Social Neuroscience

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/psns20

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To cite this article: Mark L. Hatzenbuehler, Katie A. Mclaughlin, David G. Weissman & Mina Cikara (2022): Community-level explicit racial prejudice potentiates whites' neural responses to black faces: A spatial meta-analysis, Social Neuroscience, DOI: 10.1080/17470919.2022.2153915

To link to this article: https://doi.org/10.1080/17470919.2022.2153915

SOCIAL NEUROSCIENCE
https://doi.org/10.1080/17470919.2022.2153915

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RESEARCH PAPER

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.

ARTICLE HISTORY
Received 3 June 2022
Revised 28 September 2022
Published online 16 December 2022

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-groups 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, as has been shown for psychosocial constructs (Lattanner et al., 2021; Pettigrew, 2018). Specifically, we examined whether Whites' neural responses to Black (vs. White) faces[1] 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, 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-groups relative to in-group members. Although meta-analyses of fMRI studies have

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[1]We 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, et al., 2022).

Supplemental data for this article can be accessed online at https://doi.org/10.1080/17470919.2022.2153915

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, and 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). The 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

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 and 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

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).

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 states and in 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 the 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 S1) 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 Vuletich and 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 toward 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 the 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 three alternative variables. These were as follows: 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 prejudices 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 two studies that included two 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 results. 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 into 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 three 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

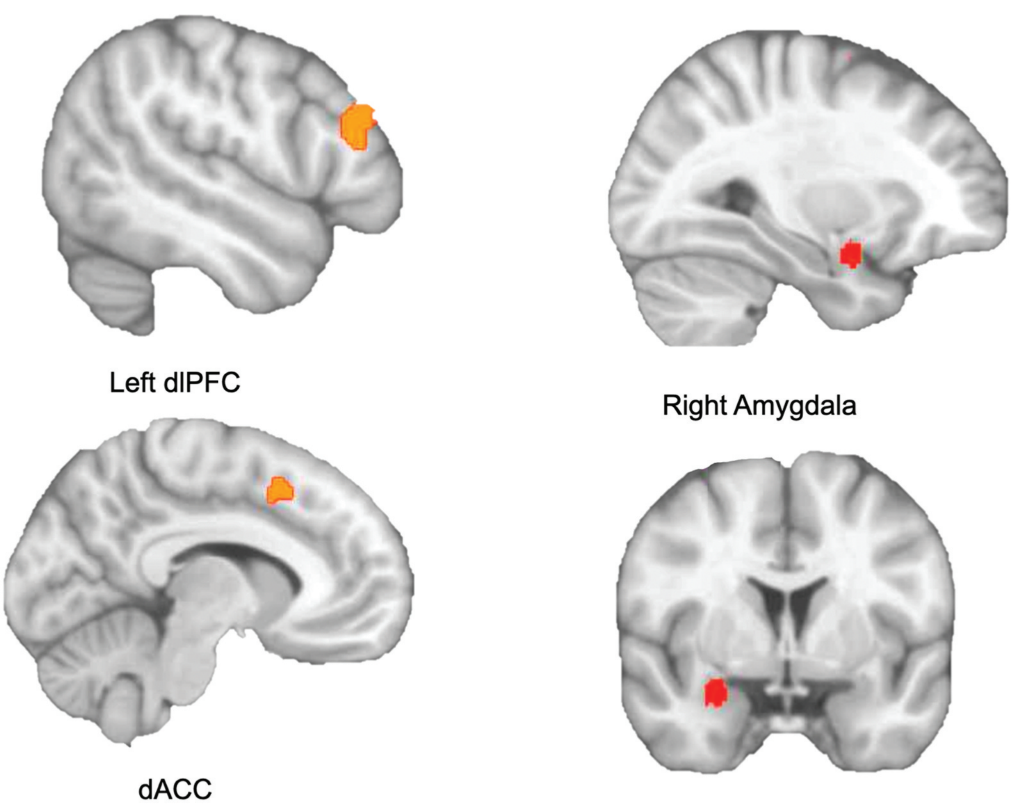

Figure 1. Clusters where significant activation to black vs. white faces was more commonly observed in studies conducted in counties with higher (vs. lower) explicit racial prejudice. Notes. Based on a meta-analytic voxel-wise weighted logistic regression analysis within the multi-kernel density analysis framework. dlPFC = dorsolateral prefrontal cortex; dACC = dorsal anterior cingulate cortex.

