HHS Public Access
Author manuscript
Dev Psychol. Author manuscript; available in PMC 2024 October 02.

Published in final edited form as:
Dev Psychol. 2024 April ; 60(4): 649–664. doi:10.1037/dev0001721.

How is Race Perceived During Adolescence? A Meta-Analysis of the Own-Race Bias

Junqiang Dai[1], **Jason W. Griffin**[2], **K. Suzanne Scherf**[*,3]

[1]Department of Psychology and Neuroscience, The University of North Carolina at Chapel Hill

[2]Yale Child Study Center, School of Medicine, Yale University

[3]Department of Psychology, Pennsylvania State University, University Park

Abstract

Adolescence is a critical developmental period that is marked by drastic changes in face recognition, which are reflected in patterns of bias (i.e., superior recognition for some individuals compared to others). Here, we evaluate how race is perceived during face recognition and whether adolescents exhibit an own-race bias (ORB). We conducted a Bayesian meta-analysis to estimate the summary effect size of the ORB across 16 unique studies (38 effect sizes) with 1,321 adolescent participants between the ages of ~10 – 22 years of age. This meta-analytic approach allowed us to inform the analysis with prior findings from the adult literature and evaluate how well they fit the adolescent literature. We report a positive, small ORB (Hedge's $g = 0.24$) that was evident under increasing levels of uncertainty in the analysis. The magnitude of the ORB was not systematically impacted by participant age or race, which is inconsistent with predictions from perceptual expertise and social cognitive theories. Critically, our findings are limited in generalizability by the study samples, which largely include White adolescents in White-dominant countries. Future longitudinal studies that include racially diverse samples and measure social context, perceiver motivation, peer re-orientation, social network composition, and ethnic-racial identity development, are critical for understanding the presence, magnitude, and relative flexibility of the ORB in adolescence.

Keywords

adolescent; face recognition; Bayesian; meta-analysis; own-race bias; other-race effect

1. Introduction

There is a large literature reporting that adults, particularly White adults, exhibit a bias to recognize individuals within their own race (i.e., other White adults) compared to individuals from another race (e.g., other Black adults). This pattern of bias has been called the "own-race bias" (ORB), "other-race effect" (ORE), "cross-race effect (CRE)" (Hugenberg, Young, Levin, 1996; Meissner & Brigham, 2001). Understanding how the

[*]Corresponding author: Correspondence concerning this article should be addressed to K. Suzanne Scherf (suzyscherf@psu.edu), Pennsylvania State University, 113 Moore Building, University Park, Pennsylvania 16802.

ORB emerges and changes developmentally has both scientific and social implications. For example, criminal justice systems, particularly in Western countries, rely on eyewitness identification of suspects, despite findings of the ORB (Sporer, 2001). The most recent Innocence Project investigation reported that the ORB is responsible for a great number of wrongful convictions (Smith, Stinson, & Prosser, 2004). In addition, the magnitude of the ORB is associated with one's implicit attitude, explicit attitude, and stereotypes toward other-race individuals (Amodio, 2014; Ito, Chiao, Devine, Lorig, & Cacioppo, 2006; Phelps, O'Connor, Funayama, Gore, & Banaji, 2000; Stanley, Sokol-Hessner, Banaji, & Phelps, 2011). Finally, perception of race-related information may influence other aspects of social behaviors including economic decisions towards (Stanley et al., 2011, 2012), and empathy (or lack thereof) for individuals from other-race groups (Cao, Contreras-Huerta, McFadyen, & Cunnington, 2015). Therefore, understanding the emergence, developmental trajectory, and plasticity of the ORB may provide researchers with an important avenue for understanding (and potentially changing) racial interactions.

The existing literature investigating the ORB has largely focused on the developmental origins in infancy (Sugden & Marquis, 2017) as well as the presence, magnitude, and moderators of the ORB in adult face recognition behavior (Bingham & Miessner, 2001; Lee & Penrod, 2022). Together, these literatures indicate that the first signs of race biases in face recognition behavior emerge in infancy (see Lee, Quinn, & Pascalis, 2017). These biases reflect the racial characteristics of adult faces in infants' ambient environment, and specifically of caregivers' faces (Anzures et al., 2013). However, the developmental trajectory of these biases can be altered using training paradigms in which other race faces are presented (and named) to infants (e.g., Heron-Delaney et al., 2011). Among adults, race biases in face recognition are robust (Lee & Penrod, 2022), but also malleable (Lebrecht et al.,2009), and curiously unrelated to self-reports of time spent with other race individuals (Corenblum & Meissner, 2006; Walker & Hewstone, 2006).

Researchers are working to integrate and understand these findings in the context of two broadly defined theoretical frameworks, namely the perceptual learning/expertise and social cognitive models (for review see Scherf & Scott, 2012). Briefly, the perceptual expertise models emphasize the disproportionate influence of own- compared to other-race faces in visual input, particularly in one's early experiences, that lead to different visuoperceptual processing strategies for recognizing own- and other-race faces (e.g., Kelly et al., 2007). The social cognitive theories argue that categorization of faces into social categories (in- versus out-group) influences the visuoperceptual processing strategies that are employed when faces are encountered (e.g., Levin, 2000). Generally, both frameworks predict a relative *increase* in the magnitude of the ORB as a function of *experience*, which is often measured with age. In other words, infants who become children, adolescents, and then adults, are expected to be gaining differentially more experience with own-race faces than with other-race faces, especially in homogenous environments. This differential experience leads to separate processing strategies that enhance recognition of own- but not other-race faces. As a result, both theories predict that the magnitude of the ORB increases as a function of age. Importantly, assessing this prediction requires an evaluation of the full developmental trajectory of ORB in face recognition behavior from infancy to adulthood, with a focus on investigating how age/experience impacts the magnitude of the ORB. Therefore, it is essential to understand the *full developmental trajectory* of the ORB in face recognition behavior to evaluate whether these are the primary mechanisms supporting the behavioral and neural basis of the ORB.

Here, as a first step in addressing this gap in the literature, we provide an empirical investigation of the existing work studying the presence and magnitude of the ORB among *adolescents*. We focused on adolescents (and not the full age range of children and adolescents) for several reasons. First, a large literature indicates that face recognition behavior develops in age-related ways in adolescence (Scherf, Behrmann, & Dahl, 2012; Scherf & Scott, 2012). For instance, several large-scale studies have reported linear improvements in face recognition abilities across the age range of adolescence (e.g., Lawrence, Bernstein, Person, Mandy, Campbell, & Skuse, 2018; Germine, Duchaine, & Nakayama, 2011; Fuhrmann et al., 2016). These behavioral improvements might reflect increasing efficiency of the visuoperceptual/cognitive strategies for encoding and representing human faces as a function of experience and/or brain development. This idea is supported by neuroimaging findings of increasing magnitude and size of category-selective activation for faces in the developing brain across multiple regions (e.g., Scherf, Behrmann, Humphreys, & Luna, 2007; Scherf, Luna, Minshew, & Behrmann, 2010) and myelination of long-range fiber pathways that connect these regions (e.g., Scherf, Thomas, Doyle, & Behrmann, 2014). These adolescent age-related improvements in face recognition behavior may disproportionately improve own- compared to other-race face recognition in ways that reflect measurable changes to the magnitude of the ORB.

Second, in the last 15 years, the literature investigating the presence and moderating factors of the ORB in adolescence has grown to reach a critical mass suitable to power an empirical meta-analysis. Table 1 provides a list of the reviewed studies with demographic characteristics.

Third, studies comparing children and adolescents in the same paradigm often suffer from restriction of range issues (i.e., floor/ceiling effects) that make interpreting age-related effects (or lack thereof) problematic. Specifically, it is challenging to develop and employ experimental paradigms that are equally developmentally sensitive in children and adolescents. As a result, paradigms that test a wide age span often have restriction of range issues. This is especially concerning when one or more groups perform at ceiling (or floor) in one condition, which prohibits the ability to measure differential performance with the other condition. These restriction of range issues can influence the interpretation of condition differences (e.g., ORB) across age groups when performance on the task changes as a function of age (for discussion see Mckone et al., 2012). Additionally, one study successfully avoided restricted range issues when comparing children and adolescents in the same ORB paradigm (Chien et al., 2018). The researchers reported that children under the age of 10 did not evince an ORB. These findings suggest that there may be discontinuities in the presence/magnitude of the ORB in the transition from childhood to adolescence. Therefore, including studies of children and adolescents in the same meta-analysis may be equivalent to comparing qualitatively different groups, rather than investigating quantitative age-related changes in the magnitude of the ORB, which is the hypothesis of the primary theories.

When defining adolescence, there are multiple factors to consider. Adolescence is conceptually defined as the developmental period surrounding the transition from late childhood to early adulthood, which includes the period between sexual maturation and the attainment of adult roles and responsibilities (Dahl, 2004). As a result, it is difficult to mark adolescence with clear age boundaries. For example, the World Health Organization proposes that adolescence commences with puberty and has a less well-defined endpoint, therefore, they recommend defining it as the second decade (i.e., ~10–20 years of age, WHO, 1977). More recently, epidemiologists have argued that the age range of approximately 10–24 years of age aligns more closely with contemporary patterns of adolescent growth and popular understandings of this life phase (Sawyer et al., 2018). Therefore, we adopted this later definition and defined *adolescence* by the age range (~10–24 years of age).

