

Reading the mind in the eyes of Black and White people: Interracial contact and perceived race affects brain activity when inferring mental states



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ABSTRACT

Inferring others' mental states, or mentalizing, is a critical social cognitive ability that underlies humans' remarkable capacity for complex social interactions. Recent work suggests that interracial contact shapes the recruitment of brain regions involved in mentalizing during impression formation. However, it remains unclear how a target's perceived racial group and a perceiver's previous contact with that racial group shapes mental state inferences. In this study, we examined brain activity in regions of interest associated with mentalizing and race perception among self-identified White perceivers who varied in lifetime contact while they inferred secondary emotions from perceived White eyes and perceived Black eyes (i.e., the Reading the Mind in the Eyes test). The interaction between lifetime contact and perceived target race predicted activity in the superior temporal sulcus (STS), a region consistently implicated in mental state inferences from perceptual cues, tracking eye gaze, and biological motion. Low and average contact White perceivers showed more left STS activity when inferring mental states from perceived White eyes than perceived Black eyes, whereas high contact White perceivers showed similar left STS activity regardless of perceived target race. These results indicate that interracial contact decreases racial biases in the recruitment of regions involved in mentalizing when inferring mental states from perceptual cues.

1. Introduction

Mentalizing, or theory of mind, is a critical component of social cognition that involves understanding others' thoughts, beliefs, and mental states as distinct from one's own (Leslie, 1987; Schurz et al., 2014, 2021; Spreng et al., 2009). This ability typically develops during early childhood between the ages of 4 and 5 years old (Flavell, 1999; Perner and Lang, 1999; Saracho, 2014; Slaughter, 2015; Wellman et al., 2001). Importantly, theory of mind underlies how we as humans can successfully navigate complex social environments. Although theory of mind is operationalized in multiple ways (e.g., trait inferences, false beliefs, mental state inferences) and may be supported by a broad range of social cognitive processes, all theory of mind tasks involve thinking about others' mental states (Frith and Frith, 2006; Gallagher and Frith, 2003; Schurz et al., 2014). One noteworthy facet of theory of mind involves inferring others' transient complex emotional states based on physical cues (e.g., facial expression, eye gaze; Baron-Cohen et al., 2001; Baron-Cohen et al., 1997, 1997). In the present work, we examine how White perceivers' history of cross-race experience with Black people influences brain activity when inferring mental states from physical cues from same-race (i.e., White) and cross-race (i.e., Black) faces.

Substantial work in social neuroscience has characterized a network of brain regions involved in mentalizing. Across different tasks, three brain regions comprise a core mentalizing network. The dorsal medial prefrontal cortex (DMPFC) is consistently found to be more active when inferring mental states than when making other types of judgments about others (Handley et al., 2021; Mitchell et al., 2005b, 2005a). The temporoparietal junction (TPJ) is also consistently preferentially recruited when people think about others' mental states relative to when they think about any other kind of social information (Saxe and Wexler, 2005; Young et al., 2010). Finally, the superior temporal sulcus (STS), which has been shown to support social perception (Deen et al., 2015; Pelphrey et al., 2004; Zilbovicius et al., 2006), is often recruited when perceivers attempt to understand others' intentions and track their eye gaze (Allison et al., 2000; Pelphrey et al., 2003; Pelphrey et al., 2004). In line with its involvement in perceiving eye gaze and biological motion (Deen et al., 2015; Pelphrey et al., 2003; Pelphrey et al., 2004, 2004; Zilbovicius et al., 2006) previous work suggests that the STS may be particularly important when deciphering others' mental states based on perceptual cues, i.e., inferring mental states based on others' eyes (Adams et al., 2009; Schurz et al., 2014). Together, these regions play an important role in how we use theory of mind to navigate our social environments.

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Social neuroscientists have increasingly been interested in the neural substrates of race perception (i.e., the perception of another's race whether accurate or not), and how interracial contact (i.e., increased expertise with other-race faces), in particular, may shape these processes. Many early studies have shown that White American perceivers display preferential amygdala activity when viewing perceived Black faces (for review, see Kubota et al., 2012), suggesting that these faces may be particularly salient or attention-grabbing to these perceivers (e.g., Cunningham and Brosch, 2012; Santos et al., 2010). However, Telzer et al. (2013) found that White perceivers do not display heightened amygdala sensitivity to perceived Black faces until they reached adolescence. Furthermore, adolescents who report more diverse peer contact show an attenuated amygdala response to perceived Black faces relative to their peers who report less diverse peer contact (Telzer et al., 2013). Similarly, Cloutier et al. (2014) showed that higher levels of childhood interracial contact is associated with reduced amygdala activity when White perceivers form private impressions of perceptually familiar perceived Black faces. Taken together, these studies suggest that White individuals who have experienced more diverse contact may experience perceived Black faces as less socially salient than White individuals who have not experienced as much diverse contact.

Although this work lays the groundwork for our understanding of the neural instantiation of how contact shapes race perception, research specifically exploring the link between interracial contact and mentalizing is relatively sparse. Recent work suggests that increased contact may reduce the selectivity with which mentalizing brain regions are recruited specifically for mentalizing (Handley et al., 2021). Regardless of target race, low- and average-contact White perceivers recruited brain regions involved in mentalizing and salience detection (right TPJ, DMPFC, left amygdala) more when inferring a mental state than when making a physical judgment about a target; however, high contact White perceivers recruited these regions to a similar extent for both mental state and physical judgments (Handley et al., 2021). Following from these findings, behavioral research found that high contact people are less accurate at inferring mental states from same- and cross-race targets, however, increased motivation to attend to the task reversed this effect (Handley et al., 2021). In other words, high contact individuals *can* mentalize more accurately than low contact individuals, but they require sufficient motivation to engage with the task to do so. We follow up on these findings in the present work by investigating how contact may impact the neural substrates of mental states inferences associated with others' secondary emotions based on perceptual cues (i.e., the eyes) irrespective of perceiver motivation.

