Scrutinizing Whether Mere Group Membership Influences the N170 Response to Faces: Results from Two Preregistered Event-Related Potential Studies

Youngki Hong[1,2], Matthew S. Mayes[2], Anudhi P. Munasinghe[2], and Kyle G. Ratner[2]

Abstract

■ A socially consequential test of the cognitive penetrability of visual perception is whether merely sharing a group membership with another person influences how you encode their face. Past research has examined this issue by manipulating group membership with techniques from social psychology and then measuring the face-sensitive N170 ERP. However, methodological differences across studies make it difficult to draw conclusions from this literature. In our research, we conducted two large-scale, preregistered ERP studies to address how critical methodological decisions could influence conclusions about top–down effects of group membership on face perception. Specifically, we examined how mere group membership, perceptual markers that signify group membership, number of trials included in the study design, the racial/ethnic identity of face stimuli, and the data analytic approach affect inferences about the N170 response to faces. In Study 1, we found no evidence that mere group membership significantly influenced the N170. However, we found that the background color used to signify group membership modulated the magnitude and latency of the N170. Exploratory analyses also showed effects of stimulus race/ethnicity. In Study 2, we dissociated background color from face encoding by presenting background color before the faces. In this second study, we found no main effect of group membership, background color, or stimulus race/ethnicity. However, we did see an unhypothesized mere group membership effect on trials toward the end of the study. Our results inform debates about social categorization effects on visual perception and show how bottom–up indicators of group membership can bias face encoding. ■

INTRODUCTION

One of the most contentious disagreements about human information processing is whether higher-order cognition can distort visual representations (Firestone & Scholl, 2016; Lupyan, Thompson-Schill, & Swingley, 2010; Pylyshyn, 1999; Goldstone & Barsalou, 1998; Churchland, 1988; Fodor, 1983). Cognitive neuroscience has played a critical role in shaping this debate. Perhaps most famously, Kosslyn (2005) and Kosslyn, Thompson, Kim, and Alpert (1995) reported PET and fMRI data showing that patches of occipital cortex functionally associated with low-level visual computations were responsive to mental imagery. These researchers reasoned that such findings were incompatible with a theoretical perspective that only allowed for a feed-forward pathway from perception to cognition. More recent investigations using fMRI analysis methods sensitive to the representational content of neural codes further support the belief that cognitive processes can stimulate early visual cortex (e.g., Koenig-Robert & Pearson, 2019; Dijkstra, Bosch, & van Gerven, 2017; Naselaris, Olman, Stansbury, Ugurbil, & Gallant, 2015).

In today's increasingly diverse society, a critical test case of the cognitive penetrability of perception is whether social categorization, such as on the basis of race, gender, and age, can bias visual encoding of other people. Precise scientific investigation of this issue is complicated by the reality that social categories are often marked both by visual cues (e.g., attire, skin color, facial features, hair) and conceptual knowledge about the categories (e.g., recognition by a perceiver that a target person is in the same group or not; Amodio & Cikara, 2021). It is uncontroversial that salient visual cues can lead to different perceptual representations of social categories (Ito & Bartholow, 2009). However, because of the implications for the broader issue of perception and cognition dissociability, it is much more controversial whether the conceptual knowledge that distinguishes social categories impacts perceptual representation (Firestone & Scholl, 2016).

Efforts to address the specific influence of cognitive aspects of group membership on visual encoding of other people have used a classic technique from social psychology called the minimal group paradigm to create novel group distinctions that are deconfounded from skin color, hairstyle, and other physical attributes that often covary with naturally occurring groups. Cognitive neuroscience methods are then used to measure the effects of these

[1]Columbia University, New York City, NY, [2]University of California, Santa Barbara

novel social groupings on neural markers of face perception (e.g., Ratner & Amodio, 2013; Van Bavel, Packer, & Cunningham, 2008). This research focuses on face perception for various reasons. The first is that faces are attended to more than other objects in our social and physical environment so they are particularly meaningful visual stimuli (Birmingham, Bischof, & Kingstone, 2009). More practically, however, face processing is easier to study than other aspects of social perception because visual neuroscientists have invested considerable effort into identifying neural responses that are reliably elicited by the presentation of a face (Nguyen, Breakspear, & Cunnington, 2014; Rossion & Jacques, 2008; Haxby, Hoffman, & Gobbini, 2000; Kanwisher, McDermott, & Chun, 1997; Bentin, Allison, Puce, Perez, & McCarthy, 1996; Puce, Allison, Gore, & McCarthy, 1995).

By bringing together social psychological experimental manipulation and neuroscience measurement techniques, multiple fMRI studies have reported a larger BOLD response to minimal ingroup versus outgroup faces in a face-sensitive part of the fusiform gyrus (Van Bavel, Packer, & Cunningham, 2011; Van Bavel et al., 2008). However, the temporal sluggishness of the BOLD response makes it unclear whether the conceptual influence of group membership on fusiform gyrus activity occurs at the initial stage of face encoding or during later recurrent processing. For this reason, the temporal specificity of EEG is useful for discerning whether group membership influences the earliest encoding of a face.

Relevant to current considerations, EEG researchers have identified a negative-going ERP called the N170 that peaks approximately 170 msec after a face is presented (Itier & Taylor, 2004; Bentin et al., 1996). Although the face specificity of the N170 has been challenged over the years (e.g., Thierry, Martin, Downing, & Pegna, 2007; Tanaka & Curran, 2001), there is wide agreement that this signal is face sensitive and indicative of sensory encoding (Rossion & Jacques, 2008; Gauthier & Curby, 2005). If conceptual information about social groups can influence encoding of faces, then the N170 response to faces should be modulated by whether the perceiver shares or does not share a group membership with a target person. Some evidence suggests that conceptual information about group membership does influence the N170 response (Cassidy, Boutsen, Humphreys, & Quinn, 2014; Zheng & Segalowitz, 2014; Ratner & Amodio, 2013). However, other research finds no effect of minimal group membership on the N170 response to faces (Gamond, Vilarem, Safra, Conty, & Grèzes, 2017; Herzmann & Curran, 2013).