As in the adult and infant ORB literatures, the studies that include adolescent participants most often evaluate the magnitude of the ORB in White participants (see Table 1). This is important to note because this work is typically conducted in countries where White individuals have sociopolitical and economic power (e.g., United States) and a history of prejudice and/or discrimination toward the "other race" faces in the experimental paradigm (e.g., Black faces). In these same environments, adult studies have revealed that marginalized participants of color do not necessarily exhibit an ORB, particularly in terms of recognizing White faces (e.g., Gross, 2009). A recent meta-analysis of the adult literature indicated that the magnitude of the ORB is larger for White compared to non-White participants (Lee & Penrod, 2022). Therefore, it is important to evaluate the generalizability of ORB findings to non-White adolescents, particularly adolescents of color from ethnic-racial minority groups and those representing historically marginalized groups[1]. Unfortunately, there are very few existing studies that evaluate this question (e.g., Chang, Murray, & Yassa, 2015; de Heering, Liedekerke, Deboni, & Rossion, 2010; Walker & Hewstone, 2006).

The Current Study

Empirical meta-analyses pool findings across and within multiple studies using a principled approach for estimating a summary effect size. Meta-analyses provide the opportunity to systematically investigate the extent to which a summary effect is externally valid and to evaluate the impact of potential moderating variables on this effect. Although there have been quantitative meta-analyses investigating the effect size of the ORB in the adult (Lee & Penrod, 2022; Meissner & Brigham, 2001; Singh et al., 2020) and infant literatures (Sugden & Marquis, 2017), there are no such analyses that investigate developmental changes in the magnitude of the ORB specifically during adolescence. Here, we fill this gap in the literature by providing an empirical meta-analysis of the ORB findings with adolescents. In this study, we had four major goals: (1) determine whether there is a reliable ORB in adolescent face

[1]Note that individuals who belong to a racial/ethnic minority group (i.e., fewer in the population) in a particular community do not necessarily experience marginalization, which is the process of disempowering and isolating people. For example, White South Africans are a minority of the population, but they do not experience marginalization due to the sociopolitical power they have in the country. Distinguishing adolescents who belong to ethnic-racial minority groups that may or may not also experience marginalization is important in this work. This distinction may help sort out predictions from hypotheses about the potential role of visuoperceptual experience/learning versus other kinds of psychosocial factors that contribute to the ORB.

recognition behavior; (2) if so, estimate the magnitude of the ORB across studies; (3) test whether there is an age-related change in the magnitude of ORB during adolescence; and (4) evaluate whether the race of the participant influences the estimated magnitude of ORB in adolescents.

All prior meta-analyses of the ORB used a traditional frequentist analytic approach. This approach estimates the summary effect size based on the current data and does not incorporate prior information. Here, we hypothesized that the existing findings, particularly from the large adult literature, would serve as a reasonable prior that we could integrate with the smaller literature to estimate the ORB in adolescence. At the same time, we are uncertain about how well the existing findings from the adult literature will fit the adolescent data. Therefore, we used a Bayesian method for estimating the summary effect size of the adolescent ORB in the current study. In using the Bayesian approach, we could constrain the current meta-analysis investigating the ORB in adolescence by providing information about the previously empirically derived summary effect sizes in the adult literature and a range of standard deviations to evaluate the relative likelihood that the data fit this distribution.

We used the estimated summary effect size of the ORB (i.e., $d = .24$) from the Meissner & Brigham (2001) meta-analysis to guide our analyses for the following reasons. First, the previous meta-analysis study was based on empirical studies in which most participants were White adults from White-majority societies where they were socio-politically dominant, which is consistent with the characteristics of the adolescent literature (see Table 1). Second, because there is reported variation in the presence and magnitude of the ORB among non-White individuals in these same countries (e.g., Tham, Bremner, & Hay, 2017; Walker & Hewstone, 2006) and of our uncertainty about the relative fit of this prior information, we used a prior distribution that had wider intervals to reflect such uncertainty. This approach allowed us to evaluate how much the summary effect size for the ORB in adolescents is impacted by using prior information from adult literature. Finally, the moderator analyses allowed us to begin evaluating whether there are linear age-related increases in the ORB as predicted by the perceptual expertise and social cognitive theories.

2. Method

We followed the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and include a detailed flow diagram (see Figure 1) of our study screening and identification process (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). The current study was not preregistered.

Study Searching and Identification

To identify potentially relevant articles, in July 2021, we conducted a literature search in the PubMed database with the following search parameters: (face OR faces OR facial) AND (adolescents OR adolescence OR "young adult" OR "early adult" OR "emerging adult") AND ("race" OR "ORB" OR "other-race effect" OR "own-race bias" OR "other race effect" OR "own race bias") AND (recognition OR discrimination OR processing). We limited our search to empirical studies that employed behavioral tasks of face recognition for multiple races with the intent to investigate the ORB in typically developing adolescents.

Behavioral data from neuroimaging studies using event-related potentials (ERPs), or functional magnetic resonance imaging (fMRI) that investigated the ORB in adolescents were also included. We searched for studies that reported a measure of behavioral accuracy, which includes either number of correct responses, percentage of correct responses, number of errors, or percentage of errors. As a secondary search, we conducted a “manual reference search” by screening the reference lists of each study that met fully inclusion criteria from the initial search results (i.e., PubMed search).

Inclusion and Exclusion Criteria

We used the following inclusion criteria: Articles must (1) include typically developing adolescents between the ages of ~10 and 24 years in the participant sample; (2) report using a task of unfamiliar face identity processing for the purposes of comparing own- and other-race face recognition; and, (3) report a within-subject effect size of the ORB (e.g., Cohen’s d) or information to compute one (e.g., *t, M, SD, N, SE*). Note if a study combined adolescents in a group with younger individuals (i.e., < 10 years of age) to generate a group mean ORB, the data were included in the summary effect analysis but not in the moderation analysis of age unless the mean age of the group was age 10 years or older. Also, we did not encounter any studies in which race was a between-subject factor in the estimation of the ORB.

Studies were excluded if they (1) investigated face identity recognition behaviors that did not focus on the own-race bias; (2) did not provide specific information about the age of participants; (3) did not report behavioral accuracy *separately* for adolescent participants, (4) were not peer reviewed, or (5) were not published in English. If the selected articles met the inclusion criteria but did not report enough information in the published article to compute an effect size, we emailed corresponding authors to request the relevant data. If we did not receive data from corresponding authors, the study was excluded from the analysis (N = 7).

Study Selection

Our full study search, screening, identification, and selection process is represented in Figure 1. There were two steps in our selection process. First, we screened the titles and abstracts of all studies retrieved from the initial PubMed search. At this early stage of applying the inclusion criteria, we emphasized overinclusion to maximize yield. For example, abstracts were rejected based on clear exclusion criteria (e.g., not peer reviewed or published in English, not focused on ORB, did not include adolescents). This process excluded 278 articles leaving 108 empirical studies for full text screening.

We carefully reviewed the remaining 108 studies for inclusion by evaluating participant characteristics regarding sample age and effect sizes (*M, SD, N, t, d*). Before determining our final selection of studies, we conducted a “manual reference search” by extracting the references for each of the articles meeting full inclusion criteria using string pattern recognition (Griffin, Bauer, & Scherf, 2021). From these extracted citations, we first removed duplicates and irrelevant citations (e.g., statistical packages, manuals) and then conducted a title screening, abstract screening, and then a full text review on all remaining articles. Articles meeting full study inclusion were incorporated with the primary search results forming the final selection of studies for the meta-analysis.

JD and JG independently reviewed all studies for inclusion. After each round of screening (i.e., Title and Abstract, Full Text Review), any criterion discrepancies were discussed by JD and JG until consensus was reached. If there was no consensus, KSS helped resolve the disagreement about study inclusion. We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (see Supplemental Table 1) and included a flow diagram of the search process (Figure. 1; Moher et al., 2009).

Additional Forward Search

In July 2023, we conducted an additional forward search to screen articles published after our original search date (July 2021). Specifically, we gathered 83 articles published from 2021–2023 that cited studies meeting full inclusion criteria from our primary search results. We applied the same title, abstract, and full text screening procedure described above. Two articles met full inclusion criteria. As a result, a new total of 16 studies are included in the meta-analyses (see Table 1).

Data Extraction

Standardizing effect sizes.—From each study, we extracted information to compute the standardized mean difference, Cohen's d_z, between own- and other-race face recognition accuracy, including means, standard deviations, standard errors, sample sizes, and test statistics. For studies that reported paired *t*-values, we converted the *t*-values directly to standardized Cohen 's d_z scores (Lakens, 2013). When raw data were provided, we calculated the means, standard deviations, and sample size manually. Some studies reported multiple effect sizes (e.g., for different age groups, different other-race faces). As a result, the data were inherently hierarchical, such that accuracy scores were nested within study. Each study and unique effect size combination was coded to account for this multilevel structure.

Cohen's d is known to overestimate the population effect size, especially when degrees of freedom are low ($df < 50$), which is characteristic of many of the studies in this sample. Therefore, we converted Cohen's d_z scores to the bias-corrected Hedge's g for meta-analytic synthesis (Cumming, 2013; Hedges, 1981).

