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Supplemental Information

Racial Bias Reduces

Empathic Sensorimotor Resonance

with Other-Race pain

Alessio Avenanti, Angela Sirigu, and Salvatore M. Aglioti

Supplemental Results

Modulation of Motor-Evoked Potential (MEP) Amplitude during Observation of Others' pain

Figure S1 illustrates MEP contrasts (pain – touch) in Whites and Blacks participating in the main TMS experiment (Figure S1A) and in the violet model experiment (Figure S1B).

Table S1 reports raw MEP amplitudes recorded from participants' first dorsal interosseus (FDI) and abductor digiti minimum (ADM) muscle (main experiment). Inspection of raw MEPs indicates that all the effects obtained in the ANOVA on MEP contrasts (pain – touch) are driven by the lower amplitude recorded from the FDI (target) muscle when watching ingroup models' pain relative to all the other conditions. No modulation was found in the ADM muscle (control) that was not involved in the painful or tactile stimulation.

MEP amplitudes across conditions were higher in the FDI than in the ADM muscle; this simply reflects the lower threshold (higher excitability) of the FDI motor representation [S1]. Note that the absence of significant modulation of MEPs recorded from the ADM muscle when watching pain on the (ingroup) models' FDI cannot be accounted for by a lower reactivity of the ADM motor representation. Rather, this selectivity reflects a body-part-specific pain resonance effect. Previous research has shown that when videos depict the ADM penetrated by a needle, a selective inhibition of this muscle can be detected [S2,S3].

Evaluation of Qualities of Ingroup and Outgroup Models' pain

After the TMS experiment, subjects were presented with all the videos and then asked to judge sensory and affective qualities of the pain supposedly felt by the ingroup and outgroup models by means of the Italian version [S4] of the McGill pain Questionnaire (MPQ) [S5], that includes sensory (1-10, 17-19) and affective items (11-15, 20). While the MPQ is classically used for testing sensory-discriminative and emotional components of one's own pain, previous studies have used this questionnaire to evaluate perception of others in pain [S2,S6-S9]. It may be relevant that in previous studies exploring observation of pain in others, we have demonstrated that sensory MPQ subscales tend to be related to subjective evaluation of the intensity of the pain

ascribed to the person in pain, while affective MPQ subscales are linked to unpleasantness judgments [S8], providing thus convergent validity for the use of MPQ in the assessment of pain in others.

MPQ sensory and affective pain ratings were compared by means of a mixed model ANOVA with Onlooker group (White, Black) as between-subjects factor, and Model (ingroup, outgroup) as within-subjects factors. The ANOVA on MPQ sensory scores failed to reveal any significant effect ($Fs < 1.45$, $Ps > 0.23$; see Table S2). The analysis of the affective score showed a non-significant trend for higher ratings in Black participants ($F_{1,33} = 3.45$, $P = 0.08$) but no main effect of Model or Onlooker group x Model interaction ($Fs < 1.77$, $Ps > 0.19$). Thus, the lack of sensorimotor contagion for the pain of outgroup models cannot be due to a reduced appraisal of their pain.

Similar findings were obtained in the eight participants tested with the violet model video-clips. After the TMS session and the MPQ measurement, these participants were presented with all the pain videos and asked to rate the intensity of the pain ascribed to the three models during needle penetrations, by marking a vertical, 10-cm visual analogue scale (VAS) with 0 cm indicating 'no effect' and 10 cm 'maximal effect imaginable'. A mixed-model ANOVA was used to analyze VAS ratings. Also in this subsample of subjects, ingroup specific sensorimotor contagion did not depend on differences in the pain attributed to the different models. Indeed, the Onlooker group x Model ANOVA on VAS pain intensity judgments showed no significant effect ($Fs < 0.49$, $Ps > 0.62$), with similar rating for ingroup (6.5 ± 1.5), outgroup (6.2 ± 1.2) and the violet model's pain (6.0 ± 1.1).

Dispositional Empathy as Revealed by the Interpersonal Reactivity Index (IRI)

After the MPQ assessment, trait empathy was measured in the two groups by means of the Italian version [S10] of the IRI [S11] (see Table S3). The two groups of participants scored similarly on both emotional empathy as measured by the Emotional Concern (EC, $t_{34} = -1.38$, $P = 0.18$) and Personal Distress subscales (PD, $t_{34} = -1.24$, $P = 0.22$), and on cognitive empathy as measured by the Perspective Taking (PT, $t_{34} = 0.93$, $P = 0.36$) and the Fantasy scale (FS, $P = 0.39$).

Dispositional Empathy and Sensorimotor Reactivity to Others in pain

A regression analysis was performed to investigate the relation between dispositional empathy and corticospinal reactivity to others in pain. Only reactivity to ingroup models' pain was explored since no significant modulation was found for the outgroup model. Scores in the four subscales of the IRI were entered as predictors in a standard regression model where MEP contrast (pain – touch) recorded from the FDI muscle during the observation of stimulations on the ingroup models' hand was the dependent variable. The model approached the significance after the removal of 3 outliers with standard residual > 2σ ($R = 0.53$, $F_{4,30} = 2.66$, $P = 0.054$). The only independent predictor was the IRI FS ($\beta = -0.49$, $t_{27} = -2.45$, $P = 0.021$), a cognitive empathy scale assessing the ability to imaginatively transpose oneself into others' feelings and actions in fictional situations (e.g. when watching a movie) [S11]. The negative relation indicates that participants who scored high in FS showed greater sensorimotor contagion. This finding is

in line with previous TMS [S8], MEG [S12] and fMRI [S13] studies on neurotypical and Asperger syndrome individuals [S7] showing a relation between cognitive empathy and sensorimotor response to others' pain. Thus, convergent evidence supports the notion that cognitive empathy may shape sensorimotor resonance phenomena [S14-S16].

