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Attitudes towards the outgroup are predicted by activity in the precuneus in Arabs and Israelis

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ABSTRACT

The modern socio-political climate is defined by conflict between ethnic, religious and political groups: Bosnians and Serbs, Tamils and Singhalese, Irish Catholics and Protestants, Israelis and Arabs. One impediment to the resolution of these conflicts is the psychological bias that members of each group harbor towards each other. These biases, and their neural bases, are likely different from the commonly studied biases towards racial outgroups. We presented Arab, Israeli and control individuals with statements about the Middle East from the perspective of the ingroup or the outgroup. Subjects rated how 'reasonable' each statement was, during fMRI imaging. Increased activation in the precuneus (PC) while reading pro-outgroup vs. pro-ingroup statements correlated strongly with both explicit and implicit measures of negative attitudes towards the outgroup; other brain regions that were involved in reasoning about emotionally-laden information did not show this pattern.

Introduction

A major modern political challenge is how to help members of different groups, especially following a history of conflict, live together in peace and equality. The challenge is exacerbated both by continuing conflict over physical and social resources, and by the psychological biases and hostility towards one another that the conflict has created. When two groups have been in conflict, prejudice, discrimination and open hostility can thrive. Social psychologists and cognitive neuroscientists have investigated the psychological and neural mechanisms of inter-group hostility, especially in the case study of White and Black Americans. However, in critical respects, the relationship between White and Black Americans in the early twenty-first century is unlike the relationships between other groups in ongoing ethnic, religious and political conflicts, such as Bosnians and Serbs, Tamils and Singhalese, Irish Catholics and Protestants, or Israelis and Arabs. We therefore set out to develop a neuroimaging measure of inter-group hostility in a very different context: the Arab–Israeli conflict in the Middle East.

White and Black Americans have a long and violent history of inter-group conflict, including hundreds of years of racially-determined slavery, followed by decades of discriminatory laws and social practices. For recent decades, though, overt discrimination and race-based violence have been illegal. Almost all White Americans explicitly disavow racism and advocate complete equality. Nevertheless, race continues to influence social decision-making by Americans, sometimes without their awareness. Even White adults who are explicitly egalitarian have "implicit associations" between Black men and hostility, violence, and threat. For example, in one task, participants see a photograph of a man holding either a gun or a cell phone, and must make an extremely fast decision whether to "shoot" (if the man is holding a gun) or withhold fire (if the man is holding a cell phone). In the lab, White participants (including professional police officers) shoot faster if the person holding the gun is Black, and mistakenly shoot a person holding a cell phone more often if they are Black (Plant and Peruche, 2005; Plant et al., 2005). In another study, participants are first taught to associate a photograph of a particular face with receiving a painful electric shock. Once the association is learned, the experimenter stops the delivery of the shock, and measures how long it takes participants to 'unlearn' their physiological fear and threat response to the (now completely safe) face. Under these conditions, it takes much longer to unlearn the negative association if the face is a Black man (Olsson et al., 2005).

The most widely used measure of "implicit associations" between a group and a characteristic (e.g. Black male and negative or threatening) is the Implicit Association Test (IAT) (Greenwald et al., 1998). In the IAT, words belonging to four categories (for example, good words, bad words, Black American names and White American names) appear sequentially. The participant then uses key presses to sort the words as quickly as possible into two compound categories (e.g. White names/good words vs. Black names/bad words). The IAT depends on the observation that White Americans make accurate sorting decisions faster when the category pairing is congruent with their implicit associations (e.g. White/good and Black/bad) than when the pairing is incongruent (e.g. White/bad and Black/good). The implicit associations revealed by the IAT are not necessarily conscious or endorsed by the participants. IATs have been

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used to assess implicit bias towards groups defined by race, gender and political partisanship, among others (Aberson et al., 2004; Greenwald et al., 2003; Knutson et al., 2007; Phelps et al., 2000).

Racial categorization even affects the very earliest stages of social perception: recognizing people's faces and facial expressions. White Americans are better at remembering, and recognizing, photographs of White than Black faces (Meissner and Brigham, 2001). Even the very same face, a morph made 50% of a White face and 50% of a Black face, is better remembered if it was described as belonging to a White person than a Black person (Shutts and Kinzler, 2007). At the same time, White participants are more likely to erroneously 'see' anger (but not other emotions) in affectively neutral Black faces relative to White faces (Maner et al., 2005), and more readily perceive anger in videos of Black faces that are engaged in dynamic emotional displays (Hugenberg and Bodenhausen, 2003).

Psychological research thus suggests that White Americans, while explicitly endorsing egalitarian values, nevertheless implicitly perceive Black people (especially Black men) as threatening and bad. Correspondingly, neuroimaging studies have reported differential neural activity when White participants look at Black, compared to White, faces — both in brain regions involved in basic social perception, and in brain regions involved in threat detection. For example, in White participants, activity in the fusiform face area (Kanwisher et al., 1997), a region involved in face perception, is lower when viewing Black than White faces (Golby et al., 2001b). On the other hand, activity in the amygdala, a region associated with fear learning and threat detection (LeDoux, 2007; Zald, 2003), is higher when viewing Black than White faces (Cunningham et al., 2004; Hart et al., 2000; Lieberman et al., 2005; Phelps et al., 2000). In these studies, activity in the amygdala is correlated, across individuals, with the participants' implicit associations, measured by the IAT, but not with their explicit attitudes towards Black people (Cunningham et al., 2004; Phelps et al., 2000).

