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**Community-Level Explicit Racial Prejudice Potentiates Whites' Neural Responses
to Black Faces: A Spatial Meta-Analysis**

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Abstract

We evaluated the hypothesis that neural responses to racial out-group members vary systematically based on the level of racial prejudice in the surrounding community. To do so, we conducted a spatial meta-analysis, which included a comprehensive set of studies ($k=22$; $N=481$). Specifically, we tested whether community-level racial prejudice moderated neural activation to Black (vs. White) faces in primarily White participants. Racial attitudes, obtained from Project Implicit, were aggregated to the county ($k=17$; $N=10,743$) in which each study was conducted. Multi-level kernel density analysis demonstrated that significant differences in neural activation to Black (vs. White) faces in right amygdala, dorsal anterior cingulate cortex, and dorsolateral prefrontal cortex were detected more often in communities with higher (vs. lower) levels of explicit (but not implicit) racial prejudice. These findings advance social-cognitive neuroscience by identifying aspects of macro-social contexts that may alter neural responses to out-group members.

Keywords: racial prejudice; social neuroscience; spatial meta-analysis; contextual sensitivity

A substantial body of work in social neuroscience has examined the neural underpinnings of racial prejudice (Amodio & Cikara, 2021; Kubota et al., 2012; Phelps et al., 2000). Initial work on this topic centered on the role of threat-related responses in the amygdala to out-group members as a potential neural mechanism underlying racial prejudice (Amodio & Cikara, 2021). Despite decades of research, however, evidence for a stronger amygdala response to racial out-group compared to in-group members has been mixed (Chekroud et al., 2014), with many fMRI studies finding no difference in amygdala response to viewing racial out-group (vs. in-group) members (Amodio & Cikara, 2021). Numerous other brain regions commonly exhibit greater activation to out-group relative to in-group members—including the dorsal anterior cingulate cortex (dACC), dorsolateral prefrontal cortex (dlPFC), and fusiform gyrus—although, similar to patterns of amygdala activation, the pattern of findings in these regions varies considerably across studies (Kubota et al., 2012; Merritt et al., 2021). The reasons for these conflicting findings remain inadequately understood. In this paper, we argue that these inconsistent results could be due, in part, to contextual factors typically ignored in cognitive neuroscience, such that observed associations are more (or less) pronounced depending on the social context in which participants are embedded (Lattanner et al., 2021; Pettigrew, 2018). Specifically, we examined whether Whites’ neural responses to Black (vs. White) faces¹ vary systematically based on the level of racial prejudice in the surrounding community.

Evaluating this contextual sensitivity hypothesis presents a methodological challenge. Because most neuroimaging studies are conducted in a single community,

¹We will refer to ‘Black faces’ and ‘White faces’ throughout the manuscript as shorthand for ‘faces that independent raters have racialized as Black or White as indicated by their subjective categorization of the faces,’ rather than reifying these as true categories (Cikara, Martinez, & Lewis, 2022).

respondents are ubiquitously exposed to the same macro-social context (Pearce, 2011), precluding the possibility of examining whether contextual factors modulate neural responses to out-group members. To overcome this challenge, we employed a novel approach known as spatial meta-analysis, which allows each study to be characterized in terms of the social context in which it was conducted (Johnson et al., 2017). Spatial meta-analyses leverage the contextual variability that naturally exists across study sites to examine associations between contextual variables (e.g., aggregate measures of racial prejudice) with relevant outcomes—in our case, patterns of neural response to racial out-group relative to in-group members. Although meta-analyses of fMRI studies have become commonplace in cognitive neuroscience (Fullana et al., 2016; Lindquist et al., 2016; Müller et al., 2018), they have not, to our knowledge, been previously used to examine *contextual* variation in effects across studies. We address this gap by providing a proof-of-concept spatial meta-analysis that re-analyzed existing studies examining Whites' neural responses to Black (vs. White) faces within the U.S. to determine whether community-level racial prejudice predicted whether neural responses to Black relative to White faces were observed. We hypothesized that White participants specifically in communities with higher (vs. lower) levels of racial prejudice would exhibit heightened neural response to Black (vs. White) faces in regions of the salience network (i.e., regions that are sometimes, but not always, observed in out-group face processing, including amygdala and dACC).

To evaluate this contextual sensitivity hypothesis, we linked aggregated measures of community-level racial prejudice to the communities where neuroimaging studies examining neural responses to Black vs. White faces were conducted. Psychological

theories—including structural stigma (Hatzenbuehler, 2016), prejudice-in-places (Murphy et al., 2018), and the Bias of Crowds (Payne et al., 2017)—conceptualize intergroup bias (and related constructs, such as prejudice and stigma) as properties not only of individuals, but also of the social contexts in which individuals are embedded. According to these theories, aggregated indicators of intergroup bias, such as implicit and explicit attitudes, reflect the influence of shared cultural and institutional norms within a particular area (Calanchini et al., 2022). Consistent with these theories, a growing body of evidence indicates that when measures of implicit and explicit racial prejudice are aggregated to the community level, they capture important features of the social context as it relates to race in the U.S. For instance, measures of implicit and explicit racial bias at the county and state level are associated with several adverse outcomes among African Americans, including low infant birth rates, higher mortality rates, smaller hippocampal volume, disparities in school-based disciplinary actions, and disproportionate lethal force by police (Calanchini et al., 2022; Hehman et al., 2019). Expanding on this literature, we examined whether racial attitudes—measured both implicitly (via the Implicit Association Test) and explicitly (via self-reports of racial stereotypes)—were associated with neural activation to Black (vs. White) faces among predominantly White participants. A recent review of regional bias found that in domains where aggregated explicit and implicit measures correlate strongly, the two measures tend to independently predict the same outcomes, because they largely measure the same construct (Calanchini et al., 2022). Consequently, we hypothesized that implicit and explicit community-level racial prejudice would each be associated with Whites’ neural activation to Black (vs. White) faces.

We additionally performed supplementary analyses to evaluate whether this activation was *specific* to community-level racial prejudice. To do so, we analyzed the relationship between Whites' neural activation to Black (vs. White) faces and other community-level factors that may serve as common causes of racial prejudice (i.e., income inequality, racial composition, average education level). These analyses can help to determine whether associations of patterns of neural response to Black (vs. White) faces are related specifically to indicators of community-level racial prejudice and not to other, related, characteristics of the same communities.

Materials and Methods

Article Selection. Our selection of articles proceeded in three steps. First, we compiled all papers from a review by Kubota et al. (2012), which was the first paper to provide an overview of the neuroscience of racial prejudice. Second, we combined papers from that review with papers categorized as “race” (i.e., Black/White) from a recent, comprehensive meta-analysis on the neural underpinnings of intergroup social cognition (Merritt et al., 2021). Third, we included three additional papers that did not appear in either the Kubota et al. (2012) review or the Merritt et al. (2021) meta-analysis, for a total of 22 studies (Table 1). Papers met the following inclusion criteria: majority White sample; conducted within the U.S.; and reported whole brain main effect contrast for Black versus White faces. Relevant papers were excluded if they included the main effect Black > White contrast only within the context of other manipulations (e.g., target race crossed with minimal group assignment; Van Bavel et al., 2008).