One noteworthy component of theory of mind involves inferring others' mental states and/or secondary emotions based on readily available perceptual information, which often includes information from the eye region (Baron-Cohen et al., 2001; Baron-Cohen et al., 1997, 1997; Emery, 2000; Zebrowitz, 2006). Differences in people's ability to use this form of mentalizing have been assessed using the Reading the Mind in the Eyes (RME) test, a well-validated task that has been used in various social cognition studies assessing mentalizing ability (e.g., Adams et al., 2009; Handley et al., 2021)) and with various clinical populations, particularly individual with autism (Baron-Cohen et al., 1999). The RME test assesses perceivers' ability to identify secondary emotion from the eye region of a face (out of four choices). This represents a specific form of mentalizing conceptualized by some as closer to emotion recognition than mentalizing per se (Oakley et al., 2016; Quesque and Rossetti, 2020). RME test scores have been found to correlate with verbal ability, raising further questions about what may impact task accuracy (Peterson and Miller, 2012). However, with the creation of new RME tasks, the use of the RME allows for comparison of cross-race mental state inferences from perceptual cues (Adams et al., 2009; Handley et al., 2021).

Although no brain imaging study has explored how interracial contact shapes mentalizing based on perceptual cues such as those included in the RME test, an fMRI study by Adams et al. (2009) explored how

native Japanese and White American perceivers respond to perceived Asian and perceived White RME tests. They found a within-culture advantage for RME accuracy; in other words, White American participants were more accurate at the RME with White than Asian targets, whereas native Japanese participants were more accurate at the RME with Asian than White targets. Notably, they also found that this cultural tuning was associated with differential STS activity; White American participants displayed greater STS activity when inferring mental states from White than Asian targets, and similarly, Japanese participants showed greater STS activity when inferring mental states from Asian than White targets (Adams et al., 2009). These findings further support the view that the STS may be particularly involved when inferring mental states from perceptual cues. Accordingly, differential STS activity across race may be moderated by interracial contact when White American perceivers complete the perceived White and perceived Black RME tests.

1.1. Current study

In the present work we explored how RME target race and participant's history of interracial contact shape White perceivers' brain activity during a perceived White/Black interracial RME test. We focus on White perceivers for this initial examination of how interracial contact shapes mentalizing activity during the completion of a White/Black interracial RME test. The sample was selected to assess the racial biases that White American perceivers may display when mentalizing about perceived Black and White targets and how contact may mitigate those biases.

Based on work suggesting that the STS may be particularly important when inferring mental states from perceptual cues like eyes and social gaze (Adams et al., 2009; Allison et al., 2000; Pelphrey et al., 2003; Pelphrey et al., 2004; Schurz et al., 2014), bilateral STS were critical *a priori* regions of interest (ROIs) for this work. We also included other regions from the mentalizing network (i.e., DMPFC; bilateral TPJ) as *a priori* ROIs, in addition to bilateral amygdalae based on this region's presumed role in race perception and salience detection. We also report exploratory whole-brain analyses; however, our analytical approach emphasizes interpreting results from ROIs associated with *a priori* predictions in accordance with best practices (Vul and Pashler, 2017; Zandbelt et al., 2008).

2. Methods

2.1. Participants

We recruited and scanned sixty-one self-identified White participants ($M_{\text{age}} = 25.05$, $SD = 7.34$, 28 females, 31 males, 2 other gender) from the University of Chicago and from the surrounding community in 2017–2018. All participants were neurotypical, had normal or corrected-to-normal vision without color blindness, and were right-handed, proficient English speakers. Participants had no history of drug or psychotropic medication use, previous head injuries, or chronic illness that might affect mental, neural, or autonomic functions.

All participants met our *a priori* inclusion criteria for participation: they were all White European-Americans who did not identify as Hispanic or mixed race, between the ages of 18–50 years old, and born in the United States. We also screened participants to ensure an adequate distribution of interracial contact. Specifically, we used an abbreviated version of the contact questionnaire described in full below to ensure at least twenty participants (32.8% of the sample) reported at least 15% childhood contact with Black people. The remaining forty participants could report any level of contact.

2.1.1. Data exclusions

For fMRI analyses, we excluded data from 3 participants due to either technical issues involving the scanner ($n = 1$) or excessive movement (> 3 mm within runs) during scanning ($n = 2$). Our final sample for fMRI



Fig. 1. Example Black RME stimulus. The answer choices provided with this image included: preoccupied, insisting, grateful, and imploring (correct answer: preoccupied). Black RME stimuli were provided by Handley et al., 2019.

analyses therefore included 58 participants ($M_{\text{age}} = 24.72$, $SD = 6.87$, 28 females, 28 males, 2 other gender). For behavioral analyses, data from all 61 participants were retained ($M_{\text{age}} = 25.05$, $SD = 7.34$, 28 females, 31 males, 2 other gender).