Skin Conductance Response (SCRs) during Observation of Ingroup and Outgroup Stimulations

An Onlooker group (White, Black) x Model (ingroup, outgroup) x Type of stimulation (touch, pain) ANOVA on amplitude of SCRs did not reveal any main effect ($F_{1,30} = 2.40$, $P = 0.13$) or interaction with factor Onlooker group ($Fs < 0.30$, $Ps < 0.58$), indicating that Blacks and Whites showed similar SCRs. Hence, data were collapsed across this factor. The Model x Type of stimulation ANOVA on SCRs amplitude revealed only a significant main effect of Type of stimulation ($F_{1,31} = 6.12$, $P = 0.019$) with higher amplitude (greater emotional reactivity) during the observation of pain relative to touch (Figure S2A). No main effect of Model ($F_{1,31} = 0.29$, $P = 0.59$) or interaction with factor Model was found ($F_{1,31} = 0.10$, $P = 0.75$), suggesting that greater emotional reaction to pain stimuli was comparable for ingroup and outgroup members.

An additional analysis was conducted on SCRs latency (Figure S2B). The Onlooker group x Model x Type of stimulation ANOVA on SCR latency revealed no main effect of Onlooker group ($F_{1,30} = 0.43$, $P = 0.52$) or interaction of this factor ($Fs < 1.11$, $Ps < 0.30$), indicating that Blacks and Whites showed similar SCR latencies. Therefore, data were collapsed across the Onlooker group factor. The Model x Type of stimulation ANOVA revealed only a main effect of Model ($F_{1,26} = 6.09$, $P = 0.021$) with shorter latencies for ingroup relative to outgroup models. No main effect of Types of stimulation ($F_{1,26} = 2.33$, $P = 0.14$) or interaction Model x Types of stimulation was found ($F_{1,26} = 0.21$, $P = 0.65$). These findings indicate that emotional reactivity to ingroup models' stimulations (both pain and touch) occurred earlier than to outgroup models' stimulations.

Changes in Heart Rate (HR) Related to Observation of Ingroup and Outgroup Stimulations

Changes in HR during the observation of the different categories of stimuli were analyzed by means of an Onlooker group (White, Black) x Model (ingroup, outgroup) x Type of stimulation (touch, pain) x Time window (early, late) ANOVA. The analysis did not reveal any significant main effect ($F_{1,30} = 1.08$, $P = 0.31$) or interaction with factor Onlooker group ($Fs < 2.89$, $Ps > 0.10$), indicating that Blacks and Whites showed the same changes in HR. Hence, data were collapsed across this factor. The Model x Type of stimulation x Time window ANOVA on HR data revealed a significant main effect of Type of stimulation ($F_{1,31} = 5.54$, $P = 0.025$) with lower HR values during observation of pain relative to touch (Figure S3A). The HR deceleration indicates pain stimuli brought about a greater orienting response than touch stimuli [S17,S18]. Greater attention for pain stimuli was present in both time windows and it was comparable for both ingroup and outgroup members (as indicated by the absence of significant interactions between Type of stimulation and factors Time window or Model; $Fs < 2.70$, $Ps > 0.11$).

No main effect of Model or Time window was found (*Fs* < 0.36, *Ps* > 0.55). However, the ANOVA showed a significant Model x Time window interaction ($F_{1,30}$ = 8.21, *P* = 0.007) (Figure S3B) that was entirely accounted for by the lower HR (i.e. greater orienting response) in the earlier time window (0-4 sec) when observing ingroup than outgroup models (*P* = 0.03); moreover, HR response to ingroup models in the earlier time window was significantly lower than HR response to ingroup models in the later time window (4-8 sec) (*P* = 0.005). No other significant effects were found (*Ps* > 0.12). These findings indicate that in the early time window (0-4 sec) watching stimulations (both touch and pain) on ingroup members was associated to a greater attentional response than watching stimulations on the outgroup members.

Dispositional Empathy and Magnitude of Autonomic Reactivity to Others' pain

Since the magnitude of autonomic reactivity to painful stimulations on ingroup and outgroup models was comparable (Figure S2A and S3A), SCRs and HR data for the two models were averaged. Then, each measure was entered as dependent variable in a regression model with IRI subscales as predictors.

The regression model for the SCRs was marginally significant after the removal of 1 outlier (*R* = 0.53, $F_{4,26}$ = 2.55, *P* = 0.063). There were two independent predictors of changes in SCRs, namely the FS (β = -0.63, t_{26} = -2.94, *P* = 0.007) and the EC (β = 0.53, t_{26} = 2.41, *P* = 0.023). FS is a cognitive empathy IRI subscale assessing the tendency to imaginatively transpose oneself into others' feelings and actions, and EC is an emotional empathy subscale assessing the tendency to feel sympathy and compassion for others in need [S11]. The relation between EC and SCRs during pain observation is in keeping with the notion that dispositional sympathy is associated with higher emotional reactivity to others' pain [S19]. The negative relation between FS and SCRs may be linked to the relation between FS and MEP contrast. Taken together these results suggest that the onlookers who are prone to identify with others' tend to show greater sensorimotor response to others' pain and at the same time, less emotional reactivity. These findings suggest that the tendency to identify with others and mentally simulate their sensory states may imply a suppression of emotional reactivity. Interestingly, people who report high aversion and distress when watching pain stimuli show less sensorimotor contagion [S8]. All in all, these findings indicate that the vicarious experience of others' pain implies both sensorimotor and emotional components; these components are under the opposite influence of cognitive disposition and emotional reactivity.