Community-level racial prejudice. Our measure of community-level explicit and implicit racial prejudice came from Project Implicit, a publicly available dataset that links respondents to state- and county-level identifiers.

Explicit racial attitudes. We used the 20 indicators of aggregated explicit racial attitudes (e.g., “It would not bother me if my new roommate was Black,” “It is likely that Black people will bring violence to neighborhoods when they move in”) that loaded highly in unidimensional factor models for state-level racism in a prior pre-registered analysis examining associations between state-level racism and neural outcomes associated with stress exposure (i.e., hippocampal volume and amygdala reactivity to threat; Hatzenbuehler et al., 2021). Because in the current study we had county-level identifiers, which are more proximal than state-level identifiers, we developed indicators of community-level explicit racial prejudice at the county level. We used responses from individuals in the Project Implicit dataset who were queried in the 50 United States and Washington, D.C., between 2002 and 2019. We coded all indicators such that higher values corresponded to higher levels of explicit racial prejudice. Participants contributed data to the Project Implicit items that they completed. Consequently, this approach did not require a completion of all survey questions, yielding a sufficiently large sample of respondents ($n=10,743$; $M=671$ ($SD=864$)). We then averaged these individual responses across 2002-2019 to the county level (Supplemental Table 1) and mean-standardized those values such that each county had one mean-standardized average value for each indicator. To be consistent with previous work (Hatzenbuehler et al., 2021), we factor analyzed the same 20 indicators at the county, rather than the state, level. The analysis was performed using PROC FACTOR in SAS 9.4, with the prior communality estimate

fixed at squared multiple correlations with all other variables. Replicating those previous results, a 1-factor solution emerged, and from confirmatory factor analysis of these 20 indicators, we generated model-based factor scores of community-level explicit racial prejudice for each unique county, as shown in Table 1. The mean value for county-level explicit racial prejudice across all U.S. counties in Project Implicit (N=1,829) was 0.00 (SD=0.95), with a minimum value of -1.76 and a maximum value of 7.09.

Evidence for the construct validity of aggregate regional measures of explicit racial bias, such as the ones used in the current study, comes from previous studies, which have documented both convergent validity (i.e., associations with other, theoretically relevant outcomes, including racially charged internet searches) and discriminant validity (i.e., lack of associations with theoretically unrelated outcomes, such as birth rates; Hehman et al., 2019).

Community-level explicit racial prejudice scores were linked to individual study sites in the meta-analytic database based on county-level identifiers of the study sample (if provided in the individual study) or the research institution of the first author (if not provided in the individual study). For studies that described samples encompassing multiple geographies (i.e., “the greater Boston area”), community-level explicit racial prejudice was scored using the average values for all counties described in that sample.

In the analytic sample (representing N=17 unique counties in N=22 unique studies), the explicit community-level racial prejudice scores ranged from a low of -0.90 to a high of -0.31 (Table 1). These were subsequently mean-centered for the purposes of analysis. Our analytic sample includes a restricted range of possible scores of community-level explicit racial prejudice across U.S. counties in the Project Implicit

dataset (low: -1.76, high: 7.09), reflecting that the counties where the target neuroimaging studies were conducted were characterized by lower community-level explicit racial prejudice, on average, than reflected across the entire U.S.

Implicit racial attitudes. We additionally examined associations with county-level implicit racial attitudes, measured using an Implicit Association Test (IAT) that assessed the implicit positive preference for White versus Black faces, made available through Project Implicit (Xu et al., 2013). To assess implicit racial attitudes at the county level, we aggregated IAT scores from the respondent level, averaged these to the county level across all included study years (i.e., 2002 to 2019), yielding an average score for each county, and mean-standardized these values. The range in our sample was from -.640 (low) to .325 (high), which is larger than that reported in Vuletic & Payne, 2019 (Vuletic & Payne, 2019).

Three points regarding our selection of the community-level racial prejudice variables and analysis warrant mention. First, whereas several previous studies have used single-item measures (e.g., difference in the feelings thermometer items between Whites and Blacks) to capture area-level racial prejudice (e.g., Kennedy et al., 1997; Leitner et al., 2016; Reid et al., 2014), we chose a factor analytic approach instead because it offers several advantages. These include: 1) it recognizes that different explicit attitudes towards Black people are highly correlated; 2) it improves construct validity; and 3) it captures shared variance, thereby reducing measurement error.

Second, we selected Project Implicit as the source for our data because it is the only large-scale dataset that simultaneously includes measures of both explicit and implicit racial attitudes and that provides sufficiently large sample sizes to create reliable

estimates across multiple geographic scales. The primary limitation of this dataset is that it is a non-probability sample, which may introduce selection bias. However, several studies of social attitudes have shown that Project Implicit produces results that are highly consistent with nationally representative samples, such as the American National Election Studies (Ofosu et al., 2019).

Third, we aggregated all responses to the county level irrespective of year queried. Although this approach reduces measurement error by allowing for all counties to have a sizable number of respondents, regardless of yearly sampling variation, it does not capture temporal trends in community-level racial prejudice. However, while explicit racial prejudice has declined nationally over time, the relative levels of prejudice at aggregated units (e.g., states' rankings relative to other states) have remained highly stable (McKetta et al., 2017), suggesting that a time-invariant measure represents a valid approach.

Additional area-level variables. Our inferences are strengthened if the observed pattern of neural activation is specific to community-level racial prejudice and not to factors that may be correlated with it. To examine this question, we re-ran our analyses with 3 alternative variables. These were: 1) income inequality, assessed using the GINI, which measures area-level income maldistribution, ranging from 0 to 1, where 0 is perfect inequality and 1 is perfect equality; 2) community-level racial composition, operationalized as the percentage of the total population who is Black; and 3) community-level education, operationalized as the percentage of the adult population over the age 25 who have a college degree or higher. These variables were continuously measured at the county level and made available by the 2010 American Community Survey (ACS) for all US counties. Correlations among these three variables and

community-level explicit and implicit racial prejudice are shown in Supplemental Table 2.

Statistical analysis. We used multilevel kernel density analysis (MKDA, Kober & Wager, 2010) to identify brain areas that consistently show activity to Black vs. White faces. Data were extracted from 24 contrasts in 22 studies (Table 1). Sample sizes from these 22 studies ranged from 7 to 60 participants, with a total of 481 participants. The 2 studies that included 2 contrasts had a fast (~30 ms) and slow (~500 ms) presentation of faces. Peak coordinates were extracted for each significant cluster in which activation was greater to Black than White faces. In MKDA, a 10 mm spherical kernel is then convolved around each of the peak coordinates from the included studies. A weighted average is then calculated of the resulting contrast indicator maps (CIMs) for each study, where the weight is the square root of the sample size, with studies that used fixed effects instead of random effects analyses down-weighted. Peak coordinates are nested within study CIMs, which are treated as random effects, accounting for the multi-level nature of the data and ensuring that no single study CIM can disproportionately contribute to the meta-analytic result. The resulting weighted average CIM is then compared to a null hypothesis in which peak coordinates are randomly distributed across gray matter (Kober & Wager, 2010).