2.2. Stimuli

During the RME test, participants viewed a cropped image depicting a pair of eyes and selected which secondary emotion (out of four possible options) those eyes convey. Although the initial RME test included only perceived White target eyes (Baron-Cohen et al., 2001), an equated version of the test using perceived Black target eyes has recently been developed (Handley et al., 2019). The equated perceived Black RME test depicts the same 36 mental states as the original perceived White RME test and lists the same answer choices with each mental state (Handley et al., 2019). The tests were equated on difficulty using a 2 (perceiver race: Black, White) \times 2 (perceived RME target race: Black, White) between subjects design (Handley et al., 2019). The present work uses a combination of both RME tests (Baron-Cohen et al., 2001; Handley et al., 2019); however, we manipulate perceived RME target race within subjects. See Fig. 1 for an example stimulus from the perceived Black RME test.

2.3. Experimental protocol

For the main experimental task of the study, participants completed an interracial RME test consisting of 36 perceived White RME trials and 36 perceived Black RME trials (72 total experimental trials). The study used a fast event-related design in which Black and White RME trials were presented in pseudo-randomized order, with randomization constrained so that participants never saw more than three consecutive Black or White RME trials. Trials were presented over three runs; each run lasted 257.5 s and contained 24 RME trials (12 Black; 12 White) with jittered fixations between trials lasting either 0.5 s, 3 s, 5.5 s, or 8 s between each trial. Stimulus presentation and jitters were optimized using optseq2 (available at <https://surfer.nmr.mgh.harvard.edu/optseq/>). Between each run, participants were given a short break and reminded of the task instructions.

Each RME trial lasted 7 s total, including stimulus presentation and response window. During stimulus presentation, participants were first shown the RME stimulus image centered on a black screen with each of the four answer choices displayed in a large white font in a different corner of the screen. Participants viewed the stimulus image and answer choices for 5.0 s. The response window immediately followed stimulus presentation. After the stimulus presentation, a green fixation cross replaced the RME stimulus image for 2.0 s while the answer choices remained on the screen in their original locations. See Fig. 2 for a diagram of the timing for one RME trial. Participants were instructed to select their answer using a button box when the green fixation appeared on the screen. Participants were given two button boxes and instructed to

use their middle and index finger on each hand to make their selections; the left hand always selected answers on the left side of the screen and the right hand always selected answers on the right side of the screen, but half of the participants used their middle finger to select the lower corner choice and their index finger to select the upper corner choice, whereas this was flipped for the other half of participants.

In the days preceding their scanning session, participants completed various questionnaires including an interracial contact questionnaire. The other questionnaires collected were used for unrelated resting state analyses and an in-scanner task which was completed before the RME task; no predictions based these questionnaires in relation to the RME were made or the related data analyzed in any way as part of this study. Immediately prior to entering the scanner, participants were trained on the scanner-adapted RME task, the stimulus presentation and response window timing and cues, and the use of the button boxes. After scanning, participants completed a visual perspective-taking task and were thanked for their participation, debriefed, and compensated at a rate of \$10/hour for out-of-scanner time and \$25/hour for in-scanner time.

2.4. Interracial contact questionnaire

Prior to scanning, participants completed a computer-based questionnaire quantifying the racial composition of their social networks in childhood and currently. Participants indicated approximate percentages of people from different racial groups (Asian, Black, Hispanic, White, and other; Cloutier et al., 2014) in social categories that varied in closeness (e.g., friendships, peers, neighbors, etc.). Percentages were required to sum to 100. Participants reported this information for four discrete time periods: 0–6 years old, 7–12 years old, 13–18 years old, and presently.

We calculated an average childhood and current contact score with Black and White people, then computed a difference score by subtracting their average contact with White people from their average contact with Black people. These difference scores could range from -100 , which represents 0% contact with Black people, to $+100$, which represents 100% contact with Black people. Overall, participants' average childhood contact score was -68.166 ($SD = 17.222$) and their average current contact score was -45.507 ($SD = 27.325$). These scores were significantly positively correlated ($r = 0.341$, $t(56) = 2.714$, $p = 0.009$), so we averaged them into a composite measure of lifetime contact ($M = -56.837$, $SD = 18.467$). In follow-up analyses, we decompose interactions with contact re-centered at ± 2 SD from the mean for consistency with previous work from our lab (Handley et al., 2021, 2021). In this instance, $+2$ SD corresponds to a lifetime contact score of -19.903 and -2 SD corresponds to a lifetime contact score of -93.771 . See Fig. 3 for violin plots depicting the distributions for childhood, current, and lifetime contact scores.

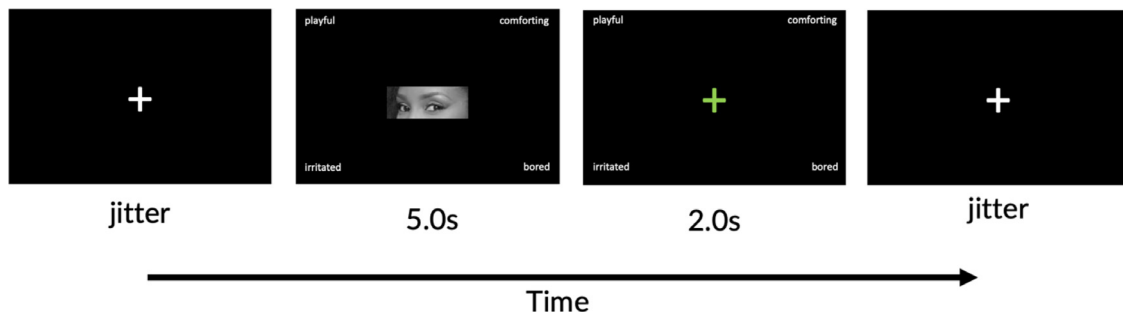


Fig. 2. Diagram depicting one RME trial, including timing information. Jittered fixations between trials lasted either 0.5 s, 3 s, 5.5 s, or 8 s.