White and Black Americans thus provide the most extensively studied example of the psychological and neural bases of inter-group biases (Golby et al., 2001a; Meissner and Brigham, 2001; Sangrigoli et al., 2005). However, these examples may not provide a good basis for generalizing to groups currently involved in open ethnic, religious or political conflict, such as Hutus and Tutsis in Rwanda, Tamils and Singhalese in Sri Lanka, Israelis and Arabs in the Middle East. First, most previous neuroimaging studies have focused on face perception. In many ongoing conflicts, members of the two groups cannot be distinguished by facial appearance alone, and instead are distinguished by abstract, invisible properties: religion, family background, and language. Second, unlike most White Americans, who are explicitly egalitarian and experience strong normative pressure against hostility or discrimination, in ongoing conflicts hostility towards the other group is explicitly endorsed and even deliberately enhanced by social norms. Third, the content of the psychological biases in ongoing conflicts may be different, going beyond simple negative associations and threat. Escalation and perpetuation of conflict often reflects higher-level biases about the thoughts, motivations and beliefs held by the outgroup (Bar-Tal, 2000). Each group's perception of the other is characterized by lack of trust, suspicion of motives, and failures of empathy (Hewstone et al., 2002). People see the other group's ideological views as ignorant, biased or irrational (Ehrlinger et al., 2005; Ross and Ward, 1995, 1996). Arabs and Jews in the U.S., for example, each consider the others' personal experience a source of bias rather than enlightenment when considering issues relating to conflict in the Middle East, but perceive their own personal experience as enlightening rather than biasing (Ehrlinger et al., 2005). These psychological effects can have important consequences: when choosing strategies to resolve conflict, people who perceive the other as biased and irrational are more likely to choose punitive strategies such as sanctions and armed conflict, rather than cooperative interventions like negotiation (Kennedy and Pronin, 2008).

In sum, prior neuroimaging research on inter-group social perception is hard to generalize to the inter-group hostility characteristic of many current ongoing conflicts. As a first step to address this gap, we therefore developed a task that would elicit, in a relatively natural context, some of the psychological biases that members of conflict groups hold towards one another. Specifically, we were interested in the perception that the other side's beliefs are ignorant, biased or irrational. This aspect of inter-group hostility is interesting because (a) practical experience suggests that it is a key sticking point in inter-group dialogue programs (Fisher, 2001; Kelman, 1998) and (b) prior neuroimaging research has identified a group of brain regions robustly recruited when people think about someone else's thoughts and beliefs (Ciaramidaro et al., 2007; Gallagher et al., 2000; Gobbini et al., 2007; Ruby and Decety, 2003; Saxe and Kanwisher, 2003; Vogeley et al., 2001). These regions include right and left temporo-parietal junction (TPJ), precuneus (PC) and posterior cingulate cortex (pCC), and regions in medial prefrontal cortex (mPFC), sometimes collectively called the "Theory of Mind network".

In the current experiment, Israeli and Arab participants read short verbal opinions or arguments about the situation in the Middle East, drawn from letters to the editor and opinion articles. While in the scanner, participants were asked to judge not whether they agreed with each stated opinion, but only whether the opinion was "reasonable". Judgments from control (i.e. White American) participants confirmed that the pro-Israeli (anti-Arab) and pro-Arab (anti-Israeli) opinions were equally "reasonable" from an external perspective. We predicted that hostility between members of groups in conflict would be reflected in judgments that opinions favoring the other group are unreasonable, and in differential activation in one or more brain region within the "Theory of Mind network."

Materials and methods

Participants

Participants who were recruited to do a study on 'social cognition in people from different cultural backgrounds' gave written informed consent in accordance with the requirements of the internal review board at MIT prior to participation in the study. Participants were adults between 18 and 36 years old (mean 25.1), from 3 groups: Jewish Israeli ($n=16$, mean age 29.0), non-Israeli Arab ($n=16$, mean age 21.5), or control (neither Arab, Muslim, Jewish nor Israeli) ($n=13$, mean age 24.6). All Arab and Israeli participants were born outside of the United States and all control participants were born in the United States. Arab participants had lived in the U.S. for 5.5 years $\pm$ 7.0 s.d. and Israeli participants had lived in the U.S. for 3.6 years $\pm$ 8.1. Arab participants were born in Lebanon ($n=6$), Egypt ($n=1$), Saudi Arabia ($n=3$), Kuwait ($n=1$), Jordan ($n=2$) and Syria ($n=2$) (1 Arab participant did not answer this survey question). Israeli participants were all born in Israel, except 2 participants (1 born in Bulgaria, one born in Russia) who emigrated to Israel as children. 4/15 Arab participants and 5/14 Israeli participants reported having at least one close friend or relative from the other group (1 Arab and 2 Israeli participants did not answer this survey question). Of the participants who responded to a question about the 'ethnic group [they] most strongly identify with', all 15/15 Arab participants reported 'Arab' or an Arab culture, and 9/12 Israelis reported 'Israeli' or 'Jewish'. All groups were similar in their political leaning (ranked on a 9 point Likert-scale from (1) liberal to (9) conservative): control, mean = 2.86 $\pm$ 1.2 s.d.; Arab, 2.56 $\pm$ 1.1; and Israeli, 2.54 $\pm$ 1.4. Participants were given the opportunity to withdraw their data from the study at any time (no participants did so), and were given compensation and fully debriefed at the end of the experiment.

Behavioral measures

Questionnaire

Prior to coming in for the fMRI study, participants filled out an online questionnaire, which included personality measures from the Meyers–

Table 1
Representative examples of stimuli for each condition.