Moderating Variables.—To test the hypotheses about age-related effect of the ORB in adolescence and the potential influence of the race of the participant, we extracted data about participant- and task-related factors from each study when available. The age of participants was extracted in one of two ways. When the mean age of the participant group was reported, this was extracted for the analysis ($N = 29$ effect sizes). If the mean age was not reported ($N = 9$ effect sizes), we contacted the authors to retrieve this information. When the mean age was unavailable, the study was excluded from the moderation analysis.

We extracted participant race (White, non-White) and race of the face stimuli that were designated as own- and other-race faces (e.g., White, Black, Asian; see Table 1). We also extracted information about the specific type of face processing task (e.g., old/new recognition memory, perceptual matching) and the context in which the data were collected (e.g., behavioral task, neuroimaging task).

Statistical Analysis

We used a three-level random effects Bayesian meta-analytic model to estimate the magnitude of the ORB and estimate the influence of study-related moderators (age, subject race). Compared to frequentist approaches, Bayesian methods allow for incorporation of prior information as well as direct probability statements about the results (usually through interpretation of the posterior distribution). These methods also better estimate different sources of variation (Sutton & Abrams, 2001) and have become increasingly used in meta-analysis (e.g., see Griffin et al., 2021, 2023). We analyzed all data using the *brms* (Bürkner, 2017; version 2.14.4) and *rstan* (Stan Development Team, 2019; version 2.21.2) packages for the statistical software program R (R Core Team, 2018; version 4.0.2). Because Cohen's d_z reflects a within-group comparison (recognition of own- and other-race faces), one must specify a correlation between these outcomes in the model (Viechtbauer, 2010), which is rarely reported in the existing literature. Therefore, we modeled this correlation with multiple imputations (i.e., $r = 0.1$, 0.3, $r = 0.5$, $r = 0.7$, $r = 0.9$) to determine whether/how it impacted the findings. To interpret our models, we reported 95% credible intervals for all posterior probability distributions (PPD). To evaluate our hypotheses, we reported the posterior probability of these effects directly and interpreted 95% as a significantly meaningful effect.

Question 1 – Is there an ORB in adolescent face recognition behavior based on what we know from the adult literature?

One of the distinctive features of Bayesian meta-analysis is the incorporation of prior information in the estimation of the summary effect size, between-study heterogeneity, and impact of moderators. The ORB has been studied extensively in adults with previous meta-analyses estimating the summary effect across studies ($M = .24$, $SD = .015$; Meissner & Brigham, 2001). Therefore, in our analyses we specified an informative prior distribution centered on .24 [Normal ~ (.24, .015)]. Note the small standard deviation around the summary effect from the analysis of the adult literature. This is a highly informative prior distribution. This means that the sample of studies would have to produce a lot of disparate information (inconsistent results or other-race biased behavior) to deviate from this prior result pattern.

For all moderator variables, we also used a weakly informative prior distribution centered on zero [Normal ~ (0, 1)] to express our uncertainty about the impact on the summary effect size.

Question 2 – Are the adult findings a good place to start to evaluate the adolescent data?

To evaluate the impact of prior distribution choice on the reported results, we compared all model results using multiple prior distributions. We evaluated sensitivity of the prior (highly informative) distribution to the adolescent data by increasing the variance parameter in two different prior distributions: [Normal ~ (.24, .25)] and [Normal ~ (.24, .50)]. This allowed us to determine whether a broader distribution that covers more recent estimates of the summary effect in the adult literature and that included adolescent participants (Lee & Penrod, 2022) is a better fit for estimating the summary effect from the adolescent studies. For all variance parameters, we used a non-negative half Cauchy distribution [Cauchy ~ (0, 0.3)] since variance estimates cannot be negative and the half Cauchy distribution has desirable properties for psychological phenomena (Williams et al., 2018). Finally, to account for the fact that this prior distribution could be wrong, we also evaluated a third, weakly informative prior ([Normal ~ (0,1)]) centered on zero with a wide standard deviation to express a large degree of uncertainty in the direction and magnitude of the ORB.

Question 3 – Does adolescent age influence the magnitude of the ORB?

To address our third question, we investigated whether variation in the summary effect size could be accounted for by variations in participant age. Specifically, we evaluated whether studies with samples of older adolescents reported larger effect sizes for the ORB than do studies with samples of younger adolescents.

Question 4 – Does participant race influence the magnitude of the ORB?

To address our fourth question, we evaluated whether variation in the summary effect size could be accounted for by variations in participant race. Because of the very small number of studies working with different groups of non-White participants (e.g., Black, Latinx, Asian), we could only investigate whether studies with samples of White participants reported larger effect sizes for the ORB than do studies with samples of non-White participants.

Hamiltonian Monte Carlo (HMC) Simulations.

To approximate quantities from the posterior probability distributions of parameters for each model, HMC simulations were performed (Neal, 2011) using open-source software Stan (Carpenter et al., 2017). Each model was run using four Markov chains with 10,000 iterations (5,000 warmup samples). The target average proposal acceptance probability during Stan's adaption period was set to 0.99 and the maximum tree depth was set at 12. Before interpreting any of the parameter estimates, we confirmed that the HMC simulation provided reasonable properties by visually inspecting trace plots, quantitatively evaluating chain convergence with the potential scale reduction factor ($\widehat{R}$) and confirming an effective sample size for each parameter. For each model to be interpretable, trace plots should mix well (i.e., highly overlapping chains), $\widehat{R}$ must be between 1 and 1.1 (Gelman & Rubin, 1992), and the effective sample size should be at least 1,000 for each parameter (Bürkner, 2017).

Assessing Heterogeneity and Bias.—We quantified the degree of heterogeneity in the meta-analysis by computing I^2 (Higgins & Thompson, 2002). The I^2 statistic is an estimate of the proportion of variance in effect sizes that is not due to sampling error. In other words, I^2 is useful for determining the proportion of variance that is due to between-study differences and can also be partitioned across random effects. Here, we report total, between-study, and within-study heterogeneity (I^2) at each level of the multilevel model.

Meta-analytic effect size estimates can be compromised by publication bias, which reflects the fact that studies are generally published based on a prominent factor of statistical significance instead of multiple factors like statistical power, magnitude of the effect, and overall quality of the study. Funnel plot visualization and Egger's Regression (Egger et al., 1997) are typically used to evaluate the effect of publication bias on univariate meta-analyses. However, these methods are not appropriate for hierarchical data (Egger et al, 1997).

Therefore, we assessed funnel plot asymmetry as in previous work (Griffin et al., 2021) by including a measure of precision (i.e., standard error) as a predictor in our multilevel model. This approach manages the statistical dependency of the hierarchical data, is conceptually equivalent to the Egger's Regression test, and has been used previously (Griffin, Bauer, & Gavett, 2022; Griffin et al., 2021; Nakagawa & Santos, 2012). After determining the effect sizes contributing to funnel plot asymmetry, we computed the summary effect size without these potential outliers to test the robustness of our results.

3. Results

Study Selection

In a total, we included 38 effect sizes from 16 unique articles in the meta-analysis (see Table 1). The final dataset included 1,321 individual participants. The average age of the samples ranged from 10.2 to 22.6 years old. The sample sizes, study characteristics, participant demographics, experimental paradigm, race of face stimuli, and the contributing effect size are reported in Table 1.

Is there an ORB in adolescent face recognition behavior based on what we know from the adult literature?

Figure 2 illustrates the summary effect size for the ORB in adolescent face recognition behavior and the effect size reported in each individual study. We estimated the magnitude of the summary effect size for the ORB among adolescents using a Bayesian meta-analysis approach that was informed by the magnitude and distribution of the ORB in adults (i.e., $d = .24$, $sd = .015$; Meissner & Brigham, 2001). This analysis indicates that the ORB in adolescents is positive, and as in the adult literature, is small in magnitude (Hedges' $g = 0.24$, $se = 0.01$, 95% CrI [.21, .27]).

Importantly, 100% of the posterior probability distribution (PPD) was consistent with this interpretation. In other words, no part of the PPD overlapped 0.0 (indicating equal performance on the two conditions) or was negative (indicating superior performance on other race faces). These results were consistent across various correlation imputations between the two conditions ($r_{0.1}$: Hedges' $g = 0.24$; $r_{0.3}$: Hedges' $g = 0.24$; $r_{0.7}$: Hedges' $g = 0.24$; $r_{0.9}$: Hedges' $g = 0.24$). There was a large and statistically significant degree of heterogeneity in the effect sizes across studies ($Q = 262.01$, $p < .0001$; $I^2 = 93.19\%$) that was attributable to both within-study ($\tau = 0.06$; $I^2 = 12.38\%$) and between-study ($\tau = 0.41$; $I^2 = 80.81\%$) heterogeneity.

We evaluated the potential influence of publication bias on the overall summary effect size by using a modified Egger's Regression test to quantify funnel plot asymmetry (Nakagawa & Santos, 2012). Although visually asymmetrical, the modified Egger's regression test did not reveal significant evidence that the summary effect size was impacted by publications bias ($b = -0.31$, $se = 1.45$, 95% CrI [−2.72, 2.05]). Specifically, 58% of the PPD was consistent with this interpretation (see Figure 3).

Are the adult findings a good place to start to evaluate the adolescent data?

The reported results are derived specifically when using the prior distribution that was directly informed by the results from a previous meta-analysis of the ORB in adults. However, this estimate of the ORB may not be generalizable to adolescent face recognition behavior. Therefore, we evaluated how our derived summary effect size estimates varied when the priors reflected more uncertainty about the magnitude of the ORB. We expressed more uncertainty in the estimate of the ORB with two different priors ([Normal ~ (.24, .25)] and [Normal ~ (.24, .50)]).