The analysis carried out on HR data did not reach the statistical significance (*R* = 0.31, $F_{4,26}$ = 0.68, *P* = 0.61, 1 outlier removed).

Racial Bias and Differential Autonomic Reactivity to Racial Groups

While the size of autonomic response to observed pain was similar in both outgroup and ingroup models, differential responses to the observation of stimuli on the two models were found when considering the time course of autonomic reactivity.

In particular, SCR latency data suggest that emotional reactivity to ingroup models' stimulations (both touch and pain) occurred earlier than to outgroup models (Figure S2B). Similarly, HR data

indicate greater orienting response to ingroup relative to outgroup models' stimulations (both touch and pain) in an early but not in a later phase of HR recording (Figure S3B).

We explored the relations between autonomic bias and Race Implicit Association Test (IAT) by computing two indices of autonomic reactivity similar to that used for the analysis of MEPs (see main text). For the SCRs, an index reflecting the temporal advantage for the ingroup model was computed by subtracting the latency of SCRs recorded when seeing stimuli delivered to the outgroup model from the latency of SCRs during perception of ingroup model (ingroup – outgroup). For the HR, we computed a similar index (ingroup – outgroup) by considering only the early time window in which seeing the two models was associated to a differential orienting response. These two SCRs and HR indices were entered as dependent variable in two standard regression analyses with Race IAT score as predictor.

We found that individuals with high level of racial bias presented greater orienting response to ingroup relative to outgroup members in the early time window ($r = 0.42$, $P = 0.026$, 3 outliers removed).

In contrast to HR, no relation between the SCR latency index and the IAT was found.

Relations between Orienting and Sensorimotor Contagion

Like MEP data (Fig. 2) the IAT predicted different orienting to ingroup and outgroup models (see previous paragraph). This finding may suggest that the lack of sensorimotor contagion for the pain of the outgroup model (Fig. 1, Fig. 3), is linked to a reduced attention to outgroup models' stimulations. To test this possibility we carried our an additional correlational analysis between HR and MEP indices of racial bias (computed as ingroup – outgroup). We found that racial bias orienting index (HR) was not related to racial bias resonant corticospinal inhibition index ($r = -0.11$, $P = 0.54$). This suggests that orienting responses do not predict the ingroup bias in sensorimotor contagion as indexed by modulation of corticospinal excitability. Therefore, it is unlikely that attentional effects *per se* can explain the lack of sensorimotor reactivity to the pain of outgroup individuals found in our study.

Visual Familiarity and Physical Similarity with the Self

At the end of the violet model experiments, VAS were used to measure participants' ratings of visual familiarity with the three models' hand and the physical similarity of the observed hands with respect to their own hand (see Fig. 3b).

The Onlooker group (White, Black) x Model (ingroup, outgroup, violet) ANOVAs performed on VAS ratings showed no main effect of Onlooker ($Fs < 0.41$, $Ps < 0.55$) or interaction between factors ($Fs < 1.69$, $Ps < 0.23$) indicating that Whites and Blacks reported similar familiarity and similarity judgments for the three models. Thus, two repeated-measure ANOVAs were performed on VAS ratings across groups.

The ANOVA on visual familiarity judgment revealed an effect of Model ($F_{2,14} = 53.77$, $P < 0.0001$) which was entirely accounted for by the lower familiarity ratings obtained for the violet

model compared to the ingroup and outgroup models (*Ps* < 0.0002) which in turn did not differ from one another (*P* = 0.73).

The ANOVA on physical similarity of the observed hand with respect to the self hand also revealed a significant effect of Model ($F_{2,14}$ = 38.56, *P* < 0.0001) accounted for by the higher similarity ratings for the ingroup model relative to the other two models (*Ps* < 0.0002); moreover, the outgroup model was perceived as more similar to the self than the violet model (*P* = 0.008).

These findings indicate that the violet model was perceived as the least familiar and similar to the self.

Table S1. Raw Mean MEP Amplitude (SD) in mV

FDI muscle				ADM muscle			
touch ingroup	pain ingroup	touch outgroup	pain outgroup	touch ingroup	pain ingroup	touch outgroup	pain outgroup
2.68 (1.83)	2.22 (1.31)	2.55 (1.88)	2.71 (1.79)	1.21 (1.00)	1.05 (0.74)	1.28 (0.98)	1.32 (1.10)

Table S2. Pain Qualities Attributed to the Ingroup and Outgroup Models

	MPQ sensory qualities (range 0-54)		MPQ affective qualities (range 0-19)	
Model:	ingroup	outgroup	ingroup	outgroup
White participants:	20.1± 2.5	19.3 ± 1.9	3.6 ± 0.9	3.6 ± 0.6
Black participants:	22.0 ± 2.4	25.1 ± 2.7	5.4 ± 1.0	6.2 ± 1.0

Mean (± s.e.m.) values of the sensory and the affective scores of the MPQ.