We ran a weighted logistic regression using the `glmfit` function in matlab across every voxel in the CIMs for the 24 contrasts. Only voxels that were active in at least three CIMs were included. The resulting map was then mapped back in to MNI space using the tool `iimg_reconstruct_vols.m` (<https://github.com/canlab/CanlabCore>).

For the purposes of these analyses, a threshold of $t > 2.81$ ($p < .01$ on 23 *df*, two-tailed), with a minimum cluster size of $k > 100$ 2-mm voxels was used. This threshold is based on the cluster extents from the traditional MKDA analysis, which are based on Monte Carlo simulations (Kober & Wager, 2010), and consistent with the estimated minimum cluster size generated by the original version of Afni's 3dClustSim (Cox et al., 2017) using a smoothing kernel density of 10 mm, the spherical kernel size used to generate the CIMs.

The independent variable was community-level racial prejudice. The outcome variable was whether there was significantly greater activation to Black vs. White faces in a voxel within 10 mm of that voxel in any given study. Weights were applied as described above. In the sensitivity analyses, community-level racial prejudice was replaced by the 3 alternative variables described above.

Data and code are available at: https://github.com/dgweissman/stigma_mkda.

Results

Using data from 22 contrasts in 22 studies (Table 1), we used multilevel kernel density analysis (MKDA; Kober & Wager, 2010) to identify brain areas that consistently show activity to Black vs. White faces in predominantly White participants ($N=481$). Two clusters of voxels demonstrated significantly greater activation to Black vs. White faces across all the studies: left dorsolateral prefrontal cortex (dlPFC; 447 voxels, Center of Mass in MNI Space = -46, 34, 22) and dorsal anterior cingulate cortex (dACC; 431 voxels, Center of Mass = -4, 16, 40).

We then used weighted logistic regression to identify voxels where community-level racial prejudice was associated with neural activity to Black vs. White faces. Three

clusters of voxels demonstrated significantly greater activation to Black vs. White faces more frequently in studies conducted in counties where community residents explicitly endorsed higher (vs. lower) levels of racial prejudice: left dlPFC (233 voxels; $t=3.92$), dACC (173 voxels; $t=3.91$), and right amygdala (116 voxels; $t=2.91$) (Figure 1). Larger, higher quality studies where significant activation differences to Black vs. White faces were observed in these regions were conducted almost exclusively in communities with higher levels of explicit racial prejudice (Figure 2). In contrast, community-level *implicit* racial attitudes were unrelated to the likelihood of activation to Black (vs. White) faces in any neural region.

Sensitivity analyses further revealed that this pattern of activation in right amygdala and dACC was specific to community-level explicit racial prejudice. Community-level income inequality was unrelated to the likelihood of activation to Black (vs. White) faces in any brain region. In contrast, the left dlPFC was less likely to be activated to Black (vs. White) faces in studies conducted in counties where a higher percentage of the population is Black and college-educated.

Discussion

In a recent review of the social neuroscience of prejudice, Amodio and Cikara (2021) argued that as the field continues to develop, “it must make connections to real life forms of prejudice that persist in society...[which] will require new methods [and] greater ecological validity.” Heeding this call to action, we explored whether Whites’ neural responses to Black (vs. White) faces vary systematically based on the level of racial prejudice of residents of the surrounding community. Our results provide support for this contextual sensitivity hypothesis: living in an environment characterized by

higher (vs. lower) levels of explicit racial prejudice was associated with the magnitude of Whites' neural response to Black (vs. White) faces not only in the amygdala, but also in a region of dACC involved in salience processing. Although we also found that community-level explicit prejudice was associated with greater dIPFC response to Black (vs. White) faces, this region was also associated with other contextual factors, including the proportion of Black community members and average education level. Thus, our results suggest that community-level explicit racial prejudice is associated specifically with heightened neural response in two key nodes of the salience network (Seeley, 2019; Seeley et al., 2007). It is important to note that the distribution in the low-prejudice contexts is clustered around no effect in these key nodes of the salience network, whereas the distribution in the high-prejudice communities is shifted, such that associations between community-level explicit racial prejudice and neural activation to Black (vs. White) faces are observed in many (if not most) of these communities. These results therefore highlight the importance of identifying additional variables—over and above community-level explicit racial prejudice—that contribute to the associations observed herein.

In contrast to our results with explicit racial attitudes, and inconsistent with our hypothesis, community-level *implicit* racial attitudes were unrelated to the likelihood of activation to Black (vs. White) faces among Whites in any neural region. A number of factors appear to influence the associations of aggregated measures of implicit and explicit racial attitudes with psychological and health outcomes—including the domain assessed (i.e., attitude vs. stereotype), the unit of aggregation (i.e., county or state), and the level of social consensus in the topic (i.e., degree of regional correspondence between

implicit and explicit measures; Calanchini et al., 2022). We suspect that each of these factors may have contributed to the divergent associations in our analysis. Specifically, correlations between aggregated estimates of explicit and implicit racial bias are lower when regions are smaller (i.e., in counties as compared to states) and when explicit attitudes are assessed via stereotypes (as compared to measures of valence, like feeling thermometers) (Calanchini et al., 2022). Our analysis (i) focused on attitudes at the county level and (ii) used a composite measure of racial stereotypes, both of which would have reduced the likelihood of correspondence between these measures, and thus increased the likelihood that they were not both associated with the study outcomes (i.e., neural activation in the salience network). Indeed, the correlation between aggregated explicit and implicit racial attitudes in the counties included in our analysis was $r = 0.06$ ($p < 0.01$). Future research with different measures of explicit racial attitudes and with different geographic units of analysis is needed to determine whether these methodological characteristics are responsible for our divergent associations across implicit vs. explicit racial attitudes, or whether these differences instead indicate that neural activation to Black (vs. White) faces may be sensitive to some features of regional bias and not others. Future research would also benefit from examining whether our results generalize to different measures of community-level racial prejudice that do not rely on assessment of attitudes, such as racial disparities in incarceration, which have been used in prior studies as indicators of structural racism (e.g., Lukachko et al., 2014), or local demographic distributions (e.g., whether the target group is largest among the minoritized groups in a given community) which have been linked to hate crimes (Cikara, Fouka, & Tabellini, 2022).

One concern in observational studies is whether associations are due to the independent variable or to factors correlated with it. We addressed this issue in part through sensitivity analyses, which showed that the pattern of neural activation in amygdala and dACC, but not dlPFC, was specific to community-level explicit racial prejudice and was not observed for other community-level characteristics that may be causes or consequences of racial prejudice, thereby strengthening our inferences. Nevertheless, future studies would benefit from the use of additional methods for exploring this question, such as longitudinal designs that examine whether changes in community-level racial prejudice are associated with changes in response to out-group members in the neural regions observed here.