Given conflicting findings in the literature, the issue of whether conceptual group information influences face encoding is far from settled. The current research sought to provide the strongest test of this issue with two preregistered studies that closely follow the design of Ratner and Amodio (2013), which was the initial ERP study to show an influence of conceptual group membership on face encoding. Our studies go further, however, by

recognizing that methodological differences between studies in the literature could explain the different conclusions that researchers have drawn about the effects of conceptual group membership on neural face encoding. Studies in the literature differ in whether perceptual markers are used to indicate minimal group membership, the racial and ethnic diversity of their facial stimuli, and the number of trials they include in their research design. In Study 1, we analyzed our data with a conventional trial-averaging approach and then with multilevel modeling (MLM) to most comprehensively assess effects of group membership and stimulus properties on the N170 response to faces in an intergroup context. Importantly, MLM allowed us to examine whether the repeated presentation of faces that is typically used to generate enough trials to calculate an aggregated N170 response could inadvertently lead to habituation that results in weaker N170 amplitudes over the course of the task (see the work of Mercure, Cohen Kadosh, and Johnson [2011] for evidence of N170 habituation when faces of various people are presented). We reasoned a priori that any decreases in N170 amplitudes over the course of the experiment could obscure true moderation of the N170 by group membership. Study 1 presented the group membership cue simultaneously with each face (following the design used by Ratner and Amodio in their 2013 study). In Study 2, we presented the group membership cue before each face. This change served two purposes. First, it provided more time for effects of conceptual group membership to take root before the bottom–up face stimuli appeared. Second, it dissociated perceptual effects of the visual cue differentiating minimal ingroups from minimal outgroups (specifically background color, which was also used by Ratner and Amodio) from potential effects of conceptual group membership on the N170 response to faces. In both studies, diverse face stimuli were used to assess whether the bottom–up cues associated with race and ethnicity influence the N170 response to minimal ingroup and outgroup faces. Together, these studies are well suited for determining whether the cognitive aspect of mere group membership can influence early face perception and whether methodological decisions in the existing literature have led to disparate theoretical inferences.

STUDY 1

Methods

Participants

One hundred six college students participated in an institutional review board–approved study about neural encoding of faces in exchange for course credit. We initially preregistered to recruit 100 participants (https://osf.io/xm2fb), but because of random assignment, we did not have equal participants in each condition when we reached this target sample size. To have an equal number

of participants in each condition, we ended up recruiting six additional participants. However, three participants were excluded because of incomplete data, resulting in 103 participants for our final analysis (M_{age} = 18.93, SD = 1.34; 78 women, 25 men). We chose to report analyses of all the participants with complete data because restricting our analyses to only the initial 100 participants who were run did not meaningfully change our results. The self-reported racial and ethnic breakdown of our sample was 37 Asian, 28 White, 23 Latinx[1], 4 Black, 2 other, and 9 unreported.

Stimuli

Face stimuli used in the current study were color photographs of male or female (matched to each participant's gender) White, Asian, and Latinx faces with neutral facial expressions from the Chicago Face Database (CFD; Ma, Correll, & Wittenbrink, 2015).[2] We selected stimuli from these racial/ethnic groups because these groups are the largest racial/ethnic groups at the university where data were collected. All faces were rated similarly on trustworthiness based on the norming data provided by the CFD (M = 3.49 out of 7, SD = .16), and there was no race/ethnicity difference, $F(1, 21)$ = .21, p = .81.

Procedure

Upon arrival, participants completed a consent form and we measured the circumference of their head size so that they could be fitted with an electrode cap for EEG recording. Participants then completed several tasks on the computer. All tasks were administered via PsychoPy (Peirce et al., 2019) except for the questionnaires at the end, which were administered via Qualtrics. Next, we used a dot estimation procedure to assign participants to arbitrary, but believable, minimal groups (Hong & Ratner, 2021; Ratner, Dotsch, Wigboldus, van Kippenberg, & Amodio, 2014; Ratner & Amodio, 2013; adapted from Tajfel, Billig, Bundy, & Flament, 1971). We told our participants that people vary in numerical estimation style, which was defined as the tendency to overestimate or underestimate the number of objects they encounter. We highlighted the arbitrary nature of group assignment by telling our participants that approximately half the population are overestimators and half are underestimators, and that numerical estimation style is not related to any other cognitive tendency or personality trait. Participants then completed the Numerical Estimation Style Test themselves. This task consisted of estimating the number of dots in 10 rapidly presented dot patterns. At the end of the test, the computer program provided predetermined nondiagnostic feedback (counter-balanced across participants), indicating that each participant was either an overestimator or an underestimator. We used additional procedures to make the novel group membership (i.e., overestimator and underestimator)

as salient as possible in participants' minds throughout the remainder of the study. First, participants reported their numerical estimation style to the experimenter, providing a public commitment to their ingroup. The experimenter then gave participants a colored wristband (green or blue). In each session, different colors were associated with different groups, randomized across participants (i.e., for some participants overestimator = blue and underestimator = green, but for others, overestimator = green and underestimator = blue). Participants also typed their numerical estimation style into the computer as another act of commitment to the ingroup.

After assignment to one of two minimal groups, each participant was escorted into the EEG recording chamber and fitted with the appropriately sized EEG cap. Sixty-four silver chloride electrodes were then attached to the cap, and conductive gel was applied until impedance levels were below 10 kΩ at each electrode. Participants then viewed faces of people who ostensibly belonged to either the overestimator or underestimator group. Because overestimators and underestimators were laboratory-created and not based on real meaningful differences in facial features, we indicated their group membership using different colored backgrounds (400 × 450 pixels) on which faces were superimposed (e.g., blue background for overestimator and green background for underestimator and vice versa). Twelve unique face identities were randomly distributed between two groups, equally across races (6 ingroup and 6 outgroup; 2 Asian, 2 Latinx, and 2 White faces in each group). Each face identity was presented 40 times in a randomized order. This resulted in a total number of 480 trials (12 identities × 40 = 480), and because of such a large number of trials, we divided the task into four blocks of an equal number of trials (120 trials). Participants were allowed to take a break in between blocks. On each trial, a face was presented on a colored background (blue or green)[3] in the center of the screen and participants were asked to press a key that corresponded to the background color on which the face appeared. Faces remained onscreen until participants pressed a key. No feedback was provided on whether they pressed the correct key or not. Following the keypress, a mask of the same dimension (400 × 450 pixels) was presented on the screen for 500 msec and then a fixation cross appeared on the screen, jittered between 500 and 900 msec. The study concluded with questionnaires about the study, demographics questions, and a debriefing.

EEG recording and processing. EEG was recorded from all 64 electrodes distributed across a BrainVision Easy-Cap, referenced to the electrode Cz (center of the midline sagittal plane). EEG signals were amplified using an actiCHamp Plus, with a 140 on-line low pass filter, and digitized at 500 Hz. Before the analysis, the signals were filtered through a .01-Hz high pass. Then, they were artifact-corrected using independent component analysis and filtered through a 30-Hz low pass, creating .01- to

.30-Hz bandpass. Next, the signals were rereferenced to the average of all 64 channels.