Table S3. Dispositional Empathy in Whites and Blacks

IRI subscale:	EC	PD	PT	PD
White participants:	18 ± 6	12 ± 5	19 ± 6	17 ± 5
Black participants:	20 ± 4	14 ± 7	18 ± 4	19 ± 6

Mean (± st.dev.) values of the different subscale of the IRI

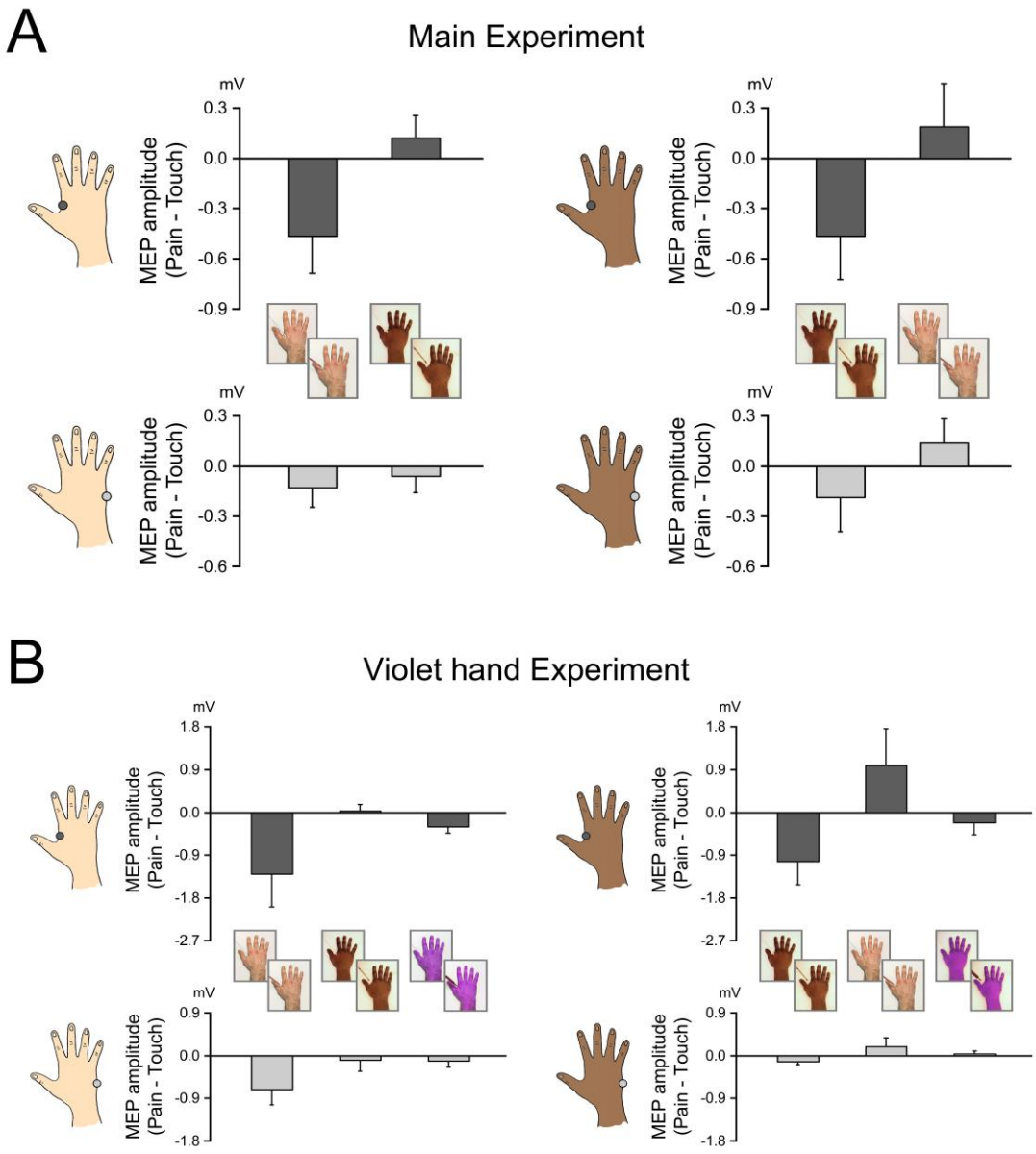

Figure S1. Sensorimotor Contagion in the Two Onlooker Groups
MEPs contrasts (pain – touch) recorded from the FDI and the ADM muscles of White (left) and Black (right) participants.
(A) Main Experiment.
(B) Violet hand Experiment.

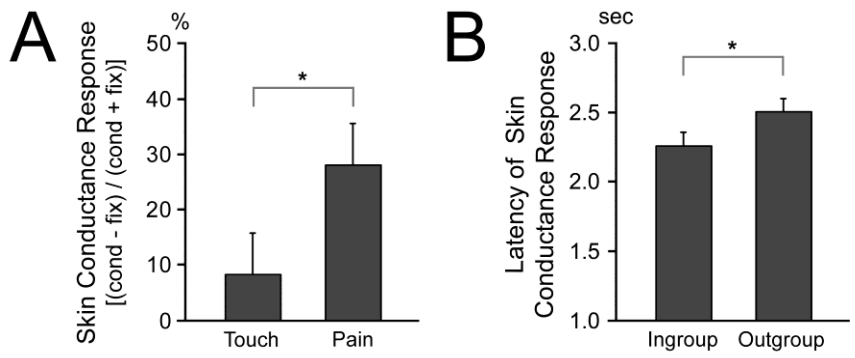

Figure S2. Emotional Reactivity as Revealed by Skin Conductance Responses (SCRs)
(A) The ANOVA on amplitude of SCRs revealed only an effect of Type of Stimulation, indicating that SCRs amplitude was higher for pain relative to touch stimuli.
(B) The ANOVA on latency of SCRs revealed only an effect of Model with shorter latencies for ingroup relative to outgroup members. SCR latencies were lower for ingroup relative to outgroup models. Bars indicate s.e.m. * $P < 0.05$.