Nonemotional (control)	Emotional (control)	Emotional (pro-Israeli/anti-Arab)	Emotional (pro-Arab/pro-Israeli)
"Watermelon is a perfect fruit: it keeps you hydrated and it is loaded with antioxidants like vitamins C and A. It is also a fantastic source of amino acid citruline, which helps your body heal it's wounds, lower your blood pressure, and protect against stroke."	"New Orleans was a city that had its doors wide open to the public celebration of sin, and the citizens of New Orleans tolerated and welcomed this sin for too long. God destroyed New Orleans with hurricane Katrina because of this wickedness."	"Palestinians have wasted 60 years. In that amount of time they could have developed a country next to Israel and together with Israel they could be experiencing a strong economic and modern country, but instead they chose violence."	"Like South Africa's apartheid regime, Israel seeks to relegate its majority indigenous population to the status of non-citizen in their own homeland, through a combination of armed terror and racist segregation laws."

Briggs Personality Inventory, the Balanced Emotional Empathy Scale (Mehrabian, 1997) and survey questions about Black and White Americans. Embedded in the personality questions and questions about U.S. ethnic groups were a series of 'feeling thermometers' (FTs) anchored at 0 ('very cold/unfavorable') and 10 ('very warm/favorable'). A difference score was determined by subtracting the rating for 'Arab Muslims' from the rating for 'Jewish Israelis', yielding a range of −10 ('pro-Arab') to +10 ('pro-Israeli').

Implicit association test

Following fMRI imaging, each subject performed an Arab–Israeli implicit association test (IAT). The IAT consisted of 8 words from each of 4 categories: Arab–Muslim names, Israeli–Jewish names, good words and bad words. The words and names were presented in the center of the screen in random order and subjects were required to sort the words and names as quickly as possible into two combined categories: either Arab names/good words vs. Israeli names/bad words or Arab names/bad words vs. Israeli names/good words. Participants were instructed to respond as fast and as accurately as possible. Each category pairing was tested twice in each participant. Since most participants did not have English as their first language, between-subject variance in reaction times was high. Negative attitudes to the outgroup were therefore measured as percent differences in reaction time (RT) between pro-Israeli (Israeli/good vs. Arab/bad) and pro-Arab (Israeli/bad vs. Arab/good) category pairings, as follows: $IAT\% = 100 \times (Avg\_RT\_Pro\_Israeli - Avg\_RT\_Pro\_Arab)/(Avg\_RT\_All)$. A positive score indicates a pro-Israeli implicit bias and a negative score indicates a pro-Arab implicit bias. *D*-scores were also computed for each participant (Greenwald et al., 2003).

Behavioral pilot data

The statements used in the study were collected from editorials, letters to the editor, blogs and websites and were designed to fit into 4 conditions (16 statements per condition): statements related to the conflict between Israel and neighboring Arab countries from a partisan Arab perspective (average statement length 38.8 ± 7.9 words (s.d.)), statements about the conflict from a partisan Israeli perspective (34.5 ± 7.0 words), control statements unrelated to the Arab/Israeli conflict that were emotionally salient and unreasonable (31.8 ± 8.6 words) and control statements unrelated to the conflict that were nonemotional and reasonable (37.0 ± 9.2 words) (Table 1; see Supplemental data for a full list of stimuli).

To test the validity of the stimuli, the pro-Israeli, pro-Arab, emotional control and nonemotional control statements, presented in pseudo-random order, were given to Israelis and Palestinians living in the Middle East as an online survey. The link to the survey was distributed by bloggers and professors in Israel, and by word of mouth in Palestine. Anonymous volunteers were asked to judge the 'reasonableness' of each statement on the following scale: 'very unreasonable (1)–(2)–(3)–(4) very reasonable'. Average responses for each statement type were calculated for each person. A response of >3.0 was categorized as 'reasonable' and <2.0 was categorized 'unreasonable'. As expected, the vast majority of Israelis (67/71) judged the pro-Israeli statements as 'reasonable' (mean: 3.2 ± 0.46 s.d). All Palestinians (10/10) judged the same statements to be 'unreasonable' (1.2 ± 0.18; $d(79) = 11.8$, $p < 0.0001$). At the same time, most Israelis (65/71) judged pro-Arab statements to be unreasonable (1.7 ± 0.53), and all Palestinians (10/10) judged the same statements to be reasonable (3.7 ± 0.13; $d(79) = 13.1$, $p < 0.0001$). Emotional control statements were rated as unreasonable by all Israelis (1.64 ± 0.31) and all Palestinians (1.39 ± 0.30), and nonemotional control statements were rated as reasonable by all Israelis (3.0 ± 0.35) and all Palestinians (2.9 ± 0.18) (Fig. 1A). These results verify that the partisan stimuli were judged differently by the two groups, while the control stimuli were not.

fMRI experiment

Participants in the fMRI study in the U.S. were asked to rate the 'reasonableness' of each of the 64 statements while they were in the scanner with 4 buttons: 'very unreasonable' (1)–(2)–(3)–(4) 'very reasonable'. Average responses to each condition were determined for each individual. Overall results for each participant were transformed