Spatial meta-analysis is uniquely suited to addressing our research question, because it capitalizes on the geographic heterogeneity in community-level racial prejudice across neuroimaging studies—heterogeneity that is not present across individuals within single-site studies. This approach also affords greater precision in the point estimates of the neural data and community racial prejudice levels by averaging over fMRI participants' neural responses and community members' prejudice scores, respectively. Despite these methodological advantages, spatial meta-analysis is less well-suited for answering questions of mechanism—that is, identifying which factors explain *why* community-level explicit racial prejudice is associated specifically with Whites' heightened neural response to Black (vs. White) faces in two key nodes of the salience network. Although caution is warranted in interpreting psychological states from neural activation patterns (Poldrack, 2011), there are several possible explanations of this pattern. For instance, for Whites living in contexts with higher levels of racial prejudice,

racial out-group members may be more salient or associated with greater uncertainty. These psychological responses could result, in part, from a variety of factors, including: less intergroup contact in high-prejudice communities (Tropp & Pettigrew, 2006); stronger norms around anti-Black prejudice as socially acceptable (Crandall et al., 2002), because individuals in high-prejudice communities are repeatedly exposed to environmental cues that differentiate and marginalize people on the basis of skin tone (Vuletic & Payne, 2019); because high-prejudice communities are places where racialization is a salient axis of intergroup conflict (Cikara, 2021; Pietraszewski, 2021); or even concerns about being exposed as prejudiced in the context of the study (Amodio 2014; Chekroud et al. 2014). We are unable to test these and other competing (though not mutually exclusive) psychological, intergroup, and contextual explanations because, like all meta-analyses, we are limited by the data that could be reliably coded across the individual studies that we have included. The current findings invite further experiments to identify the precise mechanisms by which community-level explicit racial prejudice is associated with activation of core nodes of the salience network.

An additional limitation of spatial meta-analyses has to do with data constraints in terms of the number and location of the studies, as the social contexts that are possible to study are constrained by where prior studies of neural response to Black (vs. White) faces happened to be conducted. In part, this is a reflection of the state of the social neuroscience literature, which is not geographically dispersed across the United States. As such, our sample includes a restricted range of community-level racial prejudice scores based on all possible counties from the Project Implicit dataset. For instance, the sites included in the analysis represent explicit racial prejudice values all within one

standard deviation relative to the range for all counties in the United States. It is worth noting that restricted ranges are observed in many studies aggregating prejudice data in Project Implicit. For example, in a study of 18 U.S. college campuses, the average Black-White IAT scores at baseline ranged from .50 to .63 on a scale of -2 to 2, but average outcomes in this truncated range still correlated with structural indicators of campus inequality (Vuletic & Payne, 2019). Moreover, the totality of the evidence suggests that as community-level racial prejudice increases so does adverse health among those with stigmatized identities (e.g., Calanchini et al., 2022; Hatzenbuehler, 2016; Hehman et al., 2019). Nevertheless, the restricted range in our analysis reduces generalizability, and thus we are unable to say definitively that the relationship that we observed between community-level explicit racial prejudice and Whites' neural responses to Black (vs. White) faces would remain monotonic for counties with very high levels of explicit racial prejudice, which were not represented in our dataset. Consequently, future studies would benefit from the incorporation of more sites with a wider range of community-level prejudice. One possibility for future work is to implement a multi-site study, in which investigators strategically sample respondents across a range of social contexts (e.g., counties, states) that vary on the key construct of interest (i.e., community-level prejudice), and then harmonize the collection of neuroimaging data across these sites. However, the resources needed to conduct and coordinate these large team-based efforts are often prohibitively expensive and time-consuming, which likely explains why no previous studies have used this method to evaluate our research question. As such, spatial meta-analyses currently offer the only feasible, timely approach for addressing this important, understudied topic.

As mentioned above, a limitation of meta-analyses more generally is that researchers are limited by the data that can be reliably coded across individual studies. These data limitations precluded us from adjusting for some potential study-level confounders that were either not reported across all studies included in our analytic sample or were assessed in such divergent ways that comparisons were not possible (e.g., differences across sites in scanner type or pre-processing pipelines). In particular, we were unable to examine whether community-level racial prejudice was associated with activation in amygdala and dACC above and beyond the racial attitudes and associations of the included participant samples, as over a third of the studies did not assess individual difference measures of prejudice. Among those studies that did include explicit and/or implicit individual difference measures, we counted six different measures of explicit race-related attitudes and motivations, and only 41% that included the IAT, hindering our ability to compare estimates across these studies. Thus, it is not possible with these data to disentangle the moderating effects of community- vs. individual-level bias on Whites' neural activation to Black (vs. White) faces. It is important to note, however, that many studies have documented that community-level racial prejudice predicts behavioral and health outcomes over and above the prejudice of individuals (e.g., Lee et al., 2015). Further, individual-level racial prejudice would be unlikely to generate the specific pattern of neural activation observed herein, especially given inconsistencies in the literature on the neural regions that correlate with individual racial prejudice (for review, see Amodio & Cikara, 2021). Nevertheless, future studies that simultaneously measure individual- and community-level racial prejudice are needed to explicitly test the relative

contribution of both in explaining regional variability in Whites' neural activation to Black (vs. White) faces.

Any meta-analysis of fMRI data is also limited by differences across studies in methodological choices about data pre-processing and cleaning, correction for multiple comparisons, and thresholding of significant results (see Botvinik-Nezer et al., 2020 for an empirical demonstration of this issue). Although these types of methodological differences are unlikely to explain the patterns observed here, they undoubtedly introduced noise into our estimates. To address directly whether differences in fMRI methods across time might have contributed to our results, we ran an additional analysis examining whether year of publication was associated with the pattern of neural response to Black vs. White faces. We found no association anywhere in the brain with year of publication or any association in the three regions of interest where we observed significant associations with community-level explicit racial prejudice (See Supplemental Figure 1). As such, it does not seem plausible that methodological differences in fMRI analysis over time are driving the pattern of results we observe. Nevertheless, future research using large-scale multi-site data collection focused specifically on the questions we examine here is the only remedy for the inevitable variations in fMRI methods that exist across individual studies.

Finally, the primary analytic model we utilized (multilevel kernel density analysis) cannot currently accommodate additional clustering above the study level; therefore, we were not able to cluster studies within counties. Indeed, the ability to account for the correlational structure between studies (e.g., multiple studies from the same labs, overlapping cohorts, non-independent contrasts) is a limitation of current

implementations of any meta-analysis software. Although we expect there to be minimal clustering at the county level, our inability to account for such clustering analytically could have led to inappropriately low confidence intervals if outcomes within counties were not independent. Given increasing interest in examining contextual influences on neural development (Hatzenbuehler et al., 2022), it will be important as this field develops to expand existing tools for conducting meta-analysis of fMRI data to accommodate more sources of clustering.