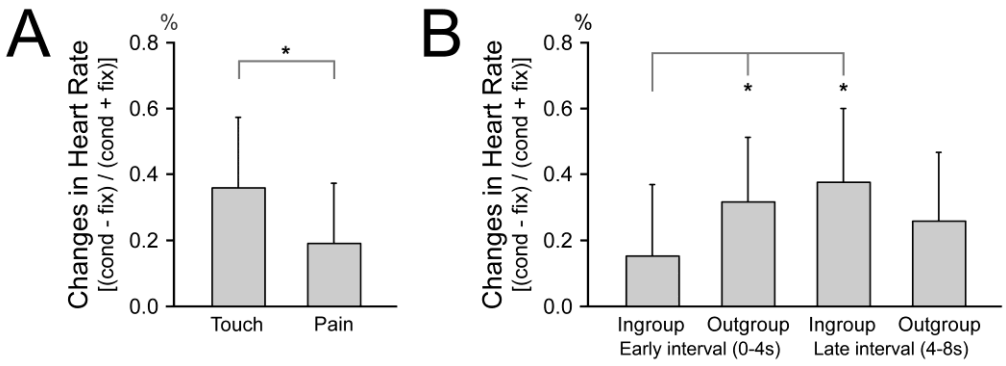

Figure S3. Attentional and Orienting Response as Revealed by Changes in Heart Rate (HR)
(A) The ANOVA on HR revealed an effect of Type of stimulation: watching pain led to lower HR than watching touch stimuli.
(B) The interaction Time window x Model was also significant. Watching pain and touch stimulations on the body of ingroup members was associated to a greater attentional response in the early observation phase. Bars indicate s.e.m. * $P < 0.05$.

Supplemental Discussion

Sensorimotor Contagion

The basic features of the form of embodied resonance with others' pain we have called sensorimotor contagion [S2,S3] are confirmed in the present research. In keeping with previous studies [S2,S3,S6-S8, S20-S22], watching needles deeply entering a given muscle of a model's hand brought about a suppression of MEPs recorded from the onlookers' very same muscle. The inhibition of motor representations has also been reported in subjects who feel pain [S23-S26] thus hinting at the similarity of the mechanisms underlying direct and vicarious experience of pain [S16]. The activation of pain-related neural representations when watching others in pain is reminiscent of the 'resonant' activations called into play when sharing motor [S15, S27], emotional [S28] and somatic representations [S29] and it is in keeping with the notion that the vicarious experience of others' feelings may rely on mirror-like simulative neural mechanisms [S16, S30-S32].

Importantly, in our experiment, the inhibition of the onlookers' muscle which was observed penetrated in the model (FDI) did not extend to a control muscle (ADM) with contiguous motor representation [S33]. The specific inhibition of the muscle vicariously involved in the painful stimulation indicates that the resonant mapping of others' pain occurred according to somatotopic rules. This topographical inhibitory effect reflects a genuinely resonant, body-part specific phenomenon rather than a differential reactivity of the two muscles *per se* for at least two reasons: i) we have demonstrated that when videos depict the ADM penetrated by a needle, similar corticospinal inhibition of this muscle has been observed [S2, S3], ii) in this study, we used the ADM optimal scalp position and thus maximized the probability of observing its modulation.

The somatotopic inhibition of corticospinal representations during the direct observation of others' pain may reflect sensorimotor contagion, i.e. an automatic embodiment of sensory qualities of pain (location [S2, S3, S6-S8, S21, S22], diffusion [S6] and intensity [S2, S3, S6-S8] of the noxious stimulus) onto the observers' corticospinal motor system. The recruitment of sensorimotor areas in empathy for pain is well in keeping with imaging evidence that shows activity in somatosensory and fronto-parietal areas when watching others in pain [S34-S39] and with neurophysiological evidence that seeing pain in others modulates the coherence of magnetoencephalography sensorimotor gamma band [S40], the power of sensorimotor alpha oscillations [S12] and the amplitude of somatosensory-evoked potentials [S41] and laser-evoked potentials [S42]. Taken together these studies indicate that the vicarious experience of others' pain relies upon the activity of not only emotional but also sensorimotor bodily representations.

Race-Related Modulation of Sensorimotor Contagion

The group-specific reduction of sensorimotor contagion during observation of outgroup members' pain provides neurophysiological foundation to the notion of a low reactivity to outgroup members' bodily feelings [S43-S44]. Previous studies [S2, S3, S6-S8, S20-S22] indicate that the somatotopic inhibition of corticospinal representations during the direct observation of others' pain may reflect the embodiment in the onlooker corticospinal system of

sensory qualities of pain ascribed to the model. Although automatic and low-level, this vicarious mapping of others' pain is permeable to higher order factors such as cognitive empathic traits which are shown to modulate cortical motor excitability during observation of others' pain [S7, S8; present study]. The most novel result of this report is that such a low-level mapping is reduced by racial stereotype and prejudice. Although the relationship between racial bias, state- and trait empathy and sensorimotor contagion may be complex, one may ask whether education to empathy may influence both racial bias and sensorimotor contagion. Theoretically, high empathy should increase sensorimotor contagion. Future studies using MEP measures have to address this outstanding question.

It is worth noting that, while suppression of empathy and reduction of neural activity in specific brain areas may index closure to social influences, this mechanism may be adaptive under specific circumstances. Studies demonstrate, for example, that expert acupuncturists [S37] and physicians [S45] who observe pain in others show reduced blood-oxygen-level-dependent (BOLD) signal [S37] and electrocortical activity [S45] with respect to non expert controls. These results suggest that controlling neural and physiological reactivity is crucial for regulating the distress of seeing others in pain.