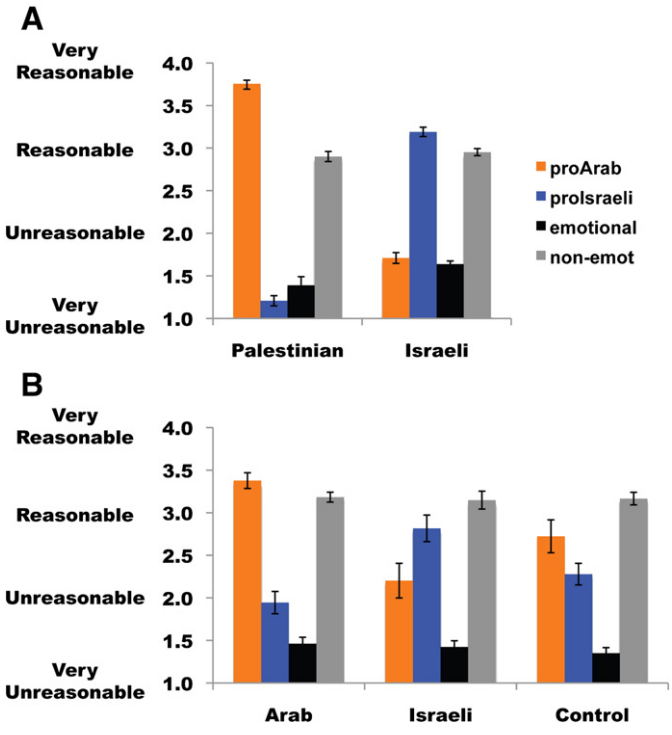


Fig. 1. Average 'reasonableness' ratings for each statement type. Pro-Arab and pro-Israeli, and emotional and nonemotional control statements unrelated to the Middle East (16 of each statement type), were presented in pseudo-random order and rated by (A) Israelis and Palestinians living in the Middle East in an online survey and (B) Israelis, Arabs and control (non-Arab, non-Israeli, non-Jewish and non-Muslim) participants living in the U.S. during neuroimaging. Israelis and Arabs in the U.S. were more moderate in their reasonableness ratings of pro-Arab and pro-Israeli statements than Israelis and Palestinians living in the Middle East, but still differed significantly from each other. Reasonableness ratings for all participants in both regions were similar for emotional and nonemotional statements that were unrelated to the conflict in the Middle East.

into a difference score by subtracting the reasonableness score for the pro-Arab statements from the reasonableness score for the pro-Israeli statements, yielding a range of −3 (pro-Arab) to +3 (pro-Israeli). A subset of the Israelis (3/16) and one Arab (1/16) rated outgroup statements as more reasonable than ingroup statements.

From the perspective of the participant, each statement was presented on a screen for 16 s, and during the last 4 s of the presentation a response prompt was presented at the bottom of the screen. A run consisted of two statements from each condition (pro-Israeli, pro-Arab, emotional control and nonemotional control) presented in pseudo-random order and separated by 10-second fixation periods (3.6 min per run, 8 total runs).

Image acquisition

Structural and functional data were collected on a 3 Tesla Siemens scanner at the Athinoula A. Martinos Imaging Center at the McGovern Institute for Brain Research at the Massachusetts Institute of Technology. A high-resolution isotropic T1-weighted MPRAGE sequence (TR/TE/T1/flip angle = 3.25 ms/3 ms/1.1 s/7°) provided 176 contiguous sagittal slices with imaging matrix = 256×256 in plane resolution and slice thickness of 1 mm. Functional MRI images were acquired using a gradient echo sequence (TR/TE/flip angle = 2 s/30 ms/1.1 s/90°). Thirty near axial functional images with 4 mm slice thickness (voxel size 3.125×3.125×4.0) were collected from head to foot.

fMRI data analysis

The fMRI data were analyzed with SPM2 (http://www.fil.ion.ucl.ac.uk/spm) and custom software. Individual subjects' data was realigned, normalized to a standard template in Montreal Neurological Institute (MNI) space, and then smoothed with a 5 mm smoothing kernel. A linear model was used to model BOLD activity of each subject as a function of condition. Noise regressors were included for effects of run, and a high-pass filter (128 s) was used to exclude low-frequency drift.

Whole brain random effect analyses

Brain regions showing reliable differences between control conditions were identified through second level, random-effects analyses.

Functional regions of interest analyses

To avoid non-independence errors (Saxe et al., 2006; Vul et al., 2009), functional regions of interest (ROIs) were found by determining brain activity in each subject in response to an orthogonal contrast (emotional statements unrelated to the Middle East–nonemotional statements unrelated to the Middle East). Clusters of $k>10$ contiguous voxels ($p<0.0001$, voxel-wise, uncorrected), within 9 mm of the peak voxel were used. For all ROIs, percent signal change (PSC) was averaged across items within a condition (pro-Israeli statements and pro-Arab statements), and across voxels within the ROI. The average responses by condition for the pre-defined intervals during which the statements were presented (corresponding to presentation of the stimulus, correcting for hemodynamic lag) were then analyzed within each subject and compared to explicit and implicit measures of outgroup negativity obtained outside of the scanner.

Results

Behavioral results: fMRI study

Israeli participants rated pro-Israel statements (mean = 2.8 ± 0.16 SEM) as more reasonable than Arab participants did (1.9 ± 0.13, $t(30) = 5.3$, $p<0.001$); and Arab participants rated pro-Arab statements (3.4 ± 0.09) as more reasonable than Israeli participants did (2.2 ± 0.20, $t(30) = 4.3$, $p<0.001$) (Fig. 1B). The responses by Israeli and Arab fMRI participants were more moderate than the pilot data gathered from Israelis and Palestinians living in the Middle East, particularly among Israeli participants, but still indicate an ingroup bias for members of both groups. Control participants judged the pro-Israeli and pro-Arab statements comparably: on average, pro-Israeli statements were rated slightly unreasonable (2.3 ± 0.13 SEM) and pro-Arab statements were rated slightly, but not significantly, more reasonable (2.7 ± 0.19; $t(12) = 1.8$, $p = 0.09$).