We found that our estimate of the ORB was still small in magnitude, but considerably more variable with both priors (Hedges' $g = .28$, $se = .14$, 95% CrI [0.05, 0.51] and Hedges' $g = .29$, $se = .16$, 95% CrI [0.02, 0.55], respectively; see Figure 2). With the less informative prior distributions (i.e., larger variance), the percentage of the PPDs that was consistent with the interpretation of the ORB in adolescents was reduced such that 97% and 96% PPDs for the ORB was above zero. Finally, when we used a noninformative prior centered on zero (Normal ~ 0,1), the PPD remained at 95% above zero (Hedges' $g = .29$, $se = .17$, 95% CrI [0.00, 0.56]).

These results reflect two findings. First, as we decrease confidence in the fit between the adolescent and adult estimates (i.e., increase the error of the distribution around the effect size), the estimated summary effect of the ORB in adolescent face recognition behavior remains positive and small. Second, confidence in the specific estimation of the ORB in adolescents is not reduced as a function of the amount of variance in the prior distribution. In sum, the existing literature coalesces to indicate the presence of an ORB in adolescent face recognition behavior.

Does adolescent age influence the magnitude of the ORB?

Given the considerable heterogeneity in effect sizes across studies, we investigated whether the ORB varies in magnitude as a function of *age* within adolescence. The summary effect size was not moderated by the average sample age ($b = 0.01$, $se = 0.05$, 95% CrI [−0.06, 0.08]). Specifically, only 43% of the PPD was consistent with this interpretation. This indicates that within this sample of adolescent studies, there is no evidence to suggest that the magnitude of the ORB in face recognition behavior of adolescents increases with participant age (see Figure 4).

Question 4 – Does participant race influence the magnitude of the ORB?

Finally, we investigated whether variations in the magnitude of the ORB in adolescence are related to participant race. Note that because of limited investigation of the ORB in non-White adolescents, we were only able to evaluate whether the presence of an ORB varied as a function of whether adolescent participants were White (24/38 effect sizes) or non-White (14/38 effect sizes). The summary effect size was not moderated by participant race, when defined this way ($b = -.02$, $se = .21$, 95% CrI [−0.36, 0.32]. Only 53% of PPD was consistent with this interpretation, which indicates relatively low confidence in this result (see Figure 5). This finding indicates that within this sample of adolescent studies, there is no evidence to suggest that the magnitude of the ORB in face recognition behavior of adolescents is modulated by participant race.

4. Discussion

We investigated evidence for the hypothesis that adolescence is an important developmental period for processing race during face recognition. Specifically, we conducted an empirical meta-analysis to determine whether and to what extent adolescents exhibit an own race bias (ORB) in their face recognition behavior. The ORB is a pattern of face recognition behavior in which individuals are more accurate when recognizing faces from within their own race compared to faces from a different race (e.g., Hugenberg, et al., 2010; Levin 1996; Meissner & Brigham, 2001). The ORB has been studied extensively in adults (for review see Lee & Penrod, 2022) and infants (see Sugden & Marquis, 2017); however, to understand the mechanisms underlying the ORB, it is essential to investigate the full developmental trajectory of the ORB in face recognition behavior. This work helps to address this gap by empirically estimating the presence and magnitude of the ORB across 38 effect sizes from 16 unique studies that included ~1,300 adolescent participants between the ages of ~10 – 22 years of age.

As in the adult and infancy literatures, most of these adolescent studies (12/16) were conducted in predominantly White countries (e.g., United States, United Kingdom, Canada). Four studies were conducted in East Asia. Therefore, most of the effect sizes (24/38) estimate the magnitude of the ORB for White participants in predominantly White countries. Approximately 17% of the effect sizes (5/28) estimate the magnitude of the ORB for adolescents from minoritized racial-ethnic groups (e.g., Black and Latinx adolescents) in predominantly White countries. Consequently, the results from this meta-analysis largely characterize the face recognition behavior of White adolescents in countries that have a history of racial and ethnic discrimination and prejudice against the minoritized groups represented by the “other race” faces in these studies.

We chose to use a Bayesian meta-analytic approach to estimate the summary effect size of the ORB from the adolescent literature, rather than a more traditional frequentist approach. This allowed us to inform the analysis with prior findings from the adult literature and evaluate how well they fit the adolescent literature. Specifically, we incorporated a prior estimate of the ORB effect from a meta-analysis of adult studies (Meissner & Brigham, 2001). To accommodate our uncertainty about the fit of this prior estimate for predicting findings in the adolescent literature, we estimated the adolescent ORB effect using multiple estimations of the variance (i.e., standard deviation) around the summary effect size of the adult ORB prior to evaluate how well this effect characterized the adolescent data. In so doing, these analyses also captured the effect size from the most recent meta-analysis of the

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adult literature (Lee & Penrod, 2022). This approach was rigorous in how it accounted for the hierarchical structure and dependencies in effect sizes (i.e., multiple effect sizes from one study). Finally, we evaluated how vulnerable the results were to publication bias.

Is there consistency of the ORB in adolescence?

Our first question was to determine whether there is a reliable ORB in adolescent face recognition behavior. This meta-analysis revealed an ORB in adolescent face recognition behavior that was small in effect. The summary effect that we observed using the highly informative adult distribution was small (Hedges' $g = 0.24$). In other words, the score of an average adolescent during own race face recognition is approximately 1/4 SD better than when they recognize other race faces. This positive effect was of comparable magnitude to that reported in the previous meta-analysis of the adult ORB (Meissner & Brigham, 2001). This estimation of the summary effect size was not impacted by publication bias.

Importantly, there was heterogeneity in the effect sizes that resulted from both within- and between-study variance. This finding was consistent with our concern for determining how well the adult distribution fit the adolescent data. To evaluate the generalizability of the findings, we computed the adolescent summary effect size under increasing levels of uncertainty (i.e., more variance in distribution). These additional analyses consistently revealed a positive, small summary effect size (Hedges' $g = .24 - .30$), indicating the presence of an own-race bias in the face recognition behavior of adolescents.

Does age of the participants moderate the ORB in adolescence?

To test predictions from the perceptual learning and social cognitive models that hypothesize a linear relation between the magnitude of the ORB and age, we investigated whether differences in the average age of the participant samples contributed to between-study heterogeneity and moderated the summary effect size of the ORB among adolescents. The average age of the study samples in this analysis ranged from 10.2 years to 22.6 years. Recall that both models emphasize the influence of differential experience on the magnitude of the ORB. For example, the perceptual learning/expertise models suggest that life-long differences in exposure to faces within one's own race compared to faces of other races leads to less practice recognizing faces from outside one's own race. As a result, the information processing strategies used to recognize other race faces are less fine-tuned (e.g., Mondloch et al., 2009; Rhodes, Hayward, & Winkler, 2006; Tanaka, Kiefer, & Bukach, 2004) or the representations for other race faces become less distinctive (Valentine, 1991).

The meta-analysis revealed that the magnitude of the ORB in adolescent face recognition behavior is not systematically impacted by the average age of the participants. In other words, studies with young samples (~ age 10 years) did not report a smaller ORB than did studies of older adolescents (~ age 21 years). This finding is consistent with previous investigations that failed to observe a positive relationship between age and the ORB magnitude (Anzures et al., 2014; Cross et al., 1971; Pezdek et al., 2003). Therefore, these findings are inconsistent with the notion that accumulated life experience (measured using age as a proxy) leads to an increase in the magnitude of the ORB across the second decade of life.

It is important to note that this null finding does not support the notion that there is a *stability* in the magnitude of the ORB during adolescence, only that there is no evidence in support of a linear increase with age. The findings clearly do not support predictions from the perceptual expertise and social cognitive frameworks. However, understanding whether and how the ORB changes in adolescence will require future work (see Mechanisms section below).

Does race of the participants moderate the ORB in adolescence?

Finally, we investigated whether participant race contributes to differences in the magnitude of the ORB among adolescents. This is an important question given findings from the adult literature that non-White participants in largely White societies have reduced or non-existent ORBs in their face recognition behavior (e.g., Walker & Hewstone, 2006; Wiese, Kaufmann, & Schweinberger, 2014). The meta-analysis revealed that the magnitude of the ORB in adolescent face recognition behavior was not systematically influenced by the race of the participants, when categorized as White versus non-White. In other words, the effect sizes of the ORB from non-White adolescents were not consistently smaller than those from White adolescents, as might have been predicted from the adult findings in non-White participants.

However, there are important caveats to interpreting this finding. Recall that 62% of the effect sizes in this meta-analysis characterize the ORB in White participants in White-dominant countries. Approximately 25% of the effect sizes characterize the ORB among Asian adolescents in Asian-dominant countries. Only 17% of the effect sizes estimate the magnitude of the ORB in non-White participants (e.g., Black, Asian) in White-dominant countries. Within this set of studies, only one effect size estimates the magnitude of the ORB among Black adolescents and four estimate the ORB among Asian adolescents in White-dominant countries. As a result, this analysis investigating whether participant race modulates the magnitude of the ORB among adolescents is underpowered and largely biased to evaluate ORB for White versus other adolescents in predominantly White countries. This is an especially meaningful consideration given that the majority of “other race” faces that are presented to White adolescents for estimation of the ORB include Asian and Black faces. In contrast, White faces are the “other race” faces most often presented to Black or Asian participants. Therefore, this literature largely reflects the ORB among White adolescents in predominantly White countries in response to Black and Asian faces.