These limitations notwithstanding, our study makes a novel contribution to the social-cognitive neuroscience literature on prejudice. Our results demonstrate that neural response to Black (vs. White) faces among Whites is significantly more likely to occur in two key nodes of the salience network—the amygdala and dACC—in communities characterized by higher (vs. lower) levels of explicit racial prejudice. The results confirm the feasibility of using spatial meta-analysis to link macro-social contexts to neural outcomes, highlight the novel insights this tool can generate regarding the influence of broad contextual factors on brain function, and underscore the utility of this method for reconciling conflicting results in the cognitive neuroscience literature (Amodio & Cikara, 2021; Chekroud et al., 2014; Kubota et al., 2012; Phelps et al., 2000). We hope this proof-of-concept study stimulates more research into the emerging field of contextual cognitive neuroscience, which holds promise for linking contextual features of the social environment to brain structure and function (Hatzenbuehler et al., 2022).

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ACCEPTED MANUSCRIPT

References

References marked with an asterisk indicate studies included in the spatial meta-analysis

Amodio, D.M. (2014). The neuroscience of prejudice and stereotyping. *Nature Reviews Neuroscience*, 15(10), 670–682.

Amodio, D. M., & Cikara, M. (2021). The social neuroscience of prejudice. *Annual Review of Psychology*, 72(1), 439–469. <https://doi.org/10.1146/annurev-psych-010419-050928>

*Brosch, T., Bar-David, E., & Phelps, E. A. (2013). Implicit race bias decreases the similarity of neural representations of Black and White faces. *Psychological Science*, 24(2), 160–166. <https://doi.org/10.1177/0956797612451465>

*Brown, T. I., Uncapher, M. R., Chow, T. E., Eberhardt, J. L., & Wagner, A. D. (2017). Cognitive control, attention, and the other race effect in memory. *PLOS ONE*, 12(3), e0173579. <https://doi.org/10.1371/journal.pone.0173579>

Calanchini, J., Hehman, E., Ebert, T., Esposito, E., Deja, S., & Liz, W. (2022). Regional intergroup bias. *Advances in Experimental Social Psychology*.

Chekroud, A. M., Everett, J. A. C., Bridge, H., & Hewstone, M. (2014). A review of neuroimaging studies of race-related prejudice: Does amygdala response reflect threat? *Frontiers in Human Neuroscience*, 8. <https://doi.org/10.3389/fnhum.2014.00179>

Cikara, M. (2021). Causes and consequences of coalitional cognition. *Advances in Experimental Social Psychology*, 64, 65-128.

Cikara, M., Fouka, V., & Tabellini, M. (2022). Hate crime towards minoritized groups increases as they increase in sized-based rank. *Nature Human Behaviour*, online.

- Cikara, M., Martinez, J., E., & Lewis, N. A., Jr. (2022). Moving beyond social categories by incorporating context in social psychological theory. *Nature Reviews Psychology*, online.
- *Cloutier, J., Li, T., & Correll, J. (2014). The impact of childhood experience on amygdala response to perceptually familiar Black and White faces. *Journal of Cognitive Neuroscience*, 26(9), 1992–2004. https://doi.org/10.1162/jocn_a_00605
- *Contreras, J. M., Banaji, M. R., & Mitchell, J. P. (2013). Multivoxel patterns in fusiform face area differentiate faces by sex and race. *PLoS ONE*, 8(7), e69684. <https://doi.org/10.1371/journal.pone.0069684>
- Cox, R. W., Chen, G., Glen, D. R., Reynolds, R. C., & Taylor, P. A. (2017). FMRI clustering and false-positive rates. *Proceedings of the National Academy of Sciences*, 114(17), E3370–E3371. <https://doi.org/10.1073/pnas.1614961114>
- Crandall, C. S., Eshleman, A., & O'brien, L. (2002). Social norms and the expression and suppression of prejudice: the struggle for internalization. *Journal of Personality and Social Psychology*, 82(3), 359.
- *Cunningham, W. A., Johnson, M. K., Raye, C. L., Gatenby, J. C., Gore, J. C., & Banaji, M. R. (2004). Separable neural components in the processing of Black and White faces. *Psychological Science*, 15(12), 806–813. <https://doi.org/10.1111/j.0956-7976.2004.00760.x>
- *Firat, R. B., Hitlin, S., Magnotta, V., & Tranel, D. (2017). Putting race in context: Social class modulates processing of race in the ventromedial prefrontal cortex and amygdala. *Social Cognitive and Affective Neuroscience*, 12(8), 1314–1324. <https://doi.org/10.1093/scan/nsx052>

- *Forbes, C. E., Cox, C. L., Schmader, T., & Ryan, L. (2012). Negative stereotype activation alters interaction between neural correlates of arousal, inhibition and cognitive control. *Social Cognitive and Affective Neuroscience*, 7(7), 771–781. <https://doi.org/10.1093/scan/nsr052>
- Fullana, M. A., Harrison, B. J., Soriano-Mas, C., Vervliet, B., Cardoner, N., Àvila-Parcet, A., & Radua, J. (2016). Neural signatures of human fear conditioning: An updated and extended meta-analysis of fMRI studies. *Molecular Psychiatry*, 21(4), 500–508. <https://doi.org/10.1038/mp.2015.88>
- *Hart, A. J., Whalen, P. J., Shin, L. M., McInerney, S. C., Fischer, H., & Rauch, S. L. (2000). Differential response in the human amygdala to racial outgroup vs ingroup face stimuli. *NeuroReport*, 11(11), 2351–2354. <https://doi.org/10.1097/00001756-200008030-00004>
- Hatzenbuehler, M. L. (2016). Structural stigma: Research evidence and implications for psychological science. *American Psychologist*, 71(8), 742–751. <https://doi.org/10.1037/amp0000068>
- Hatzenbuehler, M. L., McLaughlin, K. A., Weissman, D. G., & Cikara, M. (2022). *Does social inequality influence brain structure and function? Advancing the emerging subfield of contextual cognitive neuroscience*. Manuscript under review.
- Hatzenbuehler, M. L., Weissman, D. G., McKetta, S., Lattanner, M. R., Ford, J. V., Barch, D. M., & McLaughlin, K. A. (2021). Smaller hippocampal volume among Black and Latinx youth living in high-Stigma contexts. *Journal of the American Academy of Child & Adolescent Psychiatry*, S0890856721013617. <https://doi.org/10.1016/j.jaac.2021.08.017>

- Hehman, E., Calanchini, J., Flake, J. K., & Leitner, J. B. (2019). Establishing construct validity evidence for regional measures of explicit and implicit racial bias. *Journal of Experimental Psychology: General*, *148*(6), 1022–1040.
<https://doi.org/10.1037/xge0000623>
- *Hughes, C., Babbitt, L. G., & Krendl, A. C. (2019). Culture impacts the neural response to perceiving outgroups among Black and White faces. *Frontiers in Human Neuroscience*, *13*, 143. <https://doi.org/10.3389/fnhum.2019.00143>
- Johnson, B. T., Cromley, E. K., & Marrouch, N. (2017). Spatiotemporal meta-analysis: Reviewing health psychology phenomena over space and time. *Health Psychology Review*, *11*(3), 280–291.
<https://doi.org/10.1080/17437199.2017.1343679>
- Kennedy, B. P., Kawachi, I., Lochner, K., Jones, C., & Prothrow-Stith, D. (1997). (Dis)respect and Black mortality. *Ethnicity & Disease*, *7*(3), 207–214.
- Kober, H., & Wager, T. D. (2010). Meta-analysis of neuroimaging data. *WIREs Cognitive Science*, *1*(2), 293–300. <https://doi.org/10.1002/wcs.41>
- Kubota, J. T., Banaji, M. R., & Phelps, E. A. (2012). The neuroscience of race. *Nature Neuroscience*, *15*(7), 940–948. <https://doi.org/10.1038/nn.3136>
- Lattanner, M. R., Ford, J., Bo, N., Tu, W., Pachankis, J. E., Dodge, B., & Hatzenbuehler, M. L. (2021). A contextual approach to the psychological study of identity concealment: Examining direct, interactive, and indirect effects of structural stigma on concealment motivation across proximal and distal geographic levels. *Psychological Science*, *32*(10), 1684–1696.
<https://doi.org/10.1177/09567976211018624>