All participants (Arabs, Israelis and control) responded similarly for control statements: emotional control statements were rated as unreasonable by Israelis (1.4 ± 0.07 SEM), Arabs (1.5 ± 0.08) and control participants (1.4 ± 0.07; $p>0.25$ for all group-wise comparisons), and nonemotional control statements were rated as reasonable by Israelis (3.1 ± 0.10), Arabs (3.2 ± 0.06) and control participants (3.2 ± 0.08; $p>0.25$ for all group-wise comparisons).

fMRI results: random-effects analysis of control contrast for all participants

To perform unbiased region of interest analysis, we first identified candidate brain regions involved in emotion-laden reasoning, using the control emotional and nonemotional statements. The (emotional–nonemotional) contrast ($p<0.0001$, uncorrected, $k>10$) revealed brain regions previously implicated in social cognition, including the precuneus (PC), posterior cingulate cortex (pCC), left and right temporo-parietal junctions (TPJ) extending into the inferior parietal cortices, medial prefrontal cortex (mPFC) and dorsomedial prefrontal cortex (dmPFC). Additionally, activation was seen in the medial sensory motor area (SMA), left orbitofrontal cortex, right premotor cortex, and right dorsolateral prefrontal cortex (dlPFC) (Fig. 2). These ROIs were examined in individual subjects. Six of the regions could be identified in at least half of the individual Arab and Israeli subjects and were used in ROI analysis: the PC (identified in 27/32 subjects), pCC (23/32), dmPFC (18/32), mPFC (16/32), rTPJ (19/32) and lTPJ (17/32).

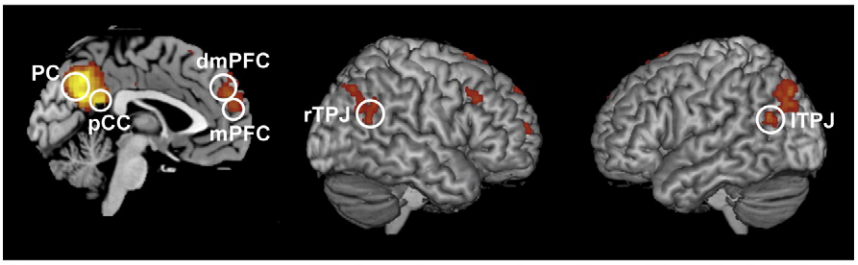
Random effects analyses were also performed separately for Arab and Israeli participants for the emotional–nonemotional, pro-Arab–pro-Israel and pro-Israel–pro-Arab contrasts (Supplementary Fig. 1).

fMRI results: ROI analysis of Arab and Israeli participants

If a region of interest generated by the orthogonal task could be identified within an individual, the percent signal change (PSC) in that region was determined for each condition. To obtain a single neural 'bias' measure for each participant and each brain region, a PSC difference score was determined by subtracting the PSC while reading pro-Israeli statements from the PSC while reading pro-Arab statements (PSC(Ar–Isr)). For each region, we asked first whether the response in the two participant groups (Arabs vs. Israelis) differed on average.

ROI analysis by groups

In each brain region, the PSC difference in activity was calculated in each individual and then averaged by group. Since these brain regions were defined by the contrast (emotional–nonemotional), we hypothesized that PSC would be lower for pro-ingroup and higher for pro-outgroup stimuli. Thus the difference in PSC, pro-Arab–pro-Israeli, should be positive for Israelis and negative for Arabs. In the PC, activity in Arab participants was lower for pro-Arab than pro-Israeli statements (PSC(Ar–Isr) = −0.24 PSC ± 0.17 s.d.), as predicted. In Israelis and control participants, the average PC response was not different for pro-Arab vs. pro-Israeli stimuli (Israelis: −0.029 ± 0.09; control −0.070 ± 0.15) (Fig. 3 and Supplemental Fig. 2). Overall, the response in the PC to the partisan stimuli depended on the participant's group membership (Group × Condition interaction, $F(2,35) = 8.6$, $p = 0.001$). The lTPJ showed a similar but weaker pattern. In Arabs, the response in the LTPJ was lower for pro-Arab than pro-Israeli statements (PSC(Ar–Isr): −0.18 ± 0.18). In Israelis and control



Region	Voxel coordinates			T value	Cluster Size	ROI identified	
	x	y	z			Arab	Israeli
Precuneus (PC)	-8	-66	28	8.16	2745	14	13
Posterior cingulate (pCC)	2	-50	22	7.68	(in PC)	14	9
Dorsomedial prefrontal (dmPFC)	-2	52	30	5.13	342	12	6
Medial prefrontal (mPFC)	4	56	20	5.18	(in dmPFC)	10	6
L. temporoparietal junction (lTPJ)	-58	-62	22	5.91	51	10	7
R. temporoparietal junction (rTPJ)	58	-54	32	4.82	58	9	10
L. inferior parietal	-36	-28	42	5.76	252		
R. inferior parietal	42	-70	42	4.84	82		
Medial sensorimotor	8	18	70	5.44	23		
R. premotor	46	24	36	5.08	60		
R. dorsolateral prefrontal	28	62	16	4.46	13		
L. orbitofrontal	-32	20	-22	5.67	35		

Fig. 2. Whole brain random effects for control contrast. Group analysis of all participants for (emotional–nonemotional statements) contrast. Thresholding was done at $p<0.001$ with $k>10$. Region, peak coordinates, statistical Z score and cluster size are indicated in the table, along with the number of Arab and Israeli participants in which each ROI was defined. All regions associated with 'Theory of Mind' (PC, pCC, left and right TPJ, dmPFC and mPFC) were identified in a majority of the 32 partisan (Arab and Israeli) participants.

participants, the average lTPJ response was not different for pro-Arab vs. pro-Israeli stimuli (Israelis: -0.02 ± 0.14; control -0.09 ± 0.07). The response in the lTPJ showed a trend to depend on group membership (Group × Condition interaction, $F(2,23)=2.6$, $p=0.09$). None of the other ROIs tested showed a significant Group by Condition interaction.