As a result, the generalizability of the findings from this meta-analysis is limited, particularly to non-White adolescents. An important conclusion from these findings is that there is much future work to be done to understand whether and to what extent the ORB is present in the face recognition behavior of non-White adolescents in predominantly White countries and in other parts of the world. Importantly, there is a dearth of studies investigating the ORB in Black, Latinx, American Indian, and Asian adolescents.

Potential Mechanisms Shaping the ORB in Adolescence?

The primary hypotheses regarding mechanisms shaping the ORB across all developmental periods are focused on the role of differential experience individuating faces from within one’s own versus another race (for review see Scherf & Scott, 2012). However, there are hints of findings within this adolescent literature suggesting that the mechanisms shaping the ORB in adolescence are more complex, particularly for minoritized individuals. For example, Cross et al. (1971) reported that Black American adolescents do not exhibit an ORB, despite living in a predominantly White country (Cross, Cross, & Daly, 1971). In the United States, even Black adolescents who live in racially segregated neighborhoods do not evince an ORB (Feinman & Entwisle, 1976). Similarly, adolescents growing up in multiracial Malaysia who are Malaysian Chinese (a racial-ethnic minority group) do not exhibit an ORB (Tham et al., 2017). Finally, when researchers quantify social interactions with other race individuals via self-report measures, they do not find a significant relation between experience with other race faces and the magnitude of ORB among White adolescents (Corenblum & Meissner, 2006; Walker & Hewstone, 2006) or Asian adolescents adopted into White families (de Heering et al., 2010). Together, these findings suggest two conclusions. First, if the existing literature included a larger number of studies with non-White participants, the magnitude of the summary effect for the ORB in adolescence would likely be *reduced*. Second, the relation between experience with other race individuals and the magnitude of the ORB in adolescence is not clear. Therefore, the presence and magnitude of the ORB in adolescence cannot simply be a product of differential visual experience with own- and other-race faces.

When thinking about the potential underlying mechanisms of the ORB during adolescence, it is important to note that there are impressive quantitative and qualitative developmental changes in face recognition behavior during this period. For example, researchers have reported a temporary "dip" in face recognition behavior that is related to pubertal development. Specifically, Diamond, Carey, and Black (1983) reported that girls undergoing pubertal change produce more face recognition errors than do pre- or post-pubertal girls. These findings converge with others indicating a nonlinear age-related dip in face recognition performance during early adolescence (Lawrence, Campbell, & Skuse, 2015; McGivern, Andersen, Byrd, Mutter, & Reilly, 2002; Vetter, Leipold, Kliegel, Phillips, & Altgassen, 2013).

We have argued that these *qualitative* alterations in face recognition behavior likely reflect changes in patterns of bias related to adolescent social developmental tasks (Scherf & Scott, 2012). For example, we have shown that pre-pubescent children in the United States are biased to recognize adult female faces compared to child or adolescent faces. They have a *Caregiver bias* (Picci & Scherf, 2016) that reflects the social developmental tasks of childhood, namely the focus on developing a sense of self-mastery while still depending on primary caregivers. In contrast, when recognizing adult faces, adolescents appear to show a "dip" in performance; meaning that they are no longer excelling at recognizing adult faces. We have shown that this behavior reflects a *re-organization of biases, not a decrement in performance*. Specifically, adolescents, who are tasked with becoming more autonomous from caregivers, lose the Caregiver bias (i.e., enhanced recognition of adult faces) and begin to evince a Peer bias (i.e., enhanced recognition of peer faces; Picci & Scherf, 2016). This is consistent with the notion that peers become the salient focus of adolescent social affiliative relationships, and their faces are disproportionately represented in the visuoperceptual systems of adolescents (Dai & Scherf, 2019; Picci & Scherf, 2016; Scherf et al., 2012; Scherf & Scott, 2012).

In addition to peers becoming a new focus of adolescent affiliative relationships, the accumulation of peer relationships contributes to a dramatic increase in the size of adolescent social networks (Wrzus et al., 2013). This growth plateaus in the mid-20's to early 30's and shrinks thereafter. These effects are not moderated by country of origin or gender distribution of the sample (Wrzus et al., 2013). We propose that these concentrated, peer-oriented social interactions may influence motivational factors, like group identification and social status, in ways that could shape the ORB in adolescence (see Scherf et al., 2012). For example, the ORB might interact with the Peer and Caregiver biases such that the ORB is only evident when recognizing Caregiver faces, but not when recognizing Peer faces among adolescents. Future work investigating the relation between adolescent social network properties, Peer and Caregiver biases, and the magnitude of the ORB longitudinally will be essential for evaluating these hypotheses.

In addition to the explosion of peer-oriented social networks during adolescence, this is a critical developmental period for identity formation (Erikson, 1968), including the formation of ethnic-racial identity (ERI). The formation of ERI is a normative developmental process that is informed by one's ethnic heritage and one's racialized experiences in a sociohistorical context (Umaña-Taylor et al., 2014). Cognitive developments that support abstract thinking, evaluation of social norms, and meta-awareness of self together with transitions into larger more diverse non-familial environments enable adolescents to notice differences that inform notions of ERI (Umaña-Taylor, 2018). Importantly, empirical work suggests that these processes are similar for both White youth and members of ethnic-racial minority groups (Syed & Azmitia, 2009). Therefore, we propose that the larger, more diverse social environments of adolescents, combined with the social focus on peers and ERI development may contribute to important changes in the way adolescents perceive own- and other-race social information. These factors may differentially contribute to the organization of the ORB in adolescents from racial majority and minority groups.

Finally, socio-political contexts are changing in ways that may give adolescents more access to heterogenous groups of peers, particularly in countries that have been predominantly White where much of the scientific work investigating the ORB has been conducted. For example, in the United States the most recent census revealed that the Multiracial population has increased in all age categories, but particularly among individuals under the age of 18, making it the fastest growing racial group in the Unites States (US Census Bureau, 2020). Furthermore, the most common age range of Multiracial individuals in the US is 10–15 years of age. This is a dramatic shift in the developmental context for contemporary adolescents. Therefore, understanding how adolescents process and perceive race during face recognition is essential for understanding how they are navigating this diverse social world.

We propose each of these factors may influence the development of the ORB in adolescence. For example, increasing access to racially and ethnically diverse peers may impact the racial-ethnic composition of adolescent peer networks, close friendships, and romantic partnerships, which may in turn inform one's own ethnic-racial identity formation and socialization, and ultimately influence the way that race information is perceived and processed among adolescents. This hypothesis would need to be tested in future work.

Limitations

The current study employed a Bayesian-based meta-analysis approach, and in so doing, incorporated prior information from the adult literature to estimate the size of the ORB summary in adolescent face processing. One limitation of this approach is that the incorporated prior information is subjective (i.e., specified by the researcher) and may not reflect the true effect. To accommodate this potential limitation, we empirically evaluated the impact of our informative prior (i.e., adult prior) on the derived adolescent summary effect size of the ORB in comparison to prior information that represented much more uncertainty (e.g., a prior including an effect size of 0 – no difference in performance). The findings were relatively robust to this evaluation, indicating a small, positive effect.

Importantly, the meta-analysis approach is inherently limited by the available data from the extant literature. As a result, meta-analysis is influenced by the file-drawer problem (Rosenthal, 1979) and the statistical significance filter. Meta-analytic estimates can be biased without access to data that is unpublished because of nonsignificant and null findings and thus overestimates the magnitude of an effect from the data that is published. Therefore, it is important to evaluate publication bias via funnel plots. Our solution to evaluate funnel plot asymmetry with multilevel data revealed that the findings from this meta-analysis were not influenced by publication bias.

However, the findings are most certainly limited by the research questions that have been addressed and the experimental paradigms that have been used in the current literature. For example, all the existing studies are cross-sectional by design. None of the existing studies were powered to investigate qualitative (i.e., nonlinear) age-related changes in the magnitude of the ORB during adolescence. The overwhelming majority of studies tested White adolescents in North American countries (i.e., majority White populations), which severely limits the generalizability of the findings. Finally, most of the studies used unfamiliar adult face stimuli. Given the emerging peer bias in adolescent face-recognition behavior (Picci & Scherf, 2016), it will be helpful to evaluate the adolescent ORB using adolescent faces and how adolescent ORB may interact with other biases in face processing system.

Last, we used Bayesian meta-analysis modeling, which includes prior information from a previous meta-analysis in adult studies (i.e., Meissner & Brigham, 2001) to estimate the summary effect size of adolescents. Nevertheless, it is important to note that this prior information may somewhat reflect the magnitude of ORB in adolescents as some of the adult studies included in previous meta-analysis might use a convenient college-aged sample (e.g., undergraduate students), which is synonymous with older adolescents in the current study. Therefore, developmental patterns of ORB in adults may be confounded with that in adolescents. Future empirical investigation will benefit from disentangling emerging adults from adult participants.