Before scoring N170 responses, we created ERP waveforms that were 1000-msec stimulus-locked epochs (200 msec before face onset and 800 msec after face onset) at left and right lateral posterior sites indicated in our preregistration (P7 and P8). The baseline was corrected by subtracting the average voltage during the 200 msec before stimulus onset from each trial. We then computed the grand average of all artifact-free trials, regardless of condition, to assess when an average N170 response peaked and to use that information to create an N170 response window for each trial. The result showed that N170 responses, on average, peaked around 130 msec during our task. The N170 was then scored for each trial as the negative peak amplitude occurring between 80 and 180 msec (50 msec before and after grand average peak) post face onset at left and right lateral posterior sites (P7 and P8). We chose to preregister analyses of N170 peak amplitudes to most closely match Ratner and Amodio's (2013) analyses; however, it is notable that analyses were also conducted on the mean amplitude response within the N170 window and our main conclusions were the same. All preprocessing steps were done using the MNE-Python package (Gramfort et al., 2013).

Results

Preregistered Analyses Closely Following Ratner and Amodio (2013)

First, we averaged behavioral responses and associated N170 responses for the first 30 ingroup White faces and the first 30 outgroup White faces for each participant.[4] This allowed us to closely follow the analyses by Ratner and Amodio (2013),[5] which had a smaller number of total trials compared with the current study and only included White faces in their stimulus set. Following their exclusion criteria (Ratner & Amodio, 2013), we excluded participants because of extreme outlying values (> 3 SD) of the N170 amplitude or RT, leaving 101 participants for analysis.

Behavioral effects. Unlike in the work of Ratner and Amodio (2013), a paired t test of the log-transformed RTs (in sec) showed that participants did not categorize ingroup faces ($M = 1.09$, $SD = .50$) faster than outgroup faces ($M = 1.08$, $SD = .46$), $t(100) = 0.28$, $p = .78$, 95% CI [−.02, 03].[6] Because the face categorization task was not a difficult task (i.e., categorizing faces based on background color), we found that participants were highly accurate in categorizing both ingroup faces ($M = 98.8\%$, $SD = 3.3$) and outgroup faces ($M = 98.9\%$, $SD = 5.5$), and a paired t test showed no significant difference between them, $t(100) = 0.24$, $p = .81$, 95% CI [−.01, 01].

N170 effects. Based on Ratner and Amodio (2013), we hypothesized in our preregistration (https://osf.io/xm2fb) that the N170 amplitude to the first 30 ingroup faces would be significantly larger than the N170 amplitude to the first 30 outgroup faces, reflecting a deeper structural encoding of the ingroup faces. To test this hypothesis, we conducted a 2 (Group: ingroup vs. outgroup) × 2 (Electrode Site: P7 vs. P8) repeated-measures ANOVA on the N170 amplitude. The results showed no main effect of Group, indicating that peak N170 amplitudes (in μV) for ingroup ($M = −6.58$, $SD = 4.98$) and outgroup ($M = −6.69$, $SD = 5.06$) did not significantly differ from each other, $F(1, 401) = 0.05$, $p = .83$, 95% CI [−.66, .1.03] (see Figure 1). The main effect of the Electrode Site was also not significant, indicating that peak N170 amplitudes at P7 (left; $M = −6.71$, $SD = 4.86$) and P8 (right; $M = −6.56$, $SD = 5.18$) did not differ, $F(1, 401) = 0.08$, $p = .77$, 95% CI [−.34, 1.34]. The interaction effect was also not significant, $F(1, 401) = 0.54$, $p = .46$.

Next, we conducted an additional 2 (Group: ingroup vs. outgroup) × 2 (Electrode Site: P7 vs. P8) repeated-measures ANOVA on N170 peak latencies. The main effect of Group was not significant, indicating that peak N170 latencies (in msec) for ingroup ($M = 129.30$, $SD = 11.88$) and outgroup ($M = 128.90$, $SD = 10.97$) did not significantly differ from each other, $F(1, 401) = 0.13$, $p = .72$, 95% CI [−2.07, 3.08]. The main effect of Electrode Site was also not significant, indicating that peak N170 latencies at P7 (left; $M = 129.48$, $SD = 11.27$) did not differ from peak N170 latencies at P8 (right; $M = 128.72$ $SD = 11.58$), $F(1, 401) = 0.45$, $p = .50$, 95% CI [−2.44, 2.70]. The interaction effect was not significant, $F(1, 401) = 0.63$, $p = .43$.

Analyses of the Full Data Set

For the analyses of the full data set (i.e., all 480 trials), we averaged behavioral responses and N170 responses within each face identity. This resulted in 2 (Group: ingroup vs. outgroup) × 2 (Electrode Site: P7 vs. P8) × 3 (Target Race: Asian vs. Latinx vs. White) × 2 unique face identities per target race = 24 data points per participant (for behavioral data, it was 12 data points because two electrode sites are simply duplicates). To take full advantage of the increased number of data points, we used MLM to analyze our data (e.g., Volpert-Esmond, Page-Gould, & Bartholow, 2021; Volpert-Esmond, Merkle, Levsen, Ito, & Bartholow, 2018). Similar exclusion criteria from above applied here: We excluded trials that were of extreme outlying values (> 3 SDs) of the N170 amplitude or RT.

Behavioral effects. We used MLM to compare the mean level differences in behavioral responses to ingroup and outgroup. In these models, the intercept and slope of group were allowed to vary by participant. The intercept was also allowed to vary by face identity. Group membership (ingroup, outgroup) was the sole Level 1 predictor. The result showed that the log-transformed response time (in sec) of categorizing ingroup faces ($M = .94$, $SD = .23$) did not differ from that of categorizing outgroup faces ($M = .95$, $SD = .22$), $b = .005$, $z = 1.47$, $p = .15$, 95% CI