ROI activity within individuals

Next, we tested whether the difference in response in each brain region to outgroup vs. ingroup statements was correlated across individuals with explicit and implicit measures of differences in attitudes toward the outgroup vs. the ingroup.

The explicit measure we used was the "feeling thermometer". As expected, Israeli participants were generally warm towards Israelis and cold towards Arabs (mean difference score, 3.1 ± 0.5 SEM). The opposite was true for Arabs (-4.3 ± 0.9, between-subjects t-test, $t(29)=-7.0$, $p<0.001$). Control participants were slightly, but not significantly, warmer towards Arabs than towards Israelis (-0.3 ± 0.2, one-sample t-test, $t(12)=-1.6$, n.s., Fig. 4A).

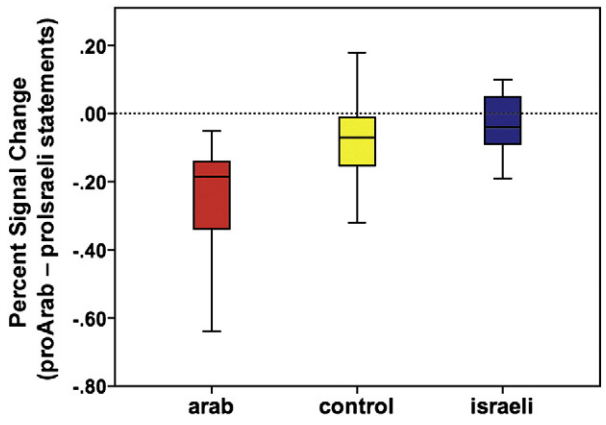


Fig. 3. Region of interest analysis of the precuneus (PC), defined in each participant by the control (emotional–nonemotional statements) contrast. Percent signal change (PSC) responses in the PC to pro-Arab–pro-Israeli statements were averaged by group. Horizontal bars in the box plots indicate mean, upper and lower box limits indicate s.d. and whiskers indicate 95% confidence intervals. In the PC there was a significant Group × Condition interaction, and Israeli participants had significantly greater activity in the PC for pro-Arab–pro-Israeli statements than did Arabs.

Implicit attitudes towards outgroup members were assessed using an IAT test. Israeli IAT scores were pro-Israeli (mean = 25.5% difference in RT ± 3.4% SEM), and Arab IAT scores were pro-Arab ($-10.8\%\pm3.0$, between-subjects t-test, $t(30)=-8.0$, $p<0.0001$). Control participants were intermediate between Arab and Israeli participants, but had a significant pro-Israeli bias ($13.1\%\pm4.3$, one-sample t-test, $t(11)=2.7$, $p<0.05$, Fig. 4B).

Interestingly, scores for warmth and IAT were strongly correlated in Arabs (Pearson $r=0.71$, $p<0.005$), but were uncorrelated in Israelis (Pearson $r=-0.01$, $p>0.9$) and control participants (Pearson $r=0.37$, $p>0.2$).

Individual behavioral responses to the explicit measure ('Warmth') and the implicit measure ('IAT') of attitudes toward the outgroup were used as regressors in each ROI. When all Arab and Israeli subjects were considered, we found a significant correlation between the PSC difference in the PC and the difference scores in Warmth (Pearson $r=0.64$, $p<0.001$; 95% confidence interval 0.37–0.91) and IAT (Pearson $r=0.70$, $p<0.001$; 95% confidence interval 0.46–0.95) (Figs. 5A, B). When calculated as a D-score (Greenwald et al., 2003), IAT and PC correlation was similar (Pearson $r=0.69$, $p<0.001$). When considered as separate groups, PSC difference in the PC correlated in Arabs with IAT (Pearson $r=0.56$, $p<0.05$, two-tailed) but not with warmth (Pearson $r=0.25$, $p=0.38$), and in Israelis with warmth (Pearson $r=0.52$, $p<0.05$, one-tailed) but not with IAT (Pearson $r=0.20$, $p=0.52$).

In the lTPJ and pCC, the PSC(Ar–Isr) difference was correlated with warmth when Arab and Israeli participants were considered together (LTPJ Pearson $r=0.50$, $p=0.05$; pCC Pearson $r=0.44$, $p=0.04$), but not for the separate groups, and the response in these regions was not correlated with the IAT scores. In all other ROIs, there were no significant correlations between PSC difference and either IAT or warmth difference scores.

Discussion

In this study we presented Arab and Israeli participants with statements (e.g. letters to the editor) of partisan views and measured the BOLD response with fMRI imaging. Whole brain analysis showed increased activity in the "Theory of Mind" brain network: PC, pCC, mPFC, dmPFC, lTPJ, rTPJ, as well as the bilateral inferior parietal cortex,