Going Forward

Previously we argued that the development of the ORB in adolescence may be influenced by the increasingly complex (and racially diverse) social contexts and motivation to re-orient to peers. In future work, it will be critical to investigate this possibility using longitudinal studies that are designed to evaluate both linear and nonlinear changes in the magnitude of the ORB as a function of age. It is also important to consider the role that ethnic-racial identity formation (even among White adolescents) may play in organizing the ORB (or lack thereof) in adolescence. Therefore, longitudinal studies that include specific assessments of social network composition, peer re-orientation, and ethnic-racial identity formation and socialization may provide essential information about the mechanisms that influence the ORB in adolescence.

For example, a principled study of the influence of ethnic-racial identity (ERI) formation and of the ethnic-racial identity of *friends* (and other prominent figures in adolescent's social networks–- teachers, coaches, mentors) may provide critical information about mechanisms impacting the magnitude and flexibility of the ORB in adolescence. Variations in the extent to which ERI is central to an adolescent's identity may affect the way racial information is perceived and processed during face recognition. For instance, some patterns of ERI development may motivate adolescents to pay more attention to individuals from their own racial ethnic group due to sense of shared destiny (Whitehead, Ainsworth, Wittig, & Gadino, 2009). On the other hand, other patterns of ERI development lead adolescents to be especially confident and comfortable befriending peers from other racial ethnic groups (Rivas-Drake, Umaña-Taylor, Schaefer, & Medina, 2017). These differential patterns of significant social relationships and experiences, particularly with peers/friends, may be reflected in the biases that shape face recognition behavior. In other words, the presence (or lack thereof) of the ORB may represent a complex confluence of social context, perceiver motivation, and social developmental tasks (i.e., peer re-orientation, identity development in adolescence; Scherf & Scott, 2012; Young, Hugenberg, Bernstein, & Sacco, 2012). Therefore, investigating these factors among racially and ethnically diverse samples with attention to the sociopolitical dynamics of the local and more national environments will be essential to understand the mechanisms that influence the development of the ORB in adolescence.

Last, it is important to note that the magnitude of ORB is not the only potential indicator of developmental change across life, but also the malleability of the ORB. Existing literature suggests that the plasticity of ORB in face processing emerges during infancy and childhood in response to the living environment (e.g., Bar-Haim et al., 2006; Sangrigoli et al., 2005). Training studies with adults also mitigate the ORB in White adults (e.g., Lebrecht et al., 2019; Tanaka & Pierce, 2009). One possibility is that adolescent face processing is particularly susceptible to the developmental processes impacting the manifestation of race biases in face processing. In future work, it will be helpful to investigate the relative malleability of ORB in adolescents using training paradigms. This information will help researchers identify optimal prevention and intervention strategies to improve the accuracy of recognizing other-race faces in social contexts.

Conclusions

The present Bayesian-based meta-analysis estimates the magnitude of the ORB in adolescent face processing by aggregating the empirical data in the current literature. Like the previous meta-analysis finding of the adult literature, we report that the effect size of adolescents' ORB is small. Importantly, there are significant limitations in the research questions and experimental sampling that limit the generalizability of these findings beyond White adolescents in predominantly White countries. In addition, the current literature is limited in its ability to evaluate whether and how age influences the development of ORB during adolescence. Therefore, we suggest that future studies should investigate whether and how multiple factors, including social context, perceiver motivation, peer re-orientation, social network composition, and ethnic-racial identity development, may dynamically influence the presence, magnitude, and relative flexibility of the ORB in adolescence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgement

The research was supported by a grant (RO1 MH112573-01) from the National Institute of Mental Health

Data Availability Statement

Researcher may access the study data and material via email to the corresponding author.

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Public Significance Statements

This meta-analysis examines whether adolescents better recognize individuals from within their own compared to another race. We report a small, positive own race bias (ORB) in the adolescent studies that was not impacted by the age or race of participants. Our findings are limited by the study samples, which largely include White adolescents in White-dominant countries. We propose that future studies should include racially and ethnically diverse sample of adolescents and consider sociocultural factors such as peer re-orientation, social network organization, ethnic-racial identity and socialization.

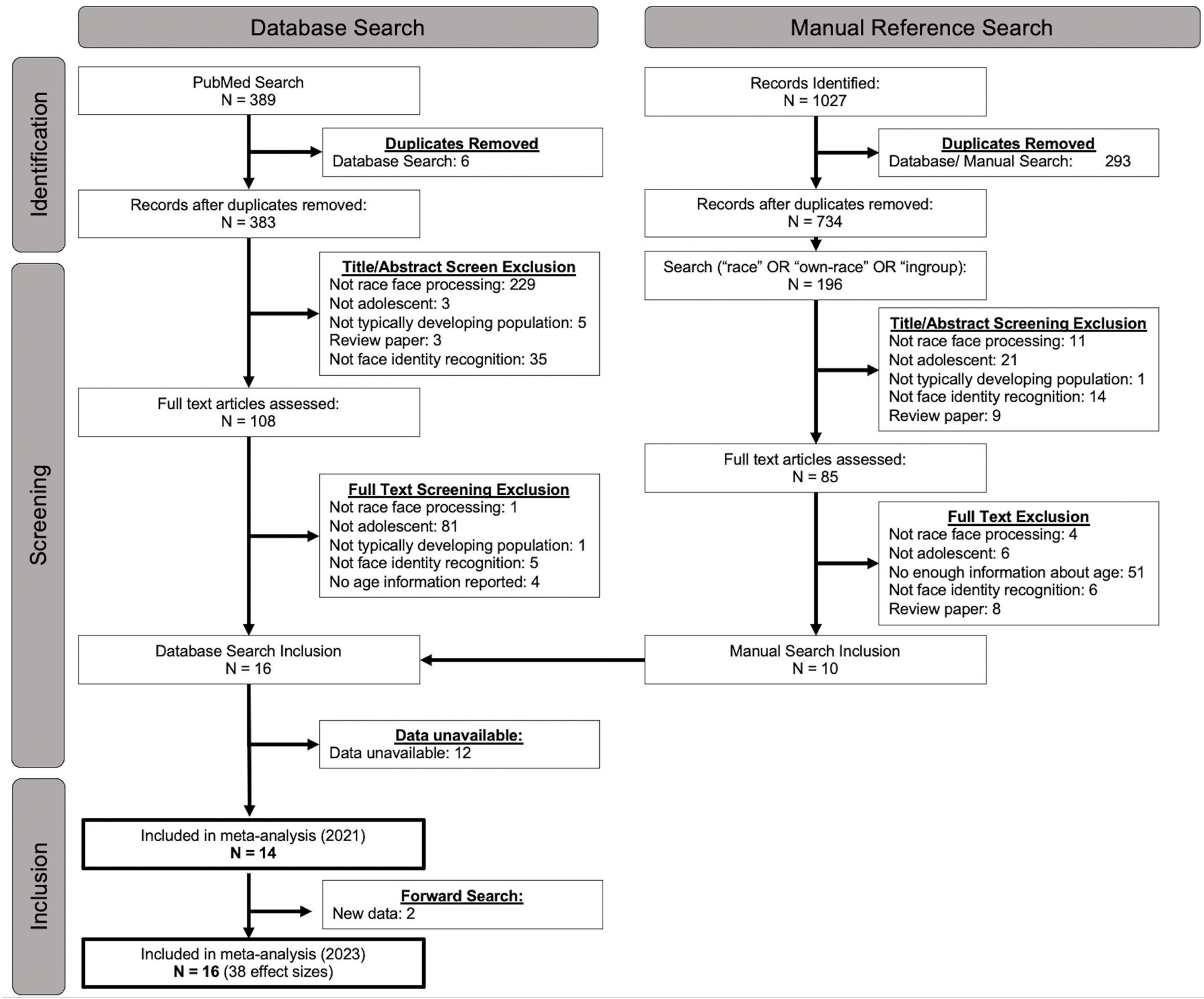

Figure 1. PRISMA flow diagram.

Note: Process for identifying, screening, and selecting studies in the meta-analysis.