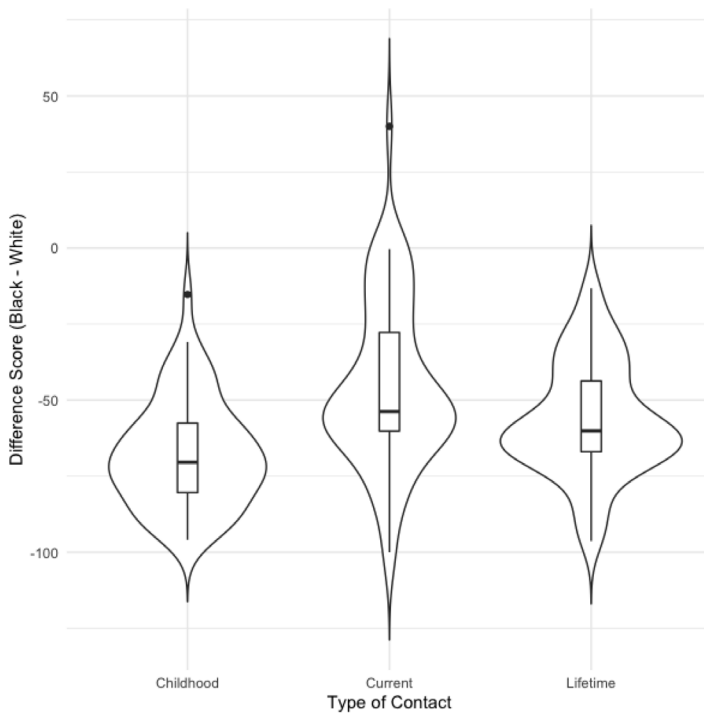


Fig. 3. Violin plots depicting the distribution of childhood, current, and lifetime contact difference scores in the study sample.

2.5. ROIs

Because previous work specifically implicates bilateral STS in inferring mental states from the eye region (e.g., Adams et al., 2009; Schurz et al., 2014), these regions were primary *a priori* ROIs for analyses. We selected additional ROIs based on their involvement in mentalizing and theory of mind, including bilateral TPJ and DMPFC (Cloutier et al., 2017; Schurz et al., 2014; Spreng et al., 2009). We note that meta-analyses of brain regions involved in mentalizing diverge regarding specific coordinates for ROIs. Specifically, Spreng et al. (2009) identify STS coordinates that differ from the region identified as STS in a later meta-analysis that specifically reviewed RME task activity as opposed to mentalizing in general (Schurz et al., 2014). For consistency with previous work addressing the effects of contact on social cognition (e.g., Cloutier et al., 2014; Cloutier et al., 2017), coordinates for all mentalizing ROIs (e.g., bilateral STS, bilateral TPJ, and DMPFC) were selected from a meta-analysis by Spreng et al., 2009. However, readers should note the coordinates presented in the results section below; the region we label left TPJ may in fact be closest to the left STS region identified by Schurz et al. (2014) as being involved in performing the RME task. Furthermore, the STS coordinates we use are situated in anterior, rather than posterior, STS.

We also selected bilateral amygdala as *a priori* ROIs because this region is often differentially recruited as a function of target race (for

review, see Kubota et al., 2012). Further, amygdala response has been shown to be modulated by perceiver's history of interracial contact (e.g., Cloutier et al., 2014; Handley et al., 2021; Telzer et al., 2013). Coordinates for amygdala ROIs were selected from Cloutier et al., 2014.

2.6. fMRI data acquisition

Anatomical and functional imaging was performed on a 3T Philips Achieva Quasar scanner at the University of Chicago Magnetic Resonance Imaging Research Center. Functional imagers were collected in 3 functional runs of 103 TRs (TR = 2.50 s) each, using pulse sequence parameters (TR/echo time = 2500/25 ms, flip angle = 79°, contiguous slices with 3.28 mm thickness, gap = 0.72 mm, FOV = 210 × 210 mm, approximately 64 × 64 mm matrix, 3.28 × 3.28mm² voxel size). High-resolution structural images were acquired in the sagittal plane using a T1-weighted 3D Turbo Field Echo (TFE/MP-RAGE) anatomical scan (TR = 8.5 ms, echo time = 4.0 ms, FOV = 240 × 228 mm, 1.0 mm slice thickness, no gap, 240 × 228 mm matrix, 1.0 × 1.0 × 1.0mm³ voxel size).

Functional imaging data were preprocessed using SPM8 (<http://www.fil.ion.ucl.ac.uk/spm>), facilitated by a custom suite of scripts for fMRI analysis (<https://github.com/ddwagner/SPM8w>), to remove sources of noise and artifacts and realigned within and across runs to correct for head movement and transformed into a

standard anatomical space (3 mm isotropic voxels) based on the ICBM 152 brain template (MNI, Montreal Neurological Institute), which approximates the Talairach and Tournoux atlas space (Talairach and Tournoux, 1988). Normalized data were then spatially smoothed (8 mm FWHM) using a Gaussian kernel to increase the signal to noise ratio and reduce the impact of anatomical variability not corrected for by stereotaxic normalization.