- Lee, Y., Kawachi, I., Muennig, P., & Hatzenbuehler, M.L. (2015). Effects of racial prejudice on the health of communities: A multilevel survival analysis. *American Journal of Public Health, 105*, 2349-2355.
- Leitner, J. B., Hehman, E., Ayduk, O., & Mendoza-Denton, R. (2016). Blacks' death rate due to circulatory diseases is positively related to Whites' explicit racial bias: A nationwide investigation using project implicit. *Psychological Science, 27*(10), 1299–1311. <https://doi.org/10.1177/0956797616658450>
- *Li, T., Cardenas-Iniguez, C., Correll, J., & Cloutier, J. (2016). The impact of motivation on race-based impression formation. *NeuroImage, 124*, 1–7. <https://doi.org/10.1016/j.neuroimage.2015.08.035>
- *Lieberman, M. D., Hariri, A., Jarcho, J. M., Eisenberger, N. I., & Bookheimer, S. Y. (2005). An fMRI investigation of race-related amygdala activity in African-American and Caucasian-American individuals. *Nature Neuroscience, 8*(6), 720–722. <https://doi.org/10.1038/nn1465>
- Lindquist, K. A., Satpute, A. B., Wager, T. D., Weber, J., & Barrett, L. F. (2016). The brain basis of positive and negative affect: Evidence from a meta-analysis of the human neuroimaging literature. *Cerebral Cortex, 26*(5), 1910–1922. <https://doi.org/10.1093/cercor/bhv001>
- *Losin, E. A. R., Cross, K. A., Iacoboni, M., & Dapretto, M. (2014). Neural processing of race during imitation: Self-similarity versus social status. *Human Brain Mapping, 35*(4), 1723–1739. <https://doi.org/10.1002/hbm.22287>

- *Losin, E. A. R., Iacoboni, M., Martin, A., Cross, K. A., & Dapretto, M. (2012). Race modulates neural activity during imitation. *NeuroImage*, *59*(4), 3594–3603.
<https://doi.org/10.1016/j.neuroimage.2011.10.074>
- Lukachko, A., Hatzenbuehler, M.L., & Keyes, K. M. (2014). Structural racism and myocardial infarction in the United States. *Social Science & Medicine*, *103*, 42-50.
- *Mathur, V. A., Harada, T., & Chiao, J. Y. (2012). Racial identification modulates default network activity for same and other races. *Human Brain Mapping*, *33*(8), 1883–1893. <https://doi.org/10.1002/hbm.21330>
- *Mathur, V. A., Harada, T., Lipke, T., & Chiao, J. Y. (2010). Neural basis of extraordinary empathy and altruistic motivation. *NeuroImage*, *51*(4), 1468–1475.
<https://doi.org/10.1016/j.neuroimage.2010.03.025>
- *Mattan, B. D., Kubota, J. T., Dang, T. P., & Cloutier, J. (2018). External motivation to avoid prejudice alters neural responses to targets varying in race and status. *Social Cognitive and Affective Neuroscience*, *13*(1), 22–31.
<https://doi.org/10.1093/scan/nsx128>
- McKetta, S., Hatzenbuehler, M. L., Pratt, C., Bates, L., Link, B. G., & Keyes, K. M. (2017). Does social selection explain the association between state-level racial animus and racial disparities in self-rated health in the United States? *Annals of Epidemiology*, *27*(8), 485-492.e6.
<https://doi.org/10.1016/j.annepidem.2017.07.002>
- Merritt, C. C., MacCormack, J. K., Stein, A. G., Lindquist, K. A., & Muscatell, K. A. (2021). The neural underpinnings of intergroup social cognition: An fMRI meta-

- analysis. *Social Cognitive and Affective Neuroscience*, 16(9), 903–914.
<https://doi.org/10.1093/scan/nsab034>
- Müller, V. I., Cieslik, E. C., Laird, A. R., Fox, P. T., Radua, J., Mataix-Cols, D., Tench, C. R., Yarkoni, T., Nichols, T. E., Turkeltaub, P. E., Wager, T. D., & Eickhoff, S. B. (2018). Ten simple rules for neuroimaging meta-analysis. *Neuroscience & Biobehavioral Reviews*, 84, 151–161.
<https://doi.org/10.1016/j.neubiorev.2017.11.012>
- Murphy, M. C., Kroeper, K. M., & Ozier, E. M. (2018). Prejudiced places: How contexts shape inequality and how policy can change them. *Policy Insights from the Behavioral and Brain Sciences*, 5(1), 66–74.
<https://doi.org/10.1177/2372732217748671>
- Oforu, E. K., Chambers, M. K., Chen, J. M., & Hehman, E. (2019). Same-sex marriage legalization associated with reduced implicit and explicit antigay bias. *Proceedings of the National Academy of Sciences*, 116(18), 8846–8851.
<https://doi.org/10.1073/pnas.1806000116>
- Payne, B. K., Vuletich, H. A., & Lundberg, K. B. (2017). The bias of crowds: How implicit bias bridges personal and systemic prejudice. *Psychological Inquiry*, 28(4), 233–248. <https://doi.org/10.1080/1047840X.2017.1335568>
- Pearce, N. (2011). Epidemiology in a changing world: Variation, causation and ubiquitous risk factors. *International Journal of Epidemiology*, 40(2), 503–512.
<https://doi.org/10.1093/ije/dyq257>