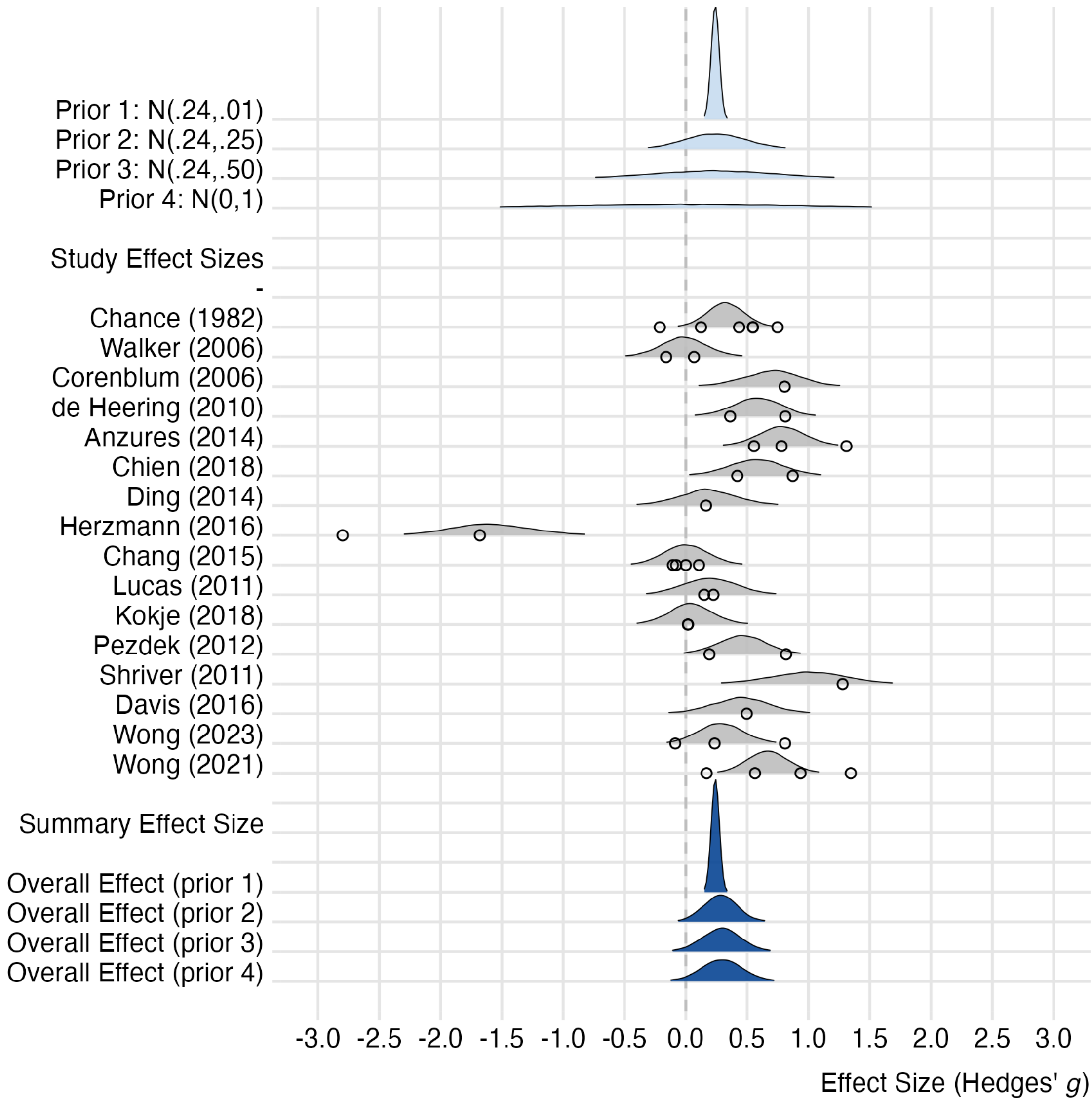

Figure 2. Individual and Overall Summary Effect Size Results.

Note: This multilevel forest plot contains the standardized estimates for each effect size nested within study, which are represented with the posterior distribution. Positive effect sizes correspond to an own-race bias (Own > Other), whereas negative effect sizes correspond to an other-race bias (Own < Other). The four prior distributions that were used to evaluate the summary effect size are shown at the top of the figure in light blue. They express different levels of uncertainty about the direction and magnitude of the ORB. The derived posterior probability distributions that correspond to these different prior distributions are shown at the bottom of the figure in dark blue.

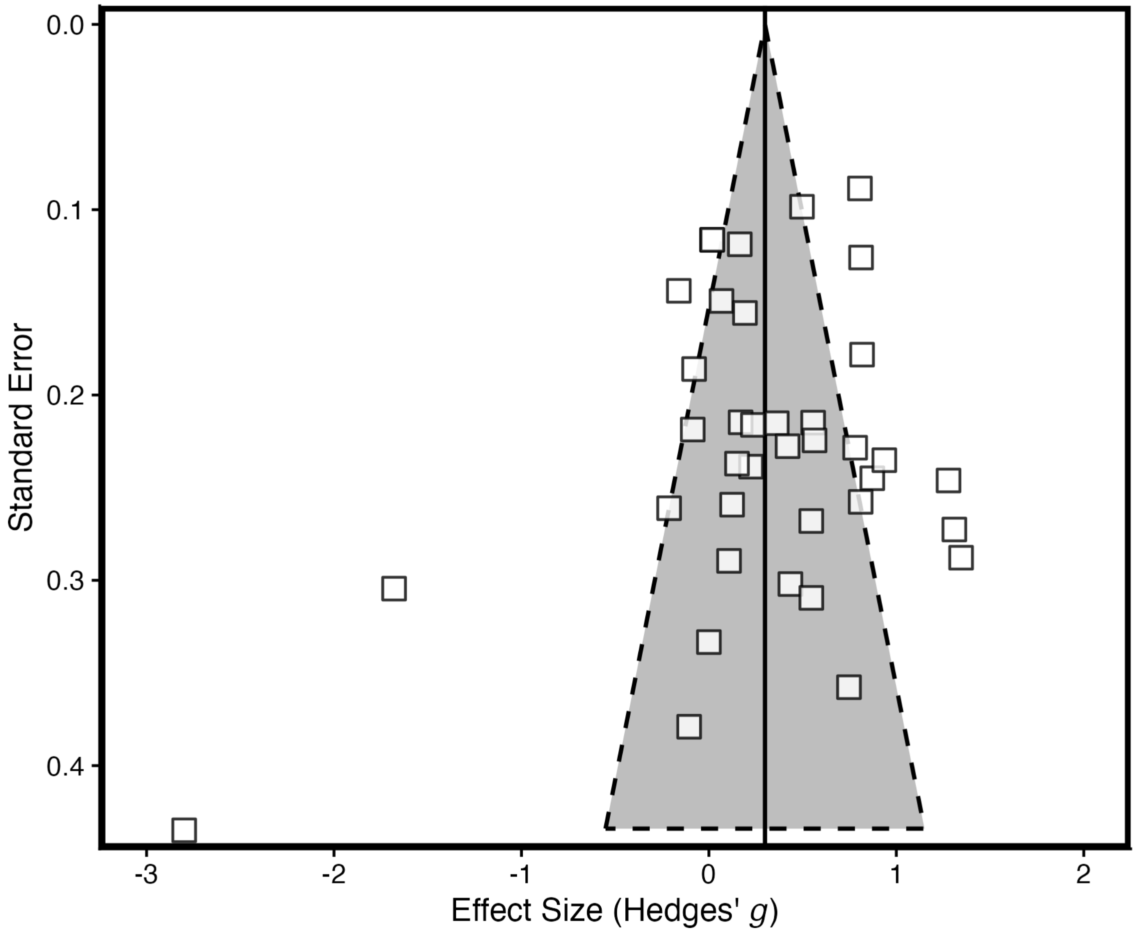

Figure 3. Investigation of Publication Bias on Results.

Note: Funnel plot displaying the standardized effect size estimates (square) as a function of precision (e.g., standard error). The funnel plot is centered on the standardized summary effect size for own-race bias in adolescent face processing (Hedge's $g = 0.24$).

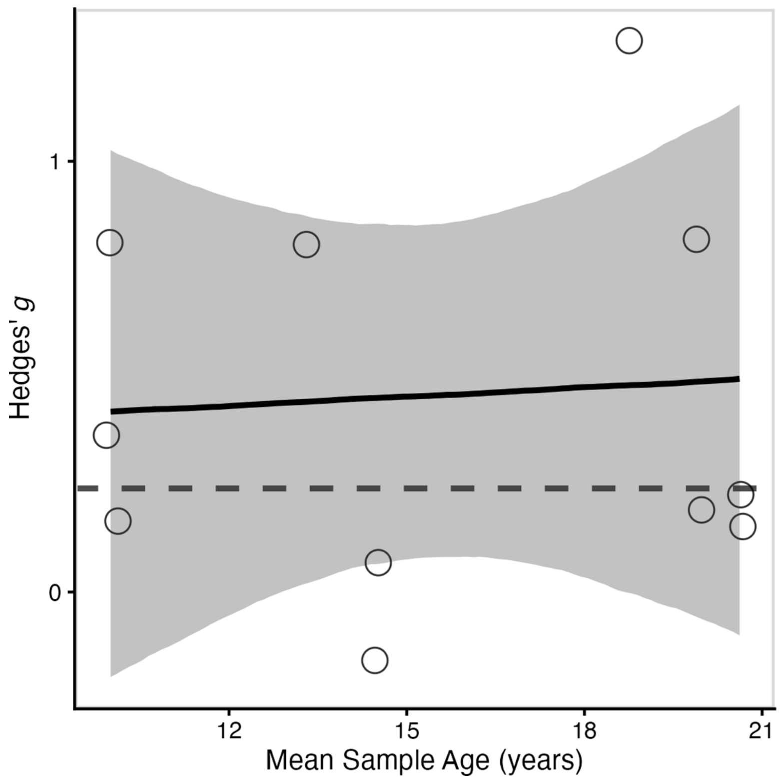

Figure 4. Analysis of Age on Magnitude of the ORB in Adolescence.

Note: Scatterplot displaying the standardized effect size estimates (circle) as a function of the mean sample age. There was no significant relation between the effect size of the ORB in face processing and age of the study samples.