Figure 1. There was no minimal group effect on N170 amplitude in response to the first 30 ingroup White and 30 outgroup White faces in Study 1. Please note, to make our statistical analyses directly comparable to Ratner and Amodio (2013), we preregistered analyses of peak amplitudes, but for visualization purposes (as is the convention), we plot the entire epoched waveform averaged across participants for ingroup and outgroup.
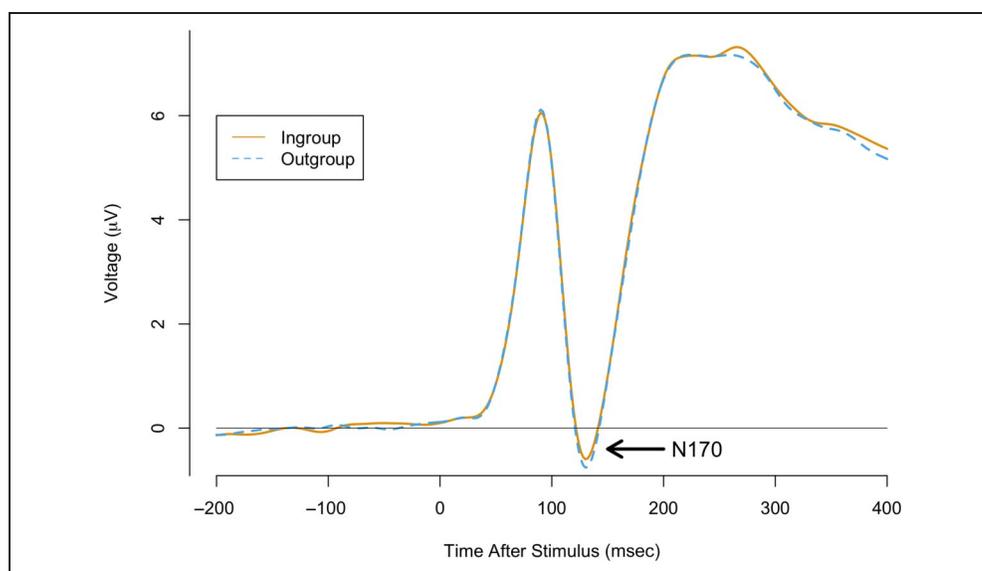
[−.00, .01]. Participants' accuracies for categorizing ingroup faces ($M = 99.1\%$, $SD = 4.1$) and outgroup faces ($M = 98.9\%$, $SD = 4.4$) also did not significantly differ, $b = .20$, $z = 0.97$, $p = .34$, 95% CI [−.61, .21].

N170 effects. We used MLM to compare the mean level differences in N170 responses to ingroup and outgroup faces. In these models, the intercept and slope of group membership were allowed to vary by participant. The intercept was also allowed to vary by face identity and channel location. Again, group membership (ingroup, outgroup) was the sole Level 1 predictor. The results showed no main effect of Group, indicating that peak N170 amplitudes (in μV) for ingroup ($M = −7.42$, $SD = 5.67$) and outgroup ($M = −7.39$, $SD = 5.44$) did not significantly differ from each other, $b = .02$, $z = 0.23$, $p = .82$, 95% CI [−.17, .22]. Next, we compared the mean-level difference in N170 peak latencies between ingroup and outgroup. The main effect of group was not significant, indicating that peak N170 latencies (in msec) for ingroup ($M = 131.49$, $SD = 9.93$) and outgroup ($M = 131.38$, $SD = 9.94$) did not significantly differ from each other, $b = .14$, $z = 0.50$, $p = .62$, 95% CI [−.71, .42].

N170 Effects of Perceptual Markers, Target Race, and the Number of Trials

Because studies in the literature examining effects of mere group membership on the N170 response to faces differ in the number of trials they include in their research design, whether perceptual markers are used to indicate minimal group membership, and the racial and ethnic diversity of their facial stimuli, we examined whether these factors contribute to inconsistencies in the literature. Thus, we assessed the effects of perceptual markers of minimal groups (in the current study, different colored backgrounds) on the N170 response. We also explored the

effects of target race (Asian, Latinx, and White) on the N170 response. Lastly, we examined how the repeated presentation of faces influenced N170 responses by analyzing trial-level data (i.e., no averaging within trial type).

Effects of background color. We used MLM to compare the mean-level differences in N170 responses between faces presented on green versus blue backgrounds. In these models, the intercept and slope of background color were allowed to vary by participant. The intercept was also allowed to vary by face identity and channel location. Background color (green, blue) was added as the sole Level 1 predictor. The results showed a significant main effect of Background Color, indicating that the peak N170 amplitudes (in μV) for faces presented on a green background ($M = −7.59$, $SD = 5.50$) was significantly greater than faces presented on a blue background ($M = −7.23$, $SD = 5.61$), $b = .37$, $z = 3.75$, $p < .001$, 95% CI [.18, .56]. Next, we compared the mean-level difference in N170 peak latencies between faces presented on blue and green backgrounds. The main effect of Background Color was significant, indicating that the peak N170 latencies (in msec) for faces presented on a blue background ($M = 132.11$, $SD = 9.89$) was significantly delayed compared with the peak N170 latency for faces presented on a green background ($M = 130.76$, $SD = 9.93$), $b = 1.31$, $z = 5.04$, $p < .001$, 95% CI [.80, 1.82].

Effects of target race. We used MLM to compare the mean level differences in N170 peak amplitudes to Asian, Latinx, and White faces. In these models, the intercept and slope of target race were allowed to vary by participant. The intercept was also allowed to vary by face identity and channel location. Target Race (Asian, Latinx, White) was added as the sole Level 1 predictor. The results showed a significant main effect of Target Race, indicating a significant difference between Latinx faces ($M = −7.14$,

$SD = 5.37$) and Asian faces ($M = -7.54$, $SD = 5.73$), $b = .38$, $z = 2.51$ $p = .02$, 95% CI [.08, .67], and also between Latinx faces and White faces ($M = -7.53$, $SD = 5.56$), $b = .39$, $z = 2.61$, $p = .02$, 95% CI [.10, .68]. The difference between Asian faces and White faces was not significant, $b = .01$, $z = 0.06$, $p = .96$, 95% CI [$-.28$, .29]. Next, we compared the mean-level difference in N170 peak latencies between Asian, Latinx, and White faces. The main effect of Target Race was significant, indicating that the peak N170 latency (in msec) for Latinx faces ($M = 130.80$, $SD = 9.95$) was significantly faster compared with the peak N170 latency for Asian faces ($M = 132.00$ $SD = 10.07$), $b = 1.07$, $z = 2.14$, $p = .04$, 95% CI [0.09, 2.04]. The difference between Latinx faces and White faces ($M = 131.50$, $SD = 9.74$) was not significant, $b = .65$, $z = 1.31$, $p = .21$, 95% CI [-0.33, 1.63]. The difference between Asian faces and White faces was also not significant, $b = .42$, $z = 0.83$, $p = .42$, 95% CI [-0.33, 1.63].