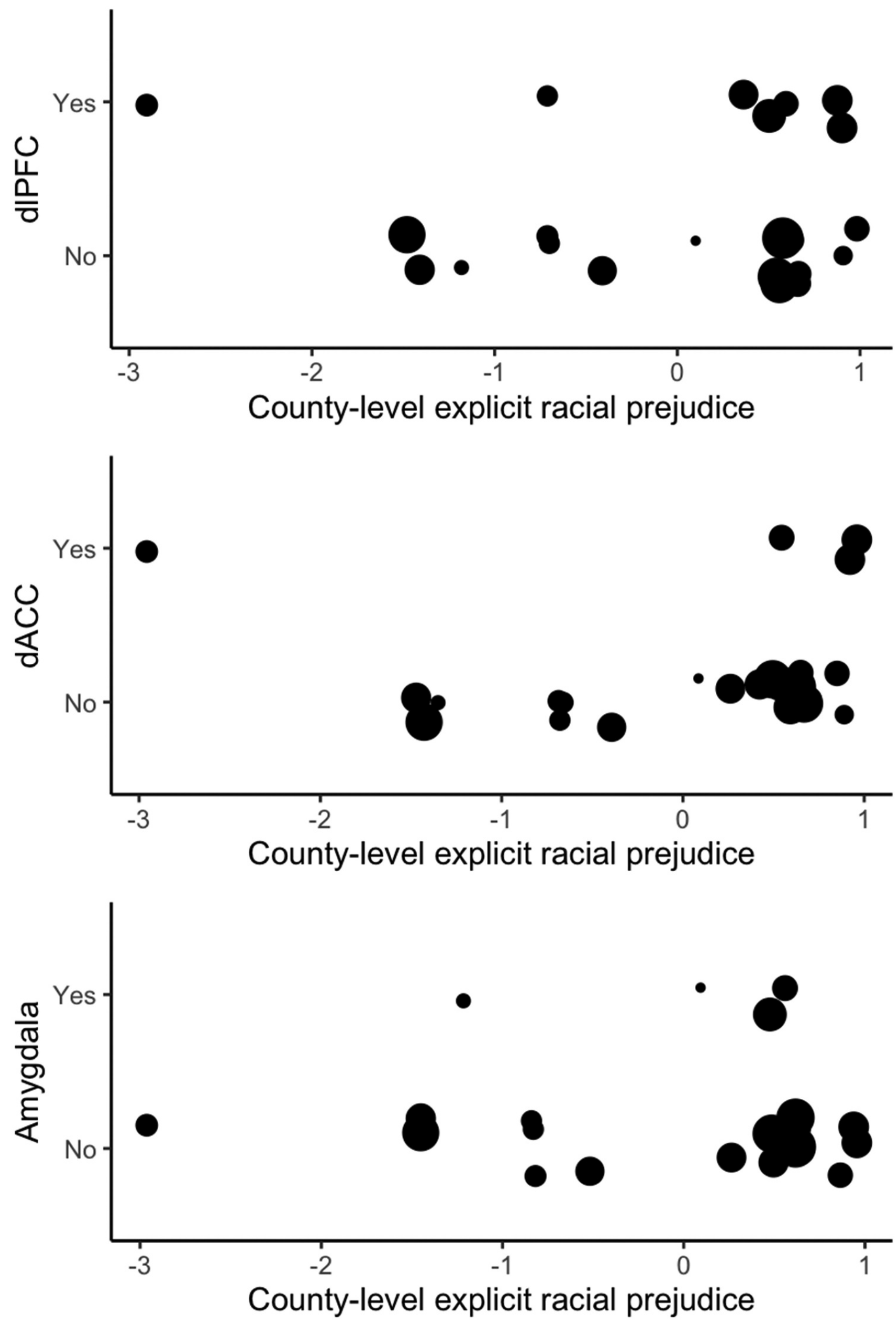

Figure 2. Plots of significant activation differences to black vs. White faces in studies conducted in counties with varying levels of explicit racial prejudice. Notes. X-axes represent the standardized explicit racial prejudice factor score for the county where the study was conducted. Y-axes represent 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.

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

n 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 dlPFC 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 et al., 2007; Seeley, 2019). 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, etal., 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 for 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 (Pettigrew & Tropp, 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 (Vuletich & Payne, 2005); because high-prejudice communities are places where racialization is a salient axis of intergroup conflict (Cikara, 2021; Pietraszewski, 2022); 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 (Vuletich & Payne, 2005). 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 and 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 types 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 the 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 the 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 the 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).

Acknowledgements

The authors would like to acknowledge Yu Six and Rachel Krasner for their help in coding articles, and Micah Lattanner and Sarah McKetta for their analysis of the Project Implicit data.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the National Institutes of Health [R01-MH106482; R37-MH119194; and K99MH127248.]; The National Science Foundation [NSF CAREER award 1653188.]

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