For each participant, general linear models (GLMs) were constructed to examine condition-specific brain activity as a function of RME target race (Black or White). At level 1, GLMs incorporating each of the two conditions (Black; White) and covariates of non-interest (a session mean, a linear trend to account for low-frequency drift, and six movement parameters derived from realignment corrections) were convolved with a canonical hemodynamic response function and used to compute parameter estimates for each condition at each voxel. At level 2, participants were compared across conditions for whole brain exploratory analyses.

2.7. Data analysis

We used mixed-effects regression to analyze both the fMRI ROI and behavioral data with the lme4 package (Bates et al., 2014) in the R programming language (R Core Team, 2016). All statistical tests were two-tailed. Target race ($-0.5 = \text{Black RME targets}$ and $0.5 = \text{White RME targets}$) was the sole within-subjects factor. The z-scored lifetime contact difference score was the sole between-subjects individual difference factor. For analyses, we modeled random effects for the intercept. We included all trials, regardless of participant accuracy, in all ROI and exploratory whole-brain analyses.

2.7.1. ROI analyses

We used linear regression to analyze BOLD activity in *a priori* ROIs (bilateral STS, bilateral TPJ, DMPFC, and bilateral amygdala) as a function of RME target race and participants' lifetime contact scores. For all fMRI results, coordinates are provided in Montreal Neurological Institute (MNI) space.

2.7.2. Exploratory whole-brain analyses

We emphasize results from our planned comparisons in *a priori* ROIs in this paper. We ran two exploratory whole-brain GLM analyses for the Black > White (i.e., greater brain activity in these regions during perceived Black RME trials than during perceived White RME trials) and White > Black (i.e., greater brain activity in these regions during perceived White RME trials than during the perceived Black RME trials) comparisons. We used an uncorrected voxel-level threshold of $p < 0.001$ and a cluster extent threshold of 53 voxels as determined by AlphaSim. The Black > White contrast was coded such that Black = +1 and White = -1. The White > Black contrast was coded such that White = +1 and Black = -1. Time and dispersion regressors for each condition for both contrasts were set to 0. These results are exploratory and should be interpreted with caution and only within the context of the planned comparisons in our *a priori* regions of interest reported in the main text.

2.7.3. Behavioral

We used logistic regression to predict RME trial accuracy (1 = correct, 0 = incorrect) as a function of RME target race and participants' lifetime contact scores.

3. Results

3.1. ROI analyses

We extracted BOLD activity from ROIs in left STS (MNI_{x,y,z} = -59, -15, -16, 8 mm sphere) right STS (MNI_{x,y,z} = 57, -10, -20, 8 mm sphere), left TPJ (MNI_{x,y,z} = -56, -55, 16, 8 mm sphere), right TPJ (MNI_{x,y,z} = 54, -51, 17, 8 mm sphere), DMPFC (MNI_{x,y,z} = -3, 55, 23, 8 mm sphere) and bilateral amygdala (left amygdala: MNI_{x,y,z} = -24,

-6, -24, 4 mm sphere; right amygdala: MNI_{x,y,z} = 18, -6, -21, 4 mm sphere). Average parameter estimates were extracted for each condition. The size of these ROIs is commensurate with differences in anatomical size between these regions and with ROI volumes from our previous work. All ROI results (including non-significant results) are reported in Table 1.¹

3.1.1. Target race and lifetime contact predict bold activity in left STS during the RME task

There was a significant main effect of target race on left STS activity such that participants showed greater STS activity when inferring mental states from White eyes than when inferring mental states from Black eyes ($b = 0.523$, $SE = 0.210$, $t(56) = 2.492$, $p = 0.016$, 95% CI = [0.112, 0.935]). However, this main effect was qualified by a significant interaction between target race and lifetime interracial contact ($b = -0.546$, $SE = 0.211$, $t(56) = -2.589$, $p = 0.012$, 95% CI = [-0.959, -0.133]; see Fig. 4). To decompose this interaction, we tested simple differences between left STS BOLD activity when inferring mental states from White eyes compared to when inferring mental states from Black eyes at low (-2SD), average (0SD), and high (+2SD) lifetime interracial contact. Low ($b = 1.615$, $SE = 0.471$, $t(56) = 3.429$, $p = 0.001$, 95% CI = [0.692, 2.539]) and average ($b = 0.523$, $SE = 0.210$, $t(56) = 2.492$, $p = 0.016$, 95% CI = [0.112, 0.935]) contact participants showed significantly more left STS activity when inferring mental states from White eyes than when doing so from Black eyes. High contact participants, however, showed similar levels of STS activity regardless of RME target race ($b = -0.569$, $SE = 0.471$, $t(56) = -1.207$, $p = 0.232$, 95% CI = [-1.492, 0.355]). We also assessed the slopes within each condition by dummy coding target race; neither slope was significant (Black trials: $b = 0.382$, $SE = 0.421$, $t(63.445) = 0.907$, $p = 0.368$, 95% CI = [-0.444, 1.208]; White trials: $b = -0.164$, $SE = 0.421$, $t(63.445) = -0.388$, $p = 0.699$, 95% CI = [-0.990, 0.662]).

A similar pattern of results was shown in right STS and right TPJ, however, the interaction was not significant in these regions (right STS: $b = -0.356$, $SE = 0.187$, $t(56) = -1.898$, $p = 0.063$, 95% CI = [-0.723, 0.012]; right TPJ: $b = -0.319$, $SE = 0.160$, $t(56) = -1.995$, $p = 0.051$, 95% CI = [-0.633, -0.006]). We did not decompose the interaction term in these regions because it was not significant in the omnibus models. Although the interaction of target race and lifetime contact only significantly predicted left STS activity, we are reluctant to make strong claims about lateralization of this effect. Based on the marginal significance values found in right STS and right TPJ, it is not clear what would emerge if a larger sample of participants were included. No significant results were found in any other ROIs (all p -values > 0.1).