Early versus late Orienting to Ingroup Individuals

The early differential orienting (as indexed by HR change and latency of SCRs) to ingroup individuals may seem at odds with previous studies suggesting that perception of outgroup members yields to immediate and automatic reactions that tend to be more visceral and affective than reactions to ingroup members [S46-S50]. It is relevant that all the above studies explored neural, autonomic, and behavioral response to same- vs. other-race faces with eye-gaze directed at the observer. It is well known that people selectively attend to threat stimuli [S51] and studies indicate other-race faces with direct eye-gaze can be perceived as a potential threat [S52, S53]. Notably, this attentional bias toward outgroup faces is eliminated when cues signaling potential threat are removed, such as when the face is presented with adverted eye-gaze [S53] or displays an expression of joy [S54].

In this study we found an opposite autonomic reactivity pattern, namely greater orienting (Figure S3) and more immediate emotional response (Figure S2) during observation of stimulations (both pain and touch) applied to ingroup than outgroup members. A possible explanation for this seeming discrepancy may reside in the fact that the effects were found for both touch and pain and were not specifically linked to threat. Thus, in our study, the early reactivity to ingroup individuals may simply signal that 'something is happening to someone who is like me'. Moreover, the relation between changes in HR and Race IAT would suggest that people with greater racial bias automatically perceive events occurring in ingroup as more salient than those occurring to outgroup members.

Supplemental Experimental Procedures

Participants

Eighteen White-Caucasian (8 men, mean age 25 years, range 20-28) and eighteen Black-African (8 men, mean age 26 years, range 19-32) subjects were tested in two experimental sessions (psychophysiology, TMS) at the IRCCS Fondazione Santa Lucia in Rome. All the Black participants were born in Africa (Burundi, Rwanda, Congo, Gabon, Angola, Senegal, Cameroon) and, at the time of testing, they had been living in Italy for a minimum of 4 years. All subjects were right-handed university students and all were fluent in Italian. None of the participants had neurological, psychiatric, or other medical problems or had any contraindication to TMS [S55]. The protocol was approved by the ethics committee of the Fondazione Santa Lucia and was carried out in accordance with the ethical standards of the 1964 Declaration of Helsinki. Participants gave their written informed consent to take part in the study and received a reimbursement for their participation. No discomfort or adverse effects were reported or noticed in any of the subjects.

Visual Stimuli

In both TMS and psychophysiological sessions, different types of video clips were presented on a 19-inch screen located 80 cm from the subjects. The video-clips showed the following: (i) a Q-tip gently touching the skin overlaying the right FDI muscle of a White model's hand; (ii) a needle deeply penetrating the FDI muscle of the same White model's hand; (iii) a Q-tip gently touching the FDI muscle of a Black model's hand; (iv) a needle deeply penetrating the FDI muscle of the Black model's hand. Eight subjects were tested in two additional visual conditions (see violet models section). Previous TMS studies report that observing moving body parts brings about an increase in corticospinal excitability [S56, S57] and that observing a hand using tools elicits activation of the primary motor cortex [S58]. To avoid such effects in the present pain study, we made sure that no hand movements were evoked by the view of pinprick stimuli. We also made sure that the syringe holder was not visible in any of the videos.

Procedure

The experiment was run in two separate days. On the first day subjects took part in a psychophysiological experiment and completed a Race IAT; on the second day they participated in the TMS experiment and provided subjective evaluations (pain ratings, dispositional empathy and explicit racial attitudes).

The psychophysiological experiment was programmed using Presentation (http://www.neuro-bs.com/). The TMS experiment was programmed using Psychophysics Toolbox (www.psychotoolbox.org/) and Matlab (www.mathworks.com) software to control sequence and duration of video clips, and to trigger TMS and EMG recording.

Of the original 36 participants, 2 Black subjects (1 male) did not participate in the psychophysiological experiment while another Black woman did not take part to the TMS experiment; two White women were discarded from the psychophysiological experiment due to

technical failure. Thus, data from 35 (18 White) and from 32 subjects (16 White) were analyzed in the TMS and the psychophysiological experiment, respectively.

Psychophysiological Session

In the psychophysiological session, skin conductance response (SCR) and electrocardiogram (ECG) signals were sampled at 1kHz and recorded with a MP35 System (BIOPAC, U.S.A.). The ECG was amplified by 1000 and band-pass filtered (0.05Hz-150Hz). The SCR was amplified by 2000 and low-pass filtered (35Hz). ECG was measured from two Ag/AgCl electrodes placed adjacently on the participant's fifth intercostal space. SCR was measured using a constant voltage (0.5V) with two Ag/AgCl electrodes placed on the volar surface of the distal phalanges of the left index and middle fingers.

The psychophysiological session included three runs. Each run started with a short block of 4 sec fixation cross trials and a 16-trials dynamic block showing the different types of video-clip in a randomized order. In each run, the clips were organized in sets of four movies (pain and touch to Black and White models) presented in across-subjects counterbalanced order. Each fixation cross trial lasted for 2,800 msec. Each trial in the dynamic block began with a fixation cross (1,000 msec duration) followed by a video-clip (1,800 msec). A 10 sec blank screen was showed in the inter-trial interval.

SCRs and HR measures were used to assess emotional reactivity and attentional and orienting responses to ingroup and outgroup models. SCR and ECG signals were analyzed off-line by algorithms developed in Matlab. The SC signal was digitally low-pass filtered at 1Hz (5^{th} order digital Butterworth filter). We considered valid SCR only those with amplitude higher than 0.01 μS and latency between 1s after the video-clip onset and 3s after the end of the movie. The SCR magnitude (i.e. mean SCR computed across all trials of the same condition including those without a measurable response) was scored for each movie category (in μS). A logarithmic transformation (log[SCRvalue+1]) was performed to reduce skewness.