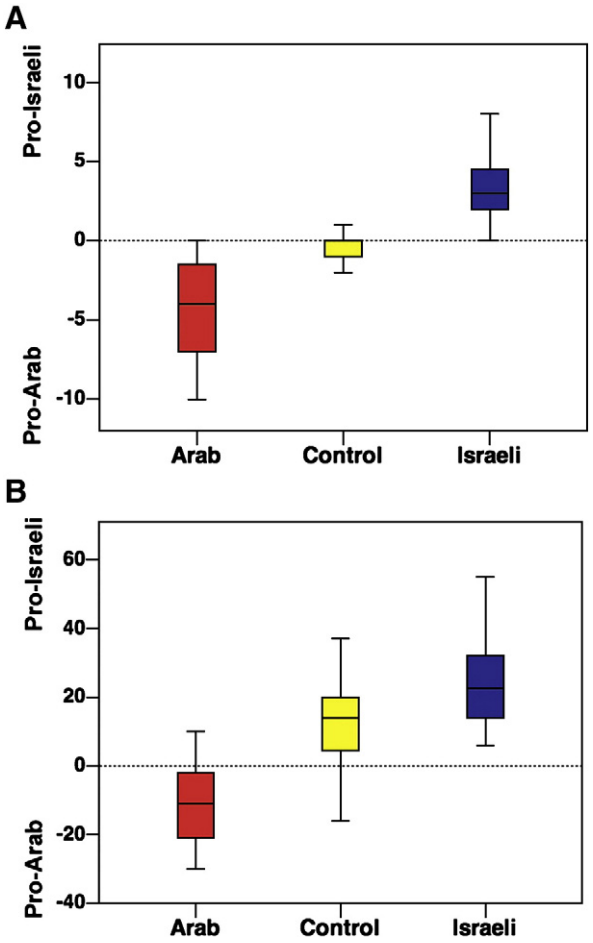


Fig. 4. Average responses to behavioral measures by group. For warmth, a higher positive number indicates higher warmth rating for Israelis than for Arabs; for the implicit association test (IAT), higher positive numbers indicate faster reaction times to Israeli name/good word and Arab name/bad word (pro-Israeli) category pairings than to Israeli name/bad word and Arab name/good word (pro-Arab) category pairings. For the IAT, differences are expressed as the difference in RT divided by the overall average RT. Box plots indicate mean, s.d. and 95% confidence intervals. As expected, on average Arab participants were pro-Arab on both explicit and implicit measures, and Israelis were pro-Israeli on both explicit and implicit measures; control participants were slightly (but non-significantly) pro-Arab explicitly, and slightly and significantly pro-Israeli implicitly.

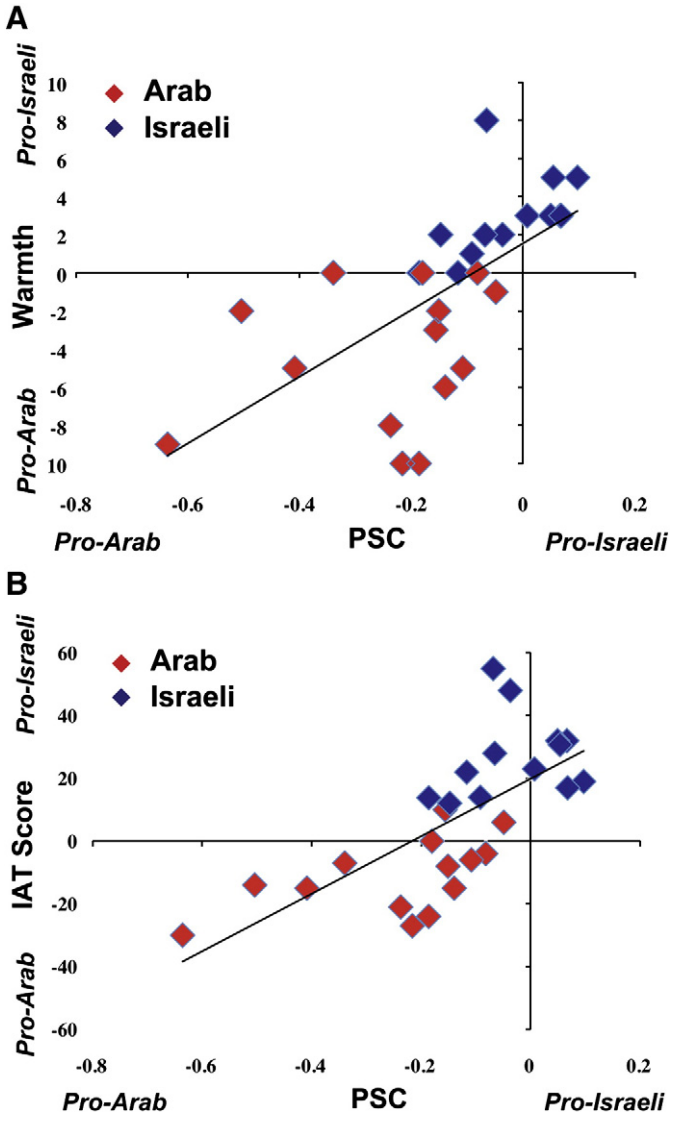


Fig. 5. Percent signal change (PSC) difference scores in the Precuneus (PC) for pro-Arab–pro-Israeli statements correlate with behavioral difference scores. For each participant, activity in the PC was determined using ROI analysis while rating the reasonableness of pro-Arab and pro-Israeli statements, and the difference in PSC while evaluating pro-Arab and pro-Israeli statements was determined. This activity was then compared to the explicit and implicit difference scores indicating pro-Arab and pro-Israeli responses on behavioral measures. For all scores, positive numbers indicate pro-Israeli and negative scores indicate pro-Arab. (A) PC activity (PSC(Ar–Isr)) compared to warmth (Ar–Isr). (B) PC activity (PSC(Ar–Isr)) compared to IAT (prolsr–proAr). Israeli participants are indicated by blue dots and Arab participants are indicated by red dots. In partisan participants (Arabs and Israelis), activity in the PC was highly correlated both with explicit warmth (Pearson $r = 0.64$, $p < 0.001$), and implicit bias (IAT) (Pearson $r = 0.70$, $p < 0.001$).

medial SMA, right premotor, right dlPFC and left orbitofrontal cortex, when participants were evaluating the reasonableness of emotionally salient statements vs. innocuous statement. Of these regions, only the PC (1) was reliably recruited during emotion-laden reasoning in most individual subjects, (2) differentiated between pro-ingroup and pro-outgroup statements across groups, and (3) was correlated with negative attitudes towards the outgroup across individuals.