3.1.2. Target race alone predicts bold activity in left TPJ during the RME task

We also found a significant main effect of target race in left TPJ such that participants showed greater activity in this region when inferring mental states from White eyes than when doing so from Black eyes ($b = 0.456$, $SE = 0.190$, $t(56) = 2.400$, $p = 0.020$, 95% CI = [0.084, 0.829]).

3.2. Exploratory whole-brain analyses

For the Black > White contrast, there were no significant clusters above the 53-voxel threshold for the Black > White contrast.

The White > Black contrast revealed one 809-voxel cluster in visual cortex for the White > Black contrast. This cluster included three significant peaks (uncorrected $p < 0.001$) at MNI_{x,y,z} = 12, -99, 15 (V2, Brodmann area 18; $t = 6.08$), MNI_{x,y,z} = 15, -93, 6 (V1, Brodmann

¹ Although the multiple ROIs were selected a priori based on an extensive literature exploring the network of brain regions involved in mentalizing, it is noteworthy that as a result the reported findings do not survive conservative Bonferroni correction.

Table 1
Regression Results Table Predicting Activity in All Regions of Interest from Target Race, z-Scored Lifetime Contact, and their Interaction.

	Beta	SE	df	t-value	p-value	95% CI
Left TPJ						
Intercept	-1.203	0.469	56	-2.565	0.013	[-2.122, -0.284]
Target race	0.456	0.190	56	2.400	0.020	[0.084, 0.829]
Lifetime contact (z-scored)	0.458	0.471	56	0.972	0.335	[-0.465, 1.381]
Target race × lifetime contact (z-scored)	-0.205	0.191	56	-1.075	0.287	[-0.579, 0.169]
Right TPJ						
Intercept	-2.124	0.309	56	-6.878	<0.001	[-2.73, -1.519]
Target race	0.002	0.159	56	0.014	0.989	[-0.31, 0.315]
Lifetime contact (z-scored)	0.410	0.310	56	1.323	0.191	[-0.198, 1.019]
Target race × lifetime contact (z-scored)	-0.319	0.160	56	-1.995	0.051	[-0.633, -0.006]
DMPFC						
Intercept	-3.595	0.548	56	-6.556	<0.001	[-4.669, -2.52]
Target race	0.358	0.363	56	0.985	0.329	[-0.354, 1.07]
Lifetime contact (z-scored)	0.312	0.551	56	0.567	0.573	[-0.767, 1.392]
Target race × lifetime contact (z-scored)	-0.604	0.365	56	-1.654	0.104	[-1.319, 0.112]
Left STS						
Intercept	-1.754	0.406	56	-4.317	<0.001	[-2.55, -0.958]
Target race	0.523	0.210	56	2.492	0.016	[0.112, 0.935]
Lifetime contact (z-scored)	0.109	0.408	56	0.268	0.790	[-0.69, 0.909]
Target race × lifetime contact (z-scored)	-0.546	0.211	56	-2.589	0.012	[-0.959, -0.133]
Right STS						
Intercept	-1.425	0.327	56	-4.353	<0.001	[-2.066, -0.783]
Target race	0.285	0.187	56	1.529	0.132	[-0.08, 0.651]
Lifetime contact (z-scored)	0.438	0.329	56	1.332	0.188	[-0.206, 1.082]
Target race × lifetime contact (z-scored)	-0.356	0.187	56	-1.898	0.063	[-0.723, 0.012]
Left Amygdala						
Intercept	-0.971	0.316	56	-3.070	0.003	[-1.591, -0.351]
Target race	0.365	0.219	56	1.670	0.101	[-0.064, 0.794]
Lifetime contact (z-scored)	0.061	0.318	56	0.193	0.848	[-0.561, 0.684]
Target race × lifetime contact (z-scored)	-0.168	0.220	56	-0.764	0.448	[-0.599, 0.263]
Right Amygdala						
Intercept	-0.876	0.382	56	-2.296	0.025	[-1.625, -0.128]
Target race	0.262	0.281	56	0.932	0.355	[-0.289, 0.813]
Lifetime contact (z-scored)	0.464	0.383	56	1.210	0.231	[-0.287, 1.215]
Target race × lifetime contact (z-scored)	-0.092	0.282	56	-0.325	0.746	[-0.645, 0.461]