- Pettigrew, T. F. (2018). The emergence of contextual social psychology. *Personality and Social Psychology Bulletin*, 44(7), 963–971.
<https://doi.org/10.1177/0146167218756033>
- Pietraszewski, D. (2022). Toward a computational theory of social groups: A finite set of cognitive primitives for representing any and all social groups in the context of conflict. *Behavioral and Brain Sciences*, 45.
- *Phelps, E. A., O'Connor, K. J., Cunningham, W. A., Funayama, E. S., Gatenby, J. C., Gore, J. C., & Banaji, M. R. (2000). Performance on indirect measures of race evaluation predicts amygdala activation. *Journal of Cognitive Neuroscience*, 12(5), 729–738. <https://doi.org/10.1162/089892900562552>
- Poldrack, R. A. (2011). Inferring mental states from neuroimaging data: From reverse inference to large-scale decoding. *Neuron*, 72(5), 692–697.
<https://doi.org/10.1016/j.neuron.2011.11.001>
- Reid, A. E., Dovidio, J. F., Ballester, E., & Johnson, B. T. (2014). HIV prevention interventions to reduce sexual risk for African Americans: The influence of community-level stigma and psychological processes. *Social Science & Medicine*, 103, 118–125. <https://doi.org/10.1016/j.socscimed.2013.06.028>
- *Richeson, J. A., Baird, A. A., Gordon, H. L., Heatherton, T. F., Wyland, C. L., Trawalter, S., & Shelton, J. N. (2003). An fMRI investigation of the impact of interracial contact on executive function. *Nature Neuroscience*, 6(12), 1323–1328.
<https://doi.org/10.1038/nn1156>

- *Richeson, J. A., Todd, A. R., Trawalter, S., & Baird, A. A. (2008). Eye-gaze direction modulates race-related amygdala activity. *Group Processes & Intergroup Relations*, *11*(2), 233–246. <https://doi.org/10.1177/1368430207088040>
- *Ronquillo, J., Denson, T. F., Lickel, B., Lu, Z.-L., Nandy, A., & Maddox, K. B. (2007). The effects of skin tone on race-related amygdala activity: An fMRI investigation. *Social Cognitive and Affective Neuroscience*, *2*(1), 39–44. <https://doi.org/10.1093/scan/nsi043>
- Seeley, W. W. (2019). The Salience Network: A neural system for perceiving and responding to homeostatic demands. *The Journal of Neuroscience*, *39*(50), 9878–9882. <https://doi.org/10.1523/JNEUROSCI.1138-17.2019>
- Seeley, W. W., Menon, V., Schatzberg, A. F., Keller, J., Glover, G. H., Kenna, H., Reiss, A. L., & Greicius, M. D. (2007). Dissociable intrinsic connectivity networks for salience processing and executive control. *Journal of Neuroscience*, *27*(9), 2349–2356. <https://doi.org/10.1523/JNEUROSCI.5587-06.2007>
- *Stanley, D. A., Sokol-Hessner, P., Fareri, D. S., Perino, M. T., Delgado, M. R., Banaji, M. R., & Phelps, E. A. (2012). Race and reputation: Perceived racial group trustworthiness influences the neural correlates of trust decisions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1589), 744–753. <https://doi.org/10.1098/rstb.2011.0300>
- Van Bavel, J. J., Packer, D. J., & Cunningham, W. A. (2008). The neural substrates of in-group bias: A functional magnetic resonance imaging investigation. *Psychological Science*, *19*(11), 1131–1139. <https://doi.org/10.1111/j.1467-9280.2008.02214.x>

Vuletich, H. A., & Payne, B. K. (2019). Stability and change in implicit bias.

Psychological Science, 30(6), 854–862.

<https://doi.org/10.1177/0956797619844270>

*Wheeler, M. E., & Fiske, S. T. (2005). Controlling racial prejudice: Social-cognitive goals affect amygdala and stereotype activation. *Psychological Science*, 16(1), 56–63. <https://doi.org/10.1111/j.0956-7976.2005.00780.x>

Xu, F. K., Lofaro, N., Nosek, B. A., Greenwald, A. G., Axt, J., & Simon, L. (2013, September 26). *Race IAT 2002-2020*. OSF. <https://osf.io/52qxl/>

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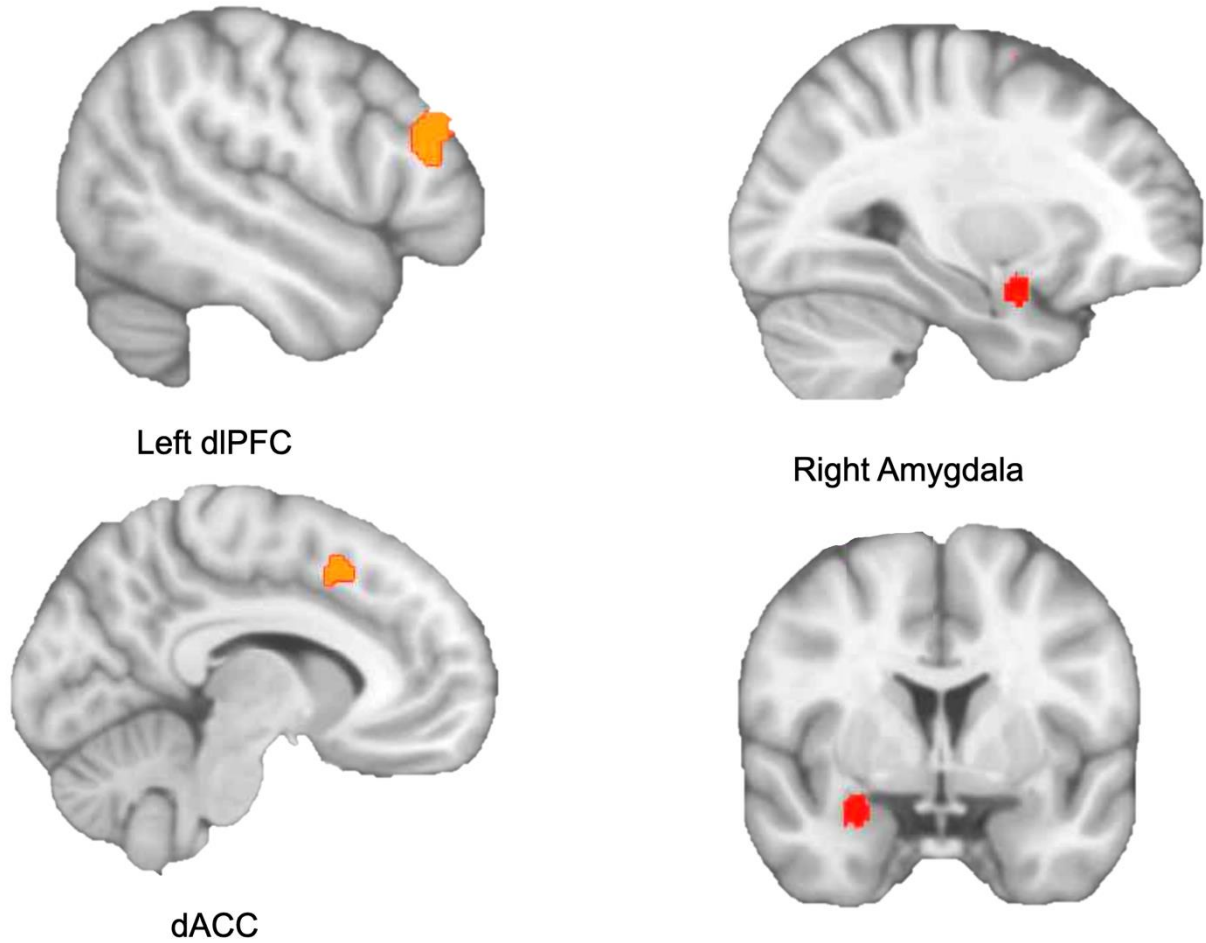
Table 1. Studies Included in Spatial Meta-Analysis by Location and Community-Level Explicit Racial Prejudice