N170 responses over time. Next, we examined variation in N170 responses over time. To do this, we used trial-level data instead of averaging across repeated presentations of the same face identity, resulting in 12 unique face identities × 40 presentations = 480 data points per participant. The models predicted N170 response (amplitude and latency) using group membership (ingroup vs. outgroup), trial number (1–480), and the interaction between the two as Level 1 predictors. The trial number was centered for ease of interpretation of the results. The models allowed the intercept and slope of group to vary for each participant. The intercept was also allowed to vary by face identity and channel location. Not surprisingly, as found in earlier analyses comparing mean-level differences in N170 responses between ingroup and outgroup, the results showed no main effect of Group on N170 amplitudes, $b = .02$, $z = 0.23$, $p = .82$, 95% CI [$-.13$, .17] or on N170 latencies, $b = .02$, $z = 0.07$, $p = .95$, 95% CI [$-.50$, .53]. However, we found a significant main effect of Trial Number on N170 amplitudes, $b = -.001$, $z = 4.01$, $p < .001$, 95% CI [$-.001$, .000], indicating that as the study progressed, the N170 amplitudes generally increased in response to faces (see Figure 2). Although the interaction between
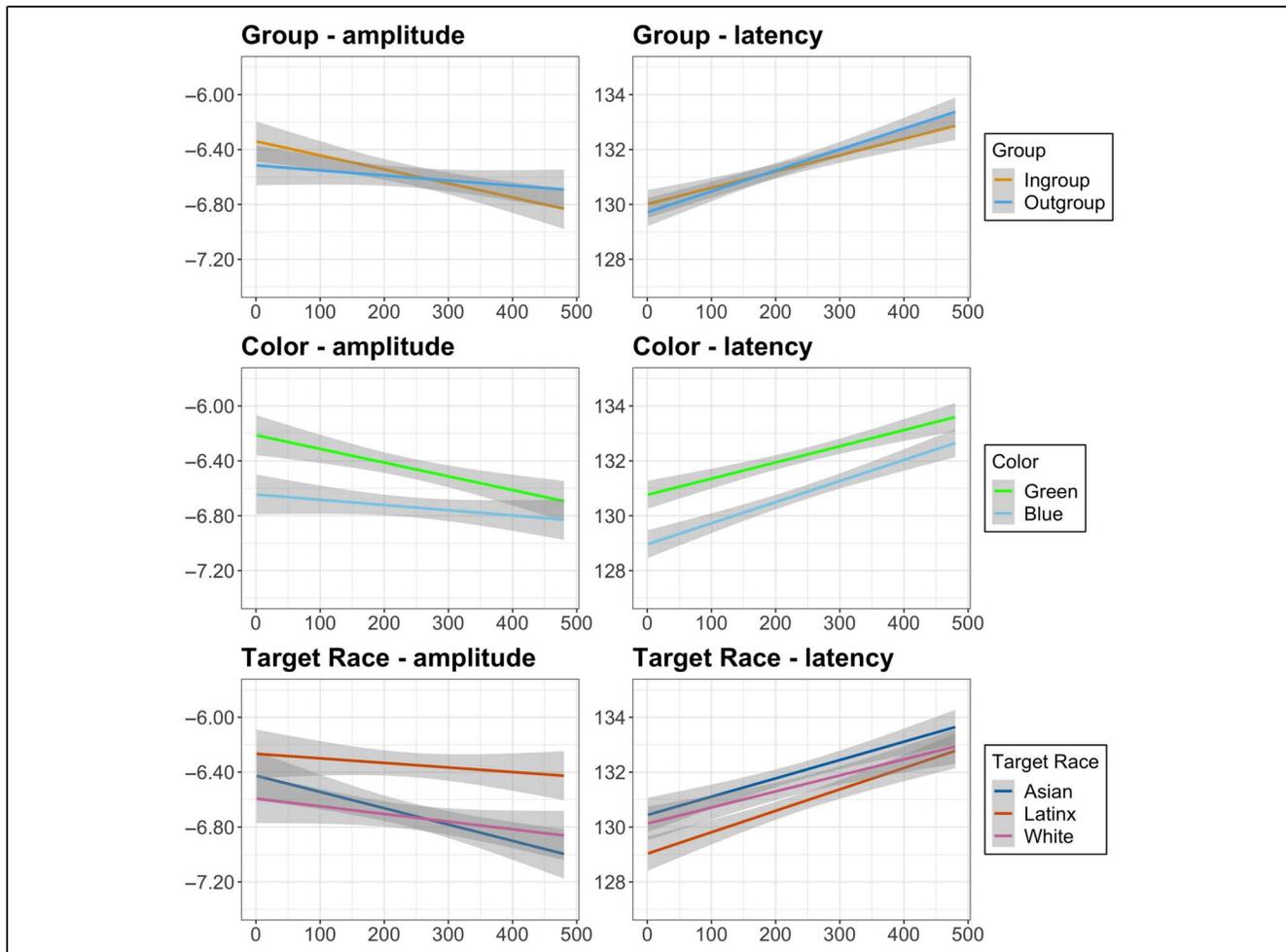
Figure 2. Predicted N170 peak amplitudes and latencies over the course of 480 trials by group (ingroup, outgroup), background color (green, blue), and target race (Asian, Latinx, White) during Study 1.

Group and Trial Number on N170 amplitudes was not significant, $b = .001$, $z = 1.61$, $p = .11$, 95% CI [−.001, −001], given the difference in the strength of the relationship between N170 amplitudes and trial number for ingroup and outgroup faces, we examined whether the difference in N170 amplitudes between ingroup and outgroup faces differed at different time points during the study. To test this, we examined the difference in N170 amplitudes between ingroup and outgroup at the beginning of the study (Trial 1) and at the end of the study (Trial 480; see the work of Volpert-Esmond et al. [2018] for a similar approach). The difference in N170 amplitudes between ingroup and outgroup remained nonsignificant at both time points during the study, ps > .05. We also found a main effect of Trial Number on N170 latencies, ingroup faces: $b = .01$, $z = 7.48$, $p < .001$, 95% CI [.005, .008]; outgroup faces: $b = .01$, $z = 9.07$, $p < .001$, 95% CI [.006, .010], indicating that, in general, the N170 latencies were delayed as the study progressed. The interaction term for N170 latencies was not significant, $b = .001$, $z = 1.11$, $p = .27$, 95% CI [−.004, .011].

Because we found significant effects of Background Color and Target Race on N170 responses, we also examined any interaction effects between these factors and the number of trials. We did not find any interaction effect between number of trials and background color or target race on N170 amplitudes or latencies, ps > .05.