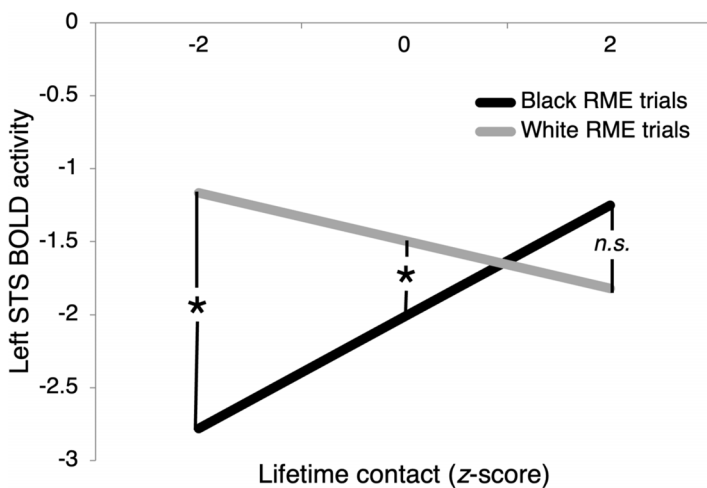


Fig. 4. The interaction between lifetime interracial contact and RME target race significantly predicted BOLD activity in left STS. Low and average contact White perceivers showed significantly greater left STS activity when inferring mental states from White eyes than when doing so from Black eyes, whereas high contact White perceivers showed no difference in left STS activity regardless of RME target race. -2SD corresponds to a lifetime contact score of -93.771, 0SD corresponds to a lifetime contact score of -56.837, and +2SD corresponds to a lifetime contact score of -19.903.

area 17; $t = 5.28$), and $MNI_{x, y, z} = 18, -81, 15$ (V1, Brodmann area 17; $t = 5.00$).

3.3. Behavioral analyses

Although this fMRI study was not powered to reliably detect individual difference effects at the behavioral level, we present exploratory behavioral results (but see Study 2 in Handley et al., 2021 for an adequately powered, preregistered behavioral test of White perceivers' performance on the Black and White RME test). We used logistic regression to predict RME trial accuracy (1 = accurate, 0 = inaccurate) from target

race (Black = -0.5, White = 0.5), z-scored lifetime interracial contact, and the interaction of these factors. We observed a significant main effect of target race ($b = -0.269$, $SE = 0.068$, $z = -3.970$, $p < 0.001$, 95% CI = [-0.401, -0.136]) such that participants were more accurate on Black RME trials ($M_{\text{accuracy}} = 68.078\%$) than they were on White RME trials ($M_{\text{accuracy}} = 62.705\%$). No significant effects involving interracial contact emerged (all p -values > 0.400). We also conducted a linear regression to predict RME reaction time during the response window from target race (Black = -0.5, White = 0.5), z-scored lifetime interracial contact, and the interaction of these factors. We observed a significant main effect of target race ($b = 28.063$, $SE = 18.200$, $t(59.038) = 2.319$,

$p = 0.024$, 95% CI = [4.345, 51.781]) such that participants were faster to respond on Black RME trials ($M_{\text{reaction time}} = 739.273$ ms) than on White RME trials ($M_{\text{reaction time}} = 767.336$ ms). Again, no significant effects involving interracial contact emerged (all p -values > 0.380).

4. Discussion

In this initial investigation of how contact shapes brain activity during an interracial RME test we found that contact moderated activity in left STS. Similar to previous work using intergroup RME paradigms (i.e., White/Asian RME; Adams et al., 2009), we found preferential left STS activity for ingroup RME targets relative to outgroup RME targets. However, this was only true among perceivers with low and average quantities of lifetime interracial contact. High contact perceivers recruited left STS similarly regardless of whether they were inferring mental states from a perceived ingroup or outgroup members' eyes. STS activity when inferring secondary emotions based on physical cues may be meaningfully shaped by the types of exposure to others that we have experienced. These findings, however, do not necessarily suggest that low and average contact White perceivers mentalize "more" in response to perceived White than perceived Black targets; in fact, our behavioral results (wherein all participants regardless of contact were more accurate at inferring mental states from Black eyes than from White eyes) suggest there is some dissociation between the neural engagement in these tasks and observed behavioral outcomes. However, it is certainly noteworthy that perceived Black and perceived White targets evoke different levels of STS activity among people with relatively limited cross-race experience, but they do not do so among people with more extensive cross-race experience. This is further evidence that STS activity when inferring mental states from perceptual cues like the eyes is, to some extent, culturally tuned (e.g., Adams et al., 2009).

The dissociation between the behavioral results, in which perceivers were overall more accurate at the perceived Black RME test than at the perceived White RME test, and fMRI results, in which contact shaped mentalizing brain activity as a function of race, is somewhat surprising. The perceived Black RME test was equated on mental states, answer choices, and overall test difficulty (see Handley et al., 2019). However, when the tests were equated, perceived RME target race was manipulated between subjects: perceivers saw either the perceived Black RME test or the perceived White RME test. It is possible that the within subjects manipulation of perceived target race in this work made race more salient, encouraging our White perceivers to accurately respond to perceived Black RME trials. Although it would be interesting to analyze RME trials as a function of accuracy, there are too few trials per condition and it is impossible to equate the content (e.g., mental states, valence of expression, target gender) so that each individual participant got equivalent correct/incorrect trial types, making such analyses uninterpretable. However, we note that this pattern of results was obtained in previous behavioral work that also manipulated perceived RME target race within subjects (Handley et al., 2021). Furthermore, it is possible that the tuning of neural responses to intergroup mentalizing as a function of lifetime interracial contact does not override other processes (i.e. motivation) impacting mentalizing accuracy. Future work should address this question more directly by either manipulating perceived RME target race between subjects or by modifying the RME task to allow separate analysis of accurate and inaccurate trials. Such studies would further contribute to our understanding of how culture, more broadly, can shape mentalizing processes and outcomes (Lin et al., 2018; Qu et al., 2021). It is also possible that the affective valence of the perceived mental states may differentially impact behavioral and neural responses as a function of the perceived race of the targets and of the contact of the perceivers. Limits of the RME task do not allow to test this hypothesis with the present data; however, future work should explore this possibility.