The ECG signal was digitally band-pass filtered (5Hz-50Hz, 4^{th} order digital Butterworth filter). Peak detection algorithm based on first derivative and amplitude threshold was used for locating the R-waves. Inter-beat-intervals (IBI) were estimated from R-R interval series and re-sampled at 0.25Hz by cubic spline interpolation. Mean heart rate (HR) for each trial was calculated in the interval ranging from 0 to 8 s after movie onset (in bpm).

TMS Session

In the TMS session, pairs of Ag/AgCl electrodes were placed over the right FDI (in the region of the index finger) and ADM (in the region of the little finger) muscles in a belly-tendon montage. MEPs were recorded by means of Viking IV (Nicolet biomedical, U.S.A.) electromyograph. EMG was sampled at 10kHz and band-pass filtered (20Hz-2.5kHz). A figure-of-8 coil connected to a Super Rapid Transcranial Magnetic Stimulator (Magstim, U.K.) was placed over the optimal scalp position (OSP) for inducing MEPs in the ADM muscle. Pulse intensity was set at 130% of the resting motor threshold [S1] computed on the higher threshold muscle. This way a stable signal could be recorded from both muscles. Importantly, previous studies suggest that

modulations due to pain observation are independent from the chosen OSP [S2, S3], at least when the two recording muscles have a contiguous motor representation in the cortex. The absence of voluntary contraction before the TMS pulse was continuously verified visually and, prior to the recording session, by auditory monitoring of the EMG signal.

In the TMS session, each type of video-clip was presented in a separate 18-trials block (dynamic block). The order of the four dynamic blocks was randomized. Previous research [S2, S3, S6-S8, S20-S22] demonstrates that this block-design paradigm is adept to explore the corticospinal response to others' pain. In each block, a central cross (1,000 msec duration) indicated the beginning of a trial, and initiated EMG recording. The duration of each video was 1,800 msec. In each trial, a magnetic pulse was randomly delivered between 200 and 600 msec before the end of the movie to avoid any priming effects that could affect MEP size. A black screen was shown for 7.2 sec in the intertrial intervals. The choice of a long intertrial interval was based on a study demonstrating that TMS delivered for 1 h at 0.1 Hz frequency did not induce any change in excitability [S59].

Experimental Instruction

In both autonomic and TMS sessions participants were instructed to keep the arms relaxed and pay attention to the movies. To probe spontaneous response to the different types of videos no empathizing instruction was provided. Subjects were warned that at the end of each block (TMS exp) or run (psychophysiological exp) they would be asked questions about the movies. The precise instructions were: "Try to keep your arms relaxed throughout the experiment. Watch and pay attention to all the video-clips. At the end of each block or run we will ask you questions about the stimuli shown on the screen."

After each block and run, there was a short pause so the experimenter could ask questions about the movies. Questions involved age (young vs old) and gender (male vs female) of the model as well as perceptual features of the syringes or Q-tips (color of the liquid – red, pink, brown – or of the Q-tip handle – blue, white, yellow). In all subjects accuracy was high (> 95%) and comparable across conditions and groups.

Subjective Data

Sensory and affective pain qualities ascribed to the different models were collected at the end of the TMS experiment using the Italian version [S4] of the MPQ [S5]. After pain ratings, emotional and cognitive empathy traits in Black and White participants were assessed by means of the Italian version [S10] of the IRI [S11]. After MPQ and IRI, a post-experimental interview was conducted to explore explicit racial attitudes. The interview was based on the Italian version [S60] of the Subtle and blatant prejudice scale [S61].

Implicit Association Test

To evaluate implicit race-related attitudes, participants completed a computer-administered Race version of the IAT [S62,S63]. The Implicit association tests provide a measure of the strength of automatic association between different concepts in memory. In particular, the Race IAT

measures the association between target racial categories (e.g. Italian, African) and attributes (positive, negative). In the present version of Race IAT, exemplars of target-categories (i.e. African and Italian faces) appeared on a screen and subjects were asked to rapidly classify them by pressing one of two keys (e.g., 'd' for Italian, 'k' for African). In a similar vein, attributes categories (e.g. positive and negative words) were presented on the screen and subjects were asked to classify them by pressing the two response keys. In one critical block (a), categories and attributes were classified by pressing the same set of keys (e.g., 'd' for Italian faces and negative words vs. 'k' for African faces and positive words). In the other critical block (b), the complementary pairing was used (i.e., Italian faces were paired with positive words and African faces with negative words). A difference in overall speed between the two blocks is taken to indicate the direction and magnitude of association between category and attribute [S62]. In the IAT, easier pairings (and faster responses) are interpreted as being more strongly associated in memory than more difficult pairings (slower responses). For example, faster responses when Italian and positive (and African and negative) are paired than when African and positive (and Italian and negative) are paired reflect a more positive association with Italian than with African [S62]. Two reversed sequences were presented to the subjects: Black participants first completed sequence (a)+(b) and then sequence (b)+(a). White participants first completed sequence (b)+(a) and then sequence (a)+(b). The two sequences were presented on the first day immediately before and after the psychophysiological session. Data were analyzed using the improved IAT scoring algorithm recommended by Greenwald et al. (2003) [S63]. The IAT scores obtained for each sequence were averaged to calculate the participant's final IAT *D* score. For both groups *D* scores greater than zero suggest an automatic preference for ingroup relative to outgroup racial members. Results are shown in the main text.

Explicit Racial Bias

The ad-hoc semi-structured interview took place in the final debriefing phase after the IRI questionnaire. We capitalized on the Italian version [S60] of the Subtle and blatant prejudice scale by Pettigrew and Meertens [S61] by selecting the questions that are adept to tap explicit prejudice toward outgroup. Participants were asked to answer to the questions below by using yes or no responses.