Discussion

Both conventional trial-averaging and MLM trial-level analyses on data from Study 1 did not reveal any mere group membership effects on either the N170 amplitude or latency. Although there was no evidence for group membership effects, the N170 amplitudes and latencies were significantly moderated by the background color used to signify group membership and also the race/ethnicity of the faces. Specifically, N170 responses to faces on green backgrounds had significantly larger and faster amplitudes than faces on blue backgrounds, suggesting that faces on green backgrounds were processed more deeply with less effort. Moreover, N170 amplitudes to White and Asian faces were significantly larger than those to Latinx faces, but N170 latencies to Latinx faces were faster than they were to Asian faces. There also seemed to be an overall sensitization effect on the N170 amplitude, indicated by larger N170 amplitudes as the study progressed. Finding evidence for sensitization was surprising given repetition suppression reported in the N170 literature to presentations of faces of different people (Mercure et al., 2011).

Study 1 presented the group membership cue simultaneously with each face. Although this design decision was reasonable because it followed the design of Ratner and Amodio (2013), there are several reasons why this might not have been the best test of top–down effects of mere group membership on the N170 response to faces. First, by not giving participants time to process group membership cues before the face presentation, it is possible that bottom–up perception of the faces occurred faster than the conceptual group membership was processed. Second, given the strong background color effect in Study 1, the lack of mere group membership effect on the N170 could have been because of the perceptual and attentional effects of color overshadowing the group membership effect. Study 2 addressed these concerns.

STUDY 2

To give mere group membership the strongest opportunity to influence the N170 response, Study 2 replicated Study 1 except the color background indicating group membership was presented before the presentation of the face on each trial. Moreover, because the background color and faces were not presented simultaneously during Study 2, this design allowed us to examine if mere group membership modulated the N170 response to faces in the absence of concurrent bottom–up stimulation from a perceptual marker of ingroup or outgroup identity.

Methods

Participants

Forty-six participants participated in an institutional review board–approved study about neural encoding of faces in exchange for course credit. We initially preregistered to recruit 50 participants (https://osf.io/kvead), but because of the COVID-19 pandemic and the subsequent in-person experiment closure at our university, we ended up with the current sample size of 46 ($M_{age} = 19.00$, $SD = 1.28$; 31 women, 15 men). The racial and ethnic breakdown of our sample was 21 Asian, 15 Latinx, 7 White, and 6 other.

Stimuli

Face stimuli used in the current study were identical to those used in Study 1.

Procedure

The procedure of the current study was nearly identical to that of Study 1, including the minimal group assignment procedure and the face categorization task, but there were two key changes. First, during the face categorization task, a perceptual marker of group membership (i.e., colored background) occurred before a face stimulus appeared (see Figure 3) instead of simultaneously with each face (as in Study 1). Specifically, on each trial, a blue or green square (400 × 450 pixels) appeared in the center of the screen for 500 msec. This screen was followed by a mask of the same dimensions for 500 msec. Next, a fixation cross appeared on the screen, jittered between 500 and 900 msec, followed by a face stimulus presented by itself in the center of the screen, which remained on
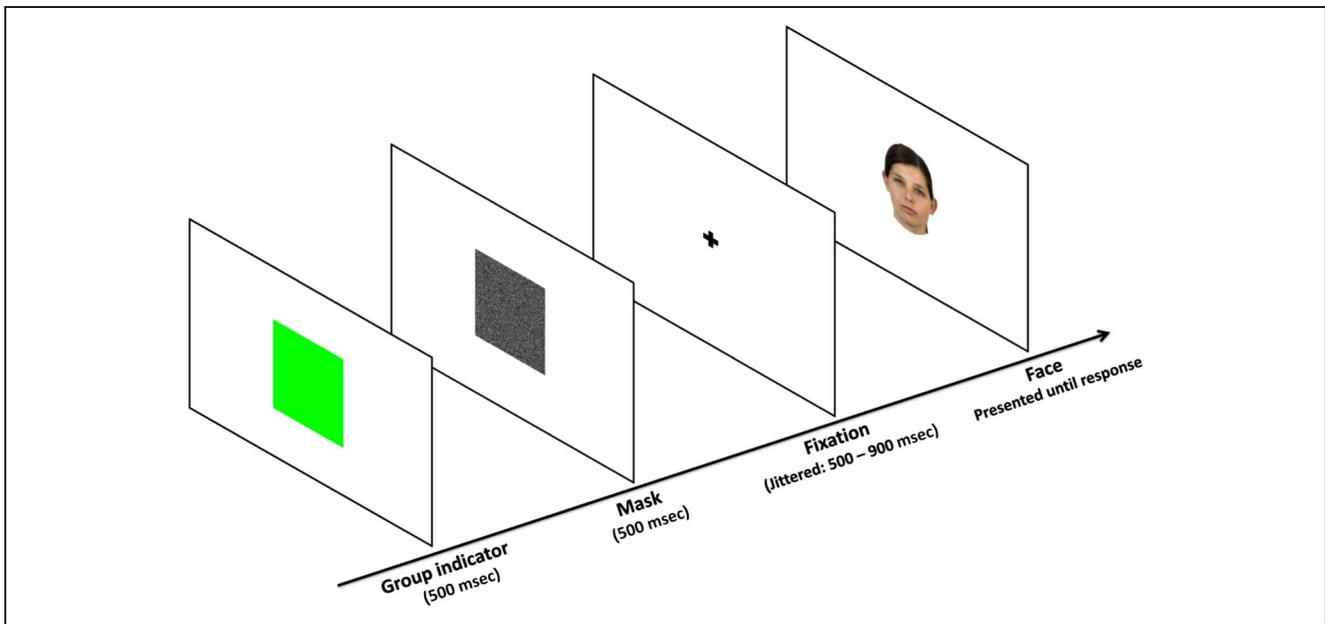
Figure 3. Sample trial of the face categorization task in Study 2. Please note that the fixation screen also appeared during the ITI (jittered 500–900 msec).

screen until participants pressed a key. No feedback was provided on whether the participants pressed the correct key or not. Following the keypress, a mask was presented on the screen for 500 msec and then a fixation cross appeared on the screen again, jittered between 500 and 900 msec. Second, because of the increased length of each trial because of two stimuli (background and face) presented separately during each trial compared with a single stimulus (face on a background) presented during each trial in Study 1, we reduced the number of times each face identity was presented from 40 times to 28 times. This resulted in a total number of 336 trials. The task was again divided into four blocks of an equal number of trials (84 trials per block).