Replicating previous research, we found preferential left TPJ activity for ingroup relative to outgroup targets (i.e., Adams et al., 2009;

Cheon et al., 2011; Liew, Han, Aziz-Zadeh, 2011; Richins, Barreto, Karl, & Lawrence, 2019; Meconi, Vaes, & Sessa, 2015), but this effect was not impacted by interracial contact. At first this finding seems to diverge from the STS response that was shaped by the perceiver's contact. However, the STS may be particularly important for inferring mental states from eyes (e.g., Saxe, 2006; Gallagher and Frith, 2003). Indeed, STS activity is observed during face perception (e.g., Haxby, Hoffman, & Gobbini, 2000; Pelphrey et al., 2004) and the perception of biological motion (Thompson, Clarke, Stewart, & Puce, 2005; Puce & Perrett, 2003; Allison et al., 2000). It is therefore not surprising that its recruitment may be tuned by social experience impacting perceptual expertise, such as interracial contact. In comparison, the TPJ, which is recruited during theory of mind, empathy, and perspective-taking (e.g., Hooker, Verosky, Germine, Knight, D'Esposito, 2010; Lombardo et al., 2010; Young, Cushman, Hauser, & Saxe, 2007), has been found to index differential engagement with stimuli during mentalizing (e.g., Dang et al., 2022; Bledowski, Prvulovic, Goebel, Zanella, & Lindin, 2004; Corbetta, Patel, & Shulman, 2008).

It is also noteworthy that these findings diverge somewhat from previous work on how interracial contact impacts the neural substrates of mentalizing from same- and cross-race face targets. Specifically, Handley et al. (2021) found that contact was associated with changes in mentalizing-related brain activity *regardless of target race* (e.g., see Cloutier et al., 2017), whereas in the present work we found that contact impacted brain regions recruited during mentalizing in a target race-dependent manner. We argue that differences between the mentalizing tasks used in these studies may underlie these divergent results. Handley et al. (2021) used a more general task in which objective accuracy was not attainable; when mentalizing, participants merely thought about one specific mental state (level of interest) for various perceived Black and White faces. In that less effortful task that did not require specific inferences based on perceptual cues, high contact peoples' experience with more diverse faces may make *all* encountered faces less salient rather than impacting face processing in any kind of race-specific way. However, in the present RME task, objective accuracy is attainable, and participants might have been more motivated to attend to the task. When processing is more effortful, or the stimuli are salient enough, our contact histories may meaningfully shape how we attend to faces in a more race-dependent manner. This possibility is further corroborated by recent evidence showing that high contact White perceivers who viewed videos of violent interactions between perceived White police officers and perceived Black civilians preferentially engaged brain regions supporting mentalizing compared to low contact White perceivers who viewed these same interactions (Dang et al., 2022). In other words, when viewing highly salient, dynamic, and attention-grabbing stimuli, contact and perceived target race impacted mentalizing-related brain activity. Similarly, it is possible that perceivers found the RME task to be socially more salient than to the more general mentalizing task used in Handley et al. (2021). This may also in part explain why participants were overall motivated to be accurate, particularly when presented with perceived Black RME trials. Contact therefore appears to have both general *and* race-specific impacts on brain activity during mentalizing.

Although this work provides an important first step toward understanding how contact shapes brain activity when inferring mental states from physical cues across target race, we acknowledge that the present work has limited generalizability. Our sample included only self-identified White American participants, and our stimuli included only perceived White and Black targets. Accordingly, it is important to note that the results and conclusions drawn from this study should not be generalized to perceivers and faces of all races. Further work involving more diverse participants and targets will be necessary to generalize beyond the present sample and stimulus set. Extending this work to participants and targets from different racial and ethnic backgrounds is a necessary future direction that will elucidate to what extent these findings reflect the specific context of White Americans thinking about

perceived Black and White peoples' emotions, or to what extent they generalize to broader contexts.

Interracial contact appears to have a nuanced, sometimes subtle, but potentially important effect on various social cognitive processes – increasingly, its complex impact on mentalizing and its relation to social salience is revealed through neuroimaging investigations such as this one (see also Dang et al., 2022; Handley et al., 2021). As highlighted by others, mentalizing may not be a panacea for prejudice reduction (e.g., Paluck et al., 2021) – in fact, our results and the results of previous brain imaging investigations (Dang et al., 2022; Handley et al., 2021) suggest that more complex downstream consequences of interracial contact cannot be explained by similar or even greater mentalizing about outgroup members alone. Although in many instances greater interracial contact appears to diminish differences in neural engagement towards perceived Black and White individuals (Cloutier et al., 2014; Cloutier et al., 2017; Handley et al., 2021; Telzer et al., 2013), it may only contribute to prejudice reduction in particularly salient contexts (e.g., Dang et al., 2022).

Author contributions

G.H., J. T. K., and J. C. conceptualized the study. G.H., J. T. K., and J. C. designed the study. G. H. collected data. G.H., J. T. K., and J. C. analyzed data. G.H., J. T. K., and J. C. wrote the manuscript. G.H., J. T. K., and J. C. revised and edited the manuscript. All authors read and approved the final manuscript.

Data and code availability

Raw fMRI data, aggregated behavioral and ROI data, and analysis scripts that support the findings reported in this paper have been deposited at <https://osf.io/m9g4p/>.

Declaration of Competing Interest

The authors declare no competing interests.

Data Availability

Raw fMRI data, aggregated behavioral and ROI data, and analysis scripts that support the findings reported in this paper have been deposited at <https://osf.io/m9g4p/>.

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