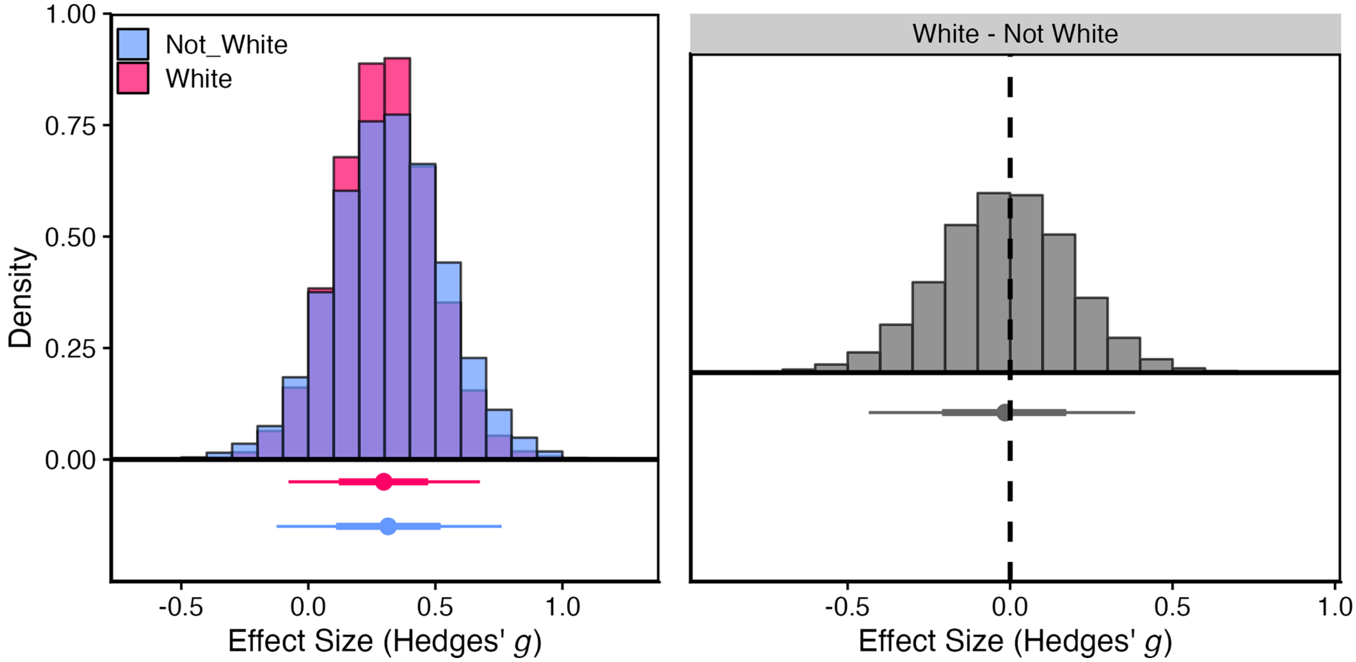

Figure 5. Analysis of Participant Race on the Magnitude of the ORB in Adolescence.

Note: The left panel shows the posterior distributions plotted as a function of participant race (White vs. Not White). The right panel shows the difference between these posterior distributions. The vertical black dashed line reflects 0 or no difference. The intervals at the bottom reflect 95% quantile intervals.

Table 1.

Study Demographics, Characteristics, and Effect Sizes Listed Chronologically for Race Face Recognition Tasks (k = 38)

Study	Task	Study Type	Sample N	Age Range	Mean Age	Country/Region	Own-race Face	Other-race Face	*g*	*SE*
Chance et al. (1982) [1]	Old/new	Behavioral	15	10–11	NR	U.S.	White	E. Asian (Japanese)	0.12	0.26
Chance et al. (1982) [2]	Old/new	Behavioral	15	13–14	NR	U.S.	White	E. Asian (Japanese)	−0.21	0.26
Chance et al. (1982) [3]	Old/new	Behavioral	12	18–19	NR	U.S.	White	E. Asian (Japanese)	0.44	0.30
Chance et al. (1982) [4]	Old/new	Behavioral	12	10–11	NR	U.S.	White	E. Asian (Japanese)	0.55	0.31
Chance et al. (1982) [5]	Old/new	Behavioral	16	13–14	NR	U.S.	White	E. Asian (Japanese)	0.55	0.27
Chance et al. (1982) [6]	Old/new	Behavioral	10	18–19	NR	U.S.	White	E. Asian (Japanese)	0.75	0.36
Corenblum et al. (2006) [1]	Old/new	Behavioral	169	9–20	13.35	Canada	White	Black	0.81	0.09
Walker et al. (2006) [1]	Old/new	Behavioral	49	13–16	14.50	U.K.	White	S. Asian	−0.16	0.14
Walker et al. (2006) [2]	Old/new	Behavioral	45	13–16	14.50	U.K.	S. Asian	White	0.07	0.15
de Heering et al. (2010) [1]	Old/new	Behavioral	23	9–12	11.75	Belgium	Asian	White	0.36	0.22
de Heering et al. (2010) [2]	Old/new	Behavioral	84	9–12	11.75	Belgium	White	Asian	0.81	0.13
Lucas et al. (2011) [1]	Old/new	Neuroimaging	18	19–22	20.62	U.S.	White	Black	0.23	0.24
Lucas et al. (2011) [2]	Old/new	Neuroimaging	18	19–22	20.62	U.S.	White	Avg of Black, E. & S. Asian, Hispanic	0.15	0.24
Shriver et al. (2008) [1]	Old/new	Behavioral	30	N/A	18.76	U.S.	White	Black	1.28	0.25
Pezdek et al. (2012) [1]	Matching	Behavioral	42	18–21	19.92	U.S.	White	Black	0.19	0.16
Pezdek et al. (2012) [2]	Matching	Behavioral	42	18–21	19.92	U.S.	White	Black	0.82	0.18
Anzures et al. (2014) [1]	Old/new	Behavioral	25	9–10	NR	U.K.	White	Asian	0.57	0.12
Anzures et al. (2014) [2]	Old/new	Behavioral	25	9–10	NR	U.K.	White	Asian	1.34	0.16
Anzures et al. (2014) [3]	Old/new	Behavioral	25	9–10	NR	U.K.	White	Asian	0.80	0.13
Ding et al. (2014) [1]	Old/new	Neuroimaging	72	7–13	10.20	China	Asian	White	0.16	0.12
Chang et al. (2015) [1]	Old/new	Behavioral	9	NR	19.86	U.S.	Black	Avg of White, E. & S. Asian	0.00	0.33
Chang et al. (2015) [2]	Old/new	Behavioral	29	NR	19.86	U.S.	White	Avg of White, E. & S. Asian	−0.08	0.19
Chang et al. (2015) [3]	Old/new	Behavioral	12	NR	19.86	U.S.	E. Asian	Avg of White, E. & S. Asian	0.11	0.29
Chang et al. (2015) [4]	Old/new	Behavioral	7	NR	19.86	U.S.	S. Asian	Avg of White, E. & S. Asian	−0.11	0.38
Davis et al. (2016) [1]	Old/new	Behavioral	116	NR	19.34	U.S.	White	Black	0.49	0.09
Herzmann et al. (2016) [1]	Matching	Neuroimaging	26	NR	18.80	U.S.	White	Asian	−1.68	0.30
Herzmann et al. (2016) [2]	Matching	Neuroimaging	26	NR	18.80	U.S.	White	Black	−2.79	0.44
Chien et al. (2018) [1]	Matching	Behavioral	21	11–13	11.50	Taiwan	Asian	White	0.42	0.23

Study	Task	Study Type	Sample N	Age Range	Mean Age	Country/Region	Own-race Face	Other-race Face	*g*	*SE*
Chien et al. (2018) [1]	Matching	Behavioral	23	NR	21.62	Taiwan	Asian	White	0.87	0.25
Kokje et al. (2018) [1]	Matching	Behavioral	74	NR	19.70	U.K.	White	Arab	0.02	0.12
Kokje et al. (2018) [2]	Matching	Behavioral	74	NR	19.70	U.K.	White	Arab	0.02	0.12
Wong et al., (2021) [1]	Old/new	Behavioral	26	NR	20.23	Malaysia	Chinese	Avg of White, Indian, & Malaysian	0.96	0.13
Wong et al., (2021) [2]	Old/new	Behavioral	23	NR	19.70	Malaysia	Malaysian	Avg of Chinese, Indian, & White	1.38	0.14
Wong et al., (2021) [3]	Old/new	Behavioral	22	NR	22.50	Malaysia	Indian	Avg of Malaysian, White, & Chinese	0.17	0.10
Wong et al., (2021) [4]	Old/new	Behavioral	23	NR	22.26	Malaysia	White	Avg of Malaysian, Indian, & Chinese	0.58	0.11
Wong et al., (2023) [1]	Old/new	Behavioral	21	NR	19.57	Malaysia	Chinese	Avg of Malaysian & Indian	−0.09	0.13
Wong et al., (2023) [2]	Old/new	Behavioral	20	NR	19.35	Malaysia	Indian	Avg of Malaysian & Chinese	0.83	0.15
Wong et al., (2023) [3]	Old/new	Behavioral	22	NR	19.91	Malaysia	Malaysian	Avg of Indian & Chinese	0.24	0.13

Note: Studies denoted by the first author, year, and unique effect size identifier in brackets. *G* = standardized effect size (Hedge's *g*); *SE* = standard error. U.S. = United States, U.K. = United Kingdom E. Asian = East Asian, S. Asian = South Asian. Positive effect sizes correspond to positive ORB (Own race > Other race), negative effect sizes reflect an other-race bias (Own race < Other race). N represents the group sample size for Hedge's *g* and SE computations. Note that 9 of these 38 effect sizes were drawn from studies that only reported age range but not the mean of age. Therefore, we estimated the median age based on the reported age range to increase the power of analysis (e.g., Chance et al., 1982).

* Indicates studies in which the mean age as not reported, but is estimated as a median age based on the reported ae range.

NR = not reported.