Behaviorally, Arab and Israeli fMRI participants showed a strong ingroup bias in evaluating the reasonableness of the partisan statements, but nevertheless were more moderate than pilot Palestinian and Israeli participants tested in the Middle East. This difference could be due to selection effects at immigration (more moderate people may be more likely to visit or move to the U.S.), or be caused by the experience of living in the U.S. (e.g. greater access to members of the outgroup, and reduced salience of the conflict experience). Also, while all of the pilot Arab participants were Palestinians, the Arab participants in the fMRI experiment were drawn from across the Arab world. The Israeli–Palestinian conflict is a key lens through which non-Palestinian Arabs view interactions with the West, but the conflict itself is still less immediate for non-Palestinian Arabs. For all these reasons we assume that the effects that we show here would be more extreme in Israelis and Palestinians living in the Middle East.

The results reported here make contributions to 2 separate areas: implicit assessments of inter-group associations and social cognitive neuroscience of inter-group attitudes.

Implicit assessments

The IAT was introduced as an assessment tool a decade ago (Greenwald et al., 1998) and has since been used in hundreds of studies, especially assessing negative associations with negatively stereotyped outgroups (Nosek et al., 2005). Many of these studies have shown a similar pattern: people tend to be explicitly pro-outgroup (or egalitarian) but

implicitly pro-ingroup. Consequently, implicit and explicit measures of one group (e.g. White Americans) towards another group (e.g. Black Americans, the elderly) are not correlated (Greenwald et al., 2003). An exception is political groups, where explicit and implicit measures consistently show very high correlations ($r>0.7$) (Greenwald et al., 2003). Interestingly, in the few studies where neuroimaging has additionally been done, individual brain activity correlates with the IAT, but not with explicit measures (Cunningham et al., 2004; Phelps et al., 2000). The authors have interpreted these results as evidence that normative pressures against prejudice in the U.S. cause White participants (or young participants) to respond explicitly in a pro-Black (or pro-elderly) manner, while implicit tests (and neuroimaging) reveal hidden biases that still exist.

Our results suggest that in conflict situations, explicit and implicit measures can be highly correlated. Unlike White and Black Americans, residents in the Middle East experience few if any normative pressures to reduce hostility towards the outgroup. In fact, many textbooks in the Middle East, in both Arab and Israeli schools, blatantly vilify the outgroup (Bar-Tal, 1999; Podeh, 2002). Our Arab participants, on average, reported explicit pro-ingroup (and anti-outgroup) attitudes that were highly correlated with their implicit pro-ingroup associations; this is similar to the high implicit and explicit attitude correlations observed among political partisans (Greenwald et al., 2003). By contrast, our control participants showed the pattern predicted by normative pressures: a weak pro-Arab bias on explicit judgments (both warmth, and "reasonableness" of the partisan statements), a weak pro-Israeli/anti-Arab bias on implicit measures, and no correlation between the two kinds of measures, across participants. Interestingly, although Israeli responses on both explicit and implicit measures were pro-Israeli, there was no correlation between them. Future work will be required to determine the role that normative pressures in Israeli society may play in dissociating explicit and implicit negativity towards Arabs.

Neuroimaging

In this study we found brain activity in a number of brain regions that have traditionally been associated with social reasoning, but in only the PC were individual differences in brain activity correlated with both implicit and explicit measures of outgroup antipathy (see Supplementary material for discussion of separate group-level analyses). The region of activation in individual participants is distinct from the pCC and corresponds with Brodmann Area 31.

These results fit well with previous work implicating the PC in emotional reasoning. For example, PC activation has been reported when participants make difficult moral judgments of harmful actions (Farrow et al., 2001; Greene et al., 2001). Our results also converge with the only other study, to our knowledge, that attempted to examine how partisanship affects reasoning (Westen et al., 2006). In this study, committed Democratic and Republican participants read about apparent contradictory statements made either by (Republican president) George W. Bush or (Democratic presidential candidate) John Kerry. When faced with contradictory statements made by their own candidate (relative to neutral control individuals), there was increased activity in the medial prefrontal cortex (mPFC) and the precuneus (PC).

While our work is consistent with previous work implicating the PC in emotional/motivated reasoning, the PC is also implicated in a number of processes, including episodic memory retrieval, visuo-spatial and mental imaging, self-reflection, and theory of mind (Buckner and Carroll, 2007; Cavanna and Trimble, 2006; Fletcher et al., 1995; Ishai et al., 2002; Spreng et al., 2009; Wagner et al., 2005); future work will need to narrow down hypotheses about the cognitive process that this activation reflects.

Conclusion

The majority of previous work in inter-group bias has focused on basic cognition (e.g. face perception). Here we demonstrate that neural activity related to biases in higher-level cognition can be measured in members of conflict groups. We found that the activity in the precuneus (PC) correlated strongly with both explicit and implicit behavioral measures of negative attitudes toward the outgroup. To our knowledge, this represents the first neuroimaging study to investigate cognitive biases in members of conflict groups.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.neuroimage.2010.05.057.

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