EEG recording and processing. EEG was recorded in the same way as in Study 1 (see EEG recording and processing under Methods section of Study 1). We created ERP waveforms that were 1000-msec epochs locked to the presentation of the face (200 msec before face onset and 800 msec after face onset) at left and right lateral posterior sites (P7 and P8). The baseline was corrected by subtracting the average voltage during 200 msec before stimulus onset from each trial. We then computed the grand average of all artifact-free trials, regardless of condition, to assess when N170 responses peaked and to use that information to create a window of N170 response for each trial. The result showed that N170 responses, on average, peaked around 140 msec. The N170 was then scored for each trial as the negative peak amplitude occurring between 90 and 190 msec (50 msec before and after grand average peak) post face onset at left and right lateral posterior sites (P7 and P8).

Results

As was the case in Study 1, we averaged behavioral responses and associated N170 responses to faces within each face identity. This resulted in 2 (Group: ingroup vs. outgroup) × 2 (Electrode Site: P7 vs. P8) × 3 (Target Race: Asian vs. Latinx vs. White) × 2 unique face identities per target race = 24 data points per participant (for behavioral data, it was 12 data points because two electrode sites are simply duplicates). Again, we used MLM to analyze our data. Our experience conducting Study 1 confirmed our belief that this approach is a more sensitive way to examine our data than the conventional signal averaging approach. Similar exclusion criteria from above applied here: We excluded trials that were of extreme outlying values (> 3 SDs) of the N170 amplitude or RT. We examined effects of group membership (ingroup, outgroup), background color (green, blue), target race (Asian, Latinx, White), and the number of trials on N170 responses to faces.

Behavioral Effects

We used MLM to compare the mean level differences in behavioral responses to ingroup and outgroup. In these models, the intercept and slope of group were allowed to vary by participant. The intercept was also allowed to vary by face identity. Group membership (ingroup, outgroup) was the sole Level 1 predictor. The results showed that the log-transformed response time (in sec) of categorizing ingroup faces ($M = .95$, $SD = .29$) did not differ from that of categorizing outgroup faces ($M = .95$, $SD = .28$), $b = .002$, $z = 0.30$, $p = .76$, 95% CI [.00, .17]. Participants'

accuracies for categorizing ingroup faces ($M = 96.1\%$, $SD = 15.7$) and outgroup faces ($M = 97.2\%$, $SD = 11.9$) also did not significantly differ, $b = 1.10$, $z = 0.95$, $p = .35$, 95% CI $[-1.17, .3.38]$.

N170 Responses to Faces

We used MLM to compare the mean-level differences in N170 responses to ingroup and outgroup faces. In these models, the intercept and slope of group membership were allowed to vary by participant. The intercept was also allowed to vary by face identity and channel location. Group membership (ingroup, outgroup) was the sole Level 1 predictor. The results showed no main effect of Group Membership, indicating that peak N170 amplitudes (in μV) for ingroup faces ($M = -6.99, SD = 3.61$) and outgroup faces ($M = -6.87, SD = 3.47$) did not significantly differ from each other, $b = .09$, $z = 0.67$, $p = .50$, 95% CI $[-.17, .35]$ (see Figure 4). Next, we compared the mean-level difference in N170 peak latencies between ingroup and outgroup. The main effect of Group was not significant, indicating that peak N170 latencies (in msec) for ingroup ($M = 137.48, SD = 8.80$) and outgroup ($M = 137.93, SD = 9.29$) did not significantly differ from each other, $b = .44$, $z = 1.21$, $p = .23$, 95% CI $[-0.27, 1.16]$.

Next, we examined the effects of different colored perceptual cues (green vs. blue) on N170 responses to faces that were subsequently presented. In these models, the intercept and slope of color (blue, green) were allowed to vary by participant. The intercept was also allowed to vary by face identity and channel location. Color (blue, green) was the sole Level 1 predictor. We did not find a significant main effect of Color, indicating that peak N170 amplitudes (in μV) for faces presented after green backgrounds ($M = -6.91, SD = 3.60$) did not differ from faces presented after blue backgrounds ($M = -6.96, SD = 3.48$), $b = .06$, $z = 0.44$, $p = .66$, 95% CI $[-.20, .32]$. The main effect of different colored perceptual cues on N170 peak latencies to the faces that were subsequently presented was not significant, indicating that peak N170 latencies (in msec) for faces presented after blue cues ($M = 137.86, SD = 9.13$) did not significantly differ from peak N170 latencies for faces presented after green cues ($M = 137.55, SD = 8.98$), $b = .17$, $z = 0.47$, $p = .64$, 95% CI $[-.53, .87]$.

Lastly, we examined the mean-level differences in N170 responses to Asian, Latinx, and White faces. In these models, the intercept and slope of target race (Asian, Latinx, White) were allowed to vary by participant. The intercept was also allowed to vary by face identity and channel location. Target race (Asian, Latinx, White) was the sole Level 1 predictor. The results showed no significant main effect of Target Race. That is, the peak N170 amplitudes for Asian faces ($M = -7.01, SD = 3.42$), Latinx faces ($M = -6.74, SD = 3.53$), and White faces ($M = -7.05, SD = 3.67$) did not significantly differ from each other, $p > .05$. The main effect of Target Race on the peak N170 latency was also not significant. This indicated that peak N170 latencies (in msec) for Asian faces ($M = 138.06, SD = 9.08$), Latinx faces ($M = 137.02, SD = 9.29$), and White faces ($M = 138.05, SD = 8.76$) did not significantly differ from each other, $p > .05$.

N170 Responses over Time

Next, we examined variation in N170 responses over time. Similar to Study 1, we used trial-level data instead of averaging across repeated presentations of the same face identity, resulting in 12 face identities × 28 presentations = 336 data points per participant. The models predicted N170 responses (amplitude and latency) using group membership (ingroup vs. outgroup), trial number (1–336),