Study	N	Number of Contrasts	Number of Significant Clusters	Study location	Community-Level Explicit Racial Prejudice Score
Richeson et al., 2003	15	1	2	Grafton County, NH	-0.902
Brosch et al., 2013	19	1	0	New York County, NY	-0.684
Stanley et al., 2012	40	1	2	New York County, NY	-0.684
Hart et al., 2000	8	1	3	Suffolk County, MA	-0.653
Cunningham et al., 2004	13	2	13	New Haven County, CT	-0.575
Phelps et al., 2000	14	1	0	New Haven County, CT	-0.575
Contreras et al., 2013	17	1	2	Middlesex County, MA	-0.531
Wheeler & Fiske, 2005	7	1	5	Mercer County, NJ	-0.455
Hughes et al., 2019	18	1	6	Multiple counties MA and NH*	-0.419
Brown et al., 2017	19	1	0	Santa Clara County, CA	-0.380
Cloutier et al., 2014	45	1	1	Cook County, IL	-0.372
Forbes et al., 2012	21	2	11	Pima County, AZ	-0.371
Li et al., 2016	44	1	0	Cook County, IL	-0.372
Mathur et al., 2010	28	1	7	Cook County, IL	-0.372
Mathur et al., 2012	20	1	2	Cook County, IL	-0.372
Mattan et al., 2018	60	1	2	Cook County, IL	-0.372
Richeson et al., 2008	9	1	1	Cook County, IL	-0.372

Firat et al., 2017	13	1	0	Johnson County, Iowa	-0.364
Lieberman et al., 2005	20	1	4	Los Angeles County, CA	-0.314
Losin et al., 2012	20	1	16	Los Angeles County, CA	-0.314
Losin et al., 2014	20	1	17	Los Angeles County, CA	-0.314
Ronquillo et al., 2007	11	1	1	Los Angeles County, CA	-0.314

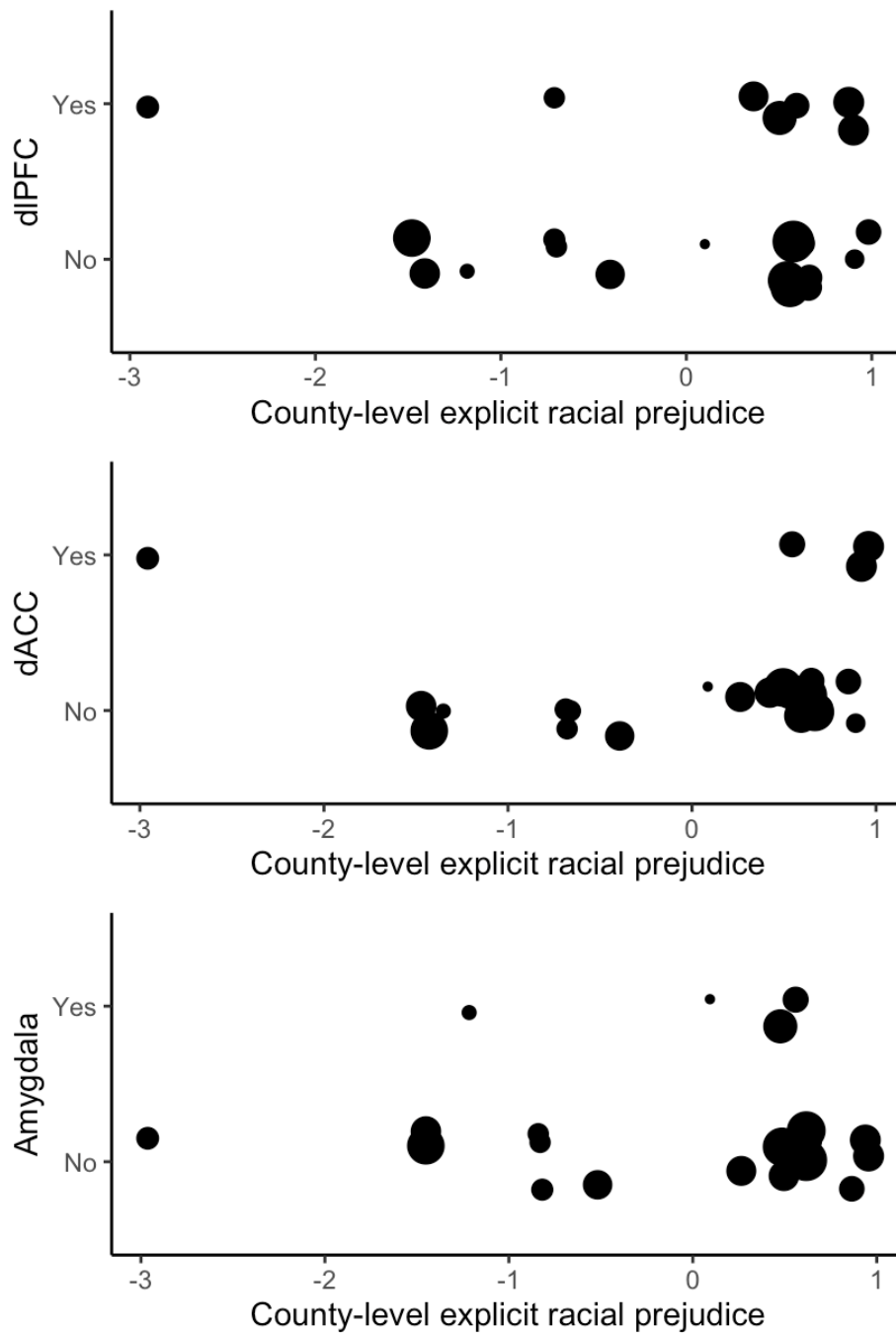
Note: Community-level explicit racial prejudice was subsequently mean-centered for analysis. *Sample represented “greater Boston area.” Included Massachusetts (MA) counties were Suffolk, Middlesex, Norfolk, Essex, Plymouth; included New Hampshire (NH) counties were Rockingham and Stratford. County scores ranged from -0.653 to 0.156 and were averaged to create a single score (shown above in the table).

Figure 1. Clusters Where Significant Activation to Black vs. White Faces was More Commonly Observed in Studies Conducted in Counties with Higher (vs. Lower) Explicit Racial Prejudice



Notes. Based on a meta-analytic voxel-wise weighted logistic regression analysis within the multi-kernel density analysis framework. dIPFC = dorsolateral prefrontal cortex; dACC = dorsal anterior cingulate cortex.

Figure 2. Plots of Significant Activation Differences to Black vs. White Faces in Studies Conducted in Counties with Varying Levels of Explicit Racial Prejudice



Notes. X-axes represent the standardized explicit racial prejudice factor score for the county where the study was conducted. Y-axes represent whether there was a significant activation reported within 10 mm of each cluster. Point sizes reflect the weight applied to each study based on its sample size and whether random or fixed effects were used in analyses.