1. Do you think that, even if Italians and Africans become friends, they will never feel completely at ease in their interactions?
2. Would you be bothered by the event that a member of your family has a child with physical features (e.g. color of the skin) different from yours?
3. Do you think that Africans/Italians take jobs that Italians/Africans deserve?
4. Do you think that Africans and Italians are comparable for what concerns their honesty?
5. Would you be keen to have intimate relationship with an African/Italian?
6. Would you be against a member of your family marry to an African/Italian, comparable economic status person?
7. Would it be a problem for you having an Italian/African boss?

The results showed that with the exception of a white male subject, all the other participants did not exhibit explicit racial bias (see main text and Supplemental discussion).

Analysis of Neurophysiological Data

Neurophysiological data were processed off-line. Trials with EMG activity prior to TMS pulse or where MEP amplitudes could not be clearly distinguished from background EMG (< 0.05 mV) were discarded from the analysis (8% of trials). Mean MEP amplitude values in each condition were measured peak-to-peak (in mV). Indices of pain-related changes in MEP amplitude for each model (ingroup, outgroup) were computed by subtracting activity recorded during observation of touch stimuli from activity recorded during observation of pain stimuli. MEP contrasts (pain - touch) were analyzed by means of a mixed-model ANOVA with Onlooker group (White, Black) as between-subjects factor, and Model (ingroup, outgroup) and Muscle (FDI, ADM) as within-subjects factors. Post-hoc analysis was conducted using Duncan's test.

One-sample t-tests were used to test whether each MEP contrast (pain – touch) separately computed for ingroup and outgroup models and for the FDI and ADM muscle, was significantly different from 0.

An index reflecting the neurophysiological bias for ingroup relative to outgroup members was computed by subtracting the MEP contrasts (pain - touch) recorded during observation of the outgroup model from the response (pain – touch) recorded during observation of the ingroup model. Greater negative values indicate that sensorimotor contagion, as indexed by corticospinal inhibition, was greater for the ingroup than for outgroup models.

A correlational analysis between behavioural and neurophysiological markers of ingroup-outgroup interpersonal reactivity was performed. Pearson's coefficient *r* was computed between the IAT index (reflecting the behavioral preference for ingroup members relative to outgroup members) and the neurophysiological bias index. One outlier (a Black woman) with standard residual > 2 sigma was removed from the analysis.

An additional analysis was conducted to explore the relation between sensorimotor contagion and dispositional empathy. See Supplemental Results for details.

Analysis of Autonomic Data

Mean SCR and HR responses in each condition were normalized by using the average of the fixation cross trials (condition – fixation) / (condition + fixation) [S64]. This index proved adept to normalize both SCR and HR data. Mean normalized SCR signals were analyzed by means of a mixed-model ANOVA with Onlooker group (White, Black) as between-subjects factor, and Model (ingroup, outgroup) and Type of stimulation (pain, touch) as within-subjects factors (see Figure S2A). An additional analysis of SCR signal was aimed at testing race-specific effects on autonomic measures by taking into account the temporal dimension. The SCR signal allowed to identify a clear SCR response in all the conditions of 27 out of 32 participants and therefore its latency was measured. In 5 Blacks participants (3 males) no evident change in SCR was detected in one of the conditions (ingroup pain: 1 subject; ingroup touch: 1 subject; outgroup touch: 3 subjects). Therefore, the analysis of the latency of SCR was performed in the subset of 27 participants by means of an Onlooker group (White, Black) x Model (ingroup, outgroup) x Type of stimulation (touch, pain) ANOVA (see Figure S2B).

For the HR responses the time-course of interpersonal reactivity was taken into account by splitting the recorded 8 s ECG response into two 4 s epochs. Thus, normalized HR values were analyzed by means of an Onlooker group (White, Black) x Model (ingroup, outgroup) x Type of stimulation (touch, pain) x Time window (early, late) ANOVA (see Figure S3).

In all the ANOVAs post-hoc analysis was conducted by using the Duncan test.

A series of regression analyses exploring the relations between physiological responses and dispositional empathy and between physiological responses and Race IAT were carried out (see Supplemental Results for details).

Violet Models

Four White and four Black participants (mean age 25, range 22-28) were tested in two additional conditions showing a third model with violet skin color receiving needles penetrating and Q-tip touching the FDI muscle. The violet model was digitally created by editing the original videoclips showing the outgroup model (the White model for Black participants and the Black model for White participants). Six subjects were tested with violet models clips in a separate session performed at least one week after the first TMS session. Two subjects were tested with all the six movies during the same session. Within each session the order of the blocks was counterbalanced. MEP contrasts (pain - touch) were analyzed by means of a mixed-model ANOVA with Onlooker group (White, Black) as between-subjects factor, and Model (ingroup, outgroup, violet) and Muscle (FDI, ADM) as within-subjects factors. Post-hoc analysis was conducted by means of Duncan's test.

After the TMS sessions and the MPQ measurement, participants were presented with all the pain videos and asked to rate the intensity of the pain ascribed to the three models during needle penetrations, by marking a vertical, 10-cm visual analogue scale (VAS) with 0 cm indicating 'no effect' and 10 cm 'maximal effect imaginable'. Moreover, they had to judge the visual familiarity of the observed hands and the physical similarity of the observed hands with respect to themselves by using VAS where 0 cm indicated 'entirely unfamiliar' and 'entirely dissimilar' and 10 cm indicated 'entirely familiar' and 'entirely similar'. VAS ratings were analyzed by means of mixed-model ANOVAs with Onlooker group (White, Black) as between-subjects factor, and Model (ingroup, outgroup, violet) as within-subjects factor. Post-hoc analysis was conducted by means of Duncan's test.

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