Figure 4. There was no main effect of minimal group membership on N170 peak amplitude in response to faces in Study 2.
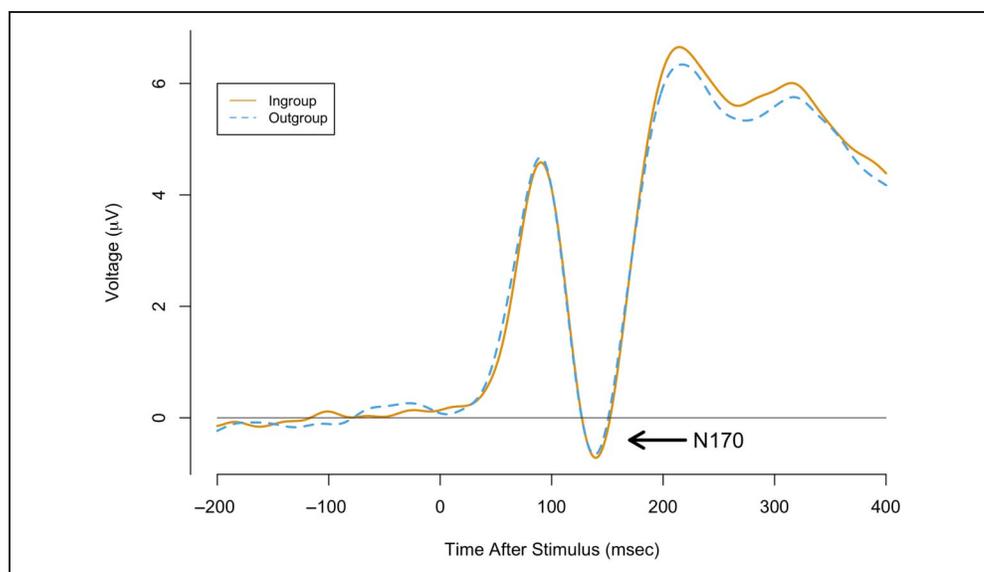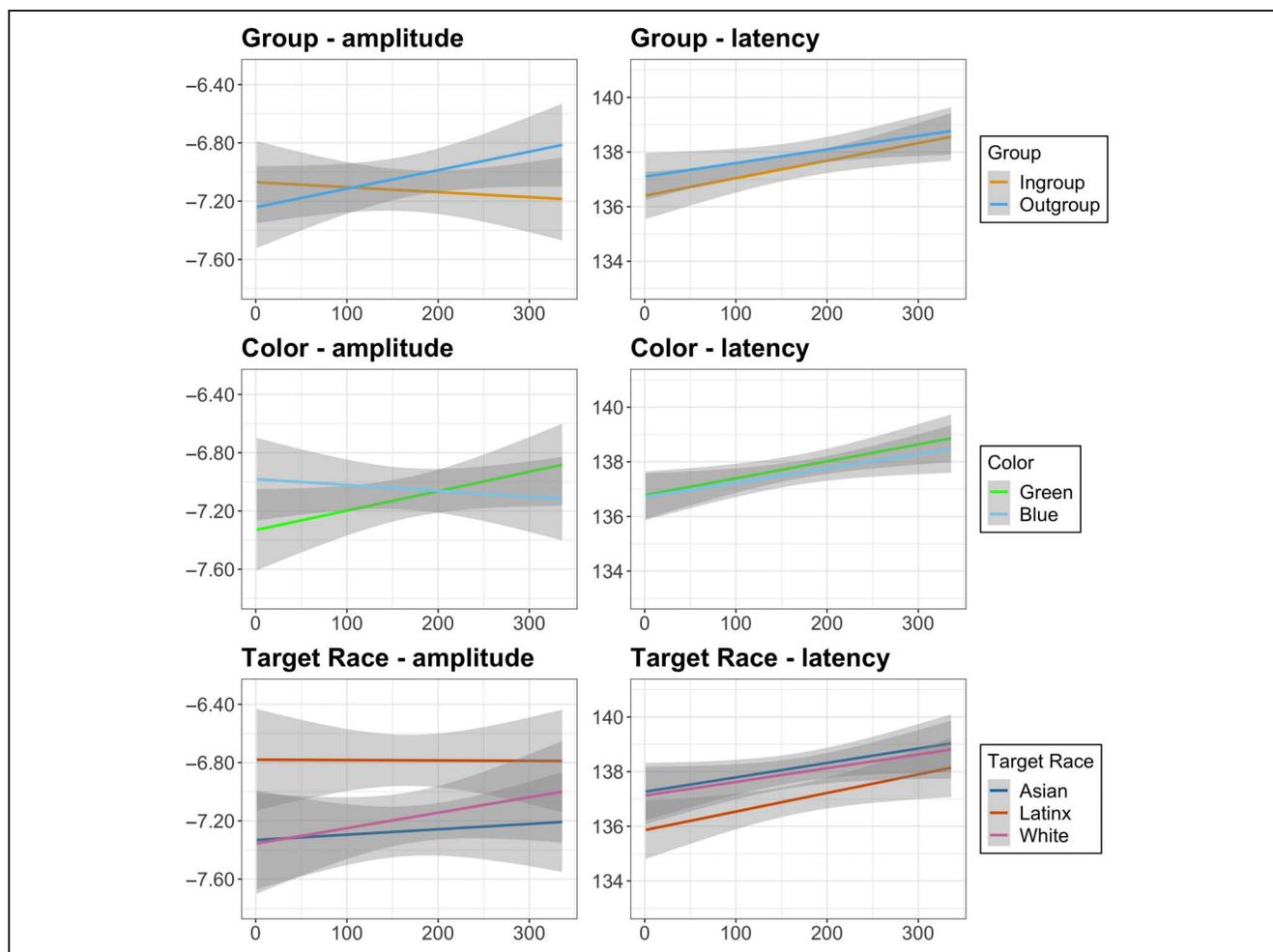
Figure 5. Predicted N170 peak amplitudes and latencies over the course of 336 trials by group (ingroup, outgroup), background color (green, blue), and target race (Asian, Latinx, White) during Study 2.

and the interaction between the two as Level 1 predictors. The trial number was centered for the ease of interpretation of the results. The models allowed the intercept and slope of group to vary for each participant. The intercept was also allowed to vary by face identity and channel location.

First, we found no significant main effect of Group Membership on N170 amplitude, $b = .08$, $z = 0.79$, $p = .43$, 95% CI $[-.11, .26]$. However, this effect was qualified by an interaction between Group Membership and Trial Number, $b = -.002$, $z = 2.20$, $p = .03$, 95% CI $[-.003, -.000]$ (see Figure 5). Specifically, the simple slope for ingroup was not significant, $b = .00$, $z = 0.06$, $p = .95$, 95% CI $[-.001, .001]$, indicating that as the study progressed, the N170 amplitudes elicited by ingroup targets did not significantly change, The simple slope for outgroup, on the other hand, was statistically significant: $b = .002$, $z = 3.05$, $p = .002$, 95% CI $[.002, .003]$, indicating that as the study progressed, N170 amplitudes significantly decreased for outgroup faces (see Figure 5).

Because the relationship between N170 amplitudes and trial number was significantly different for ingroup and outgroup faces, we further explored whether the N170

amplitudes differed between ingroup and outgroup at different time points during the study. As we did in Study 1, we tested the difference in the predicted N170 amplitudes for ingroup and outgroup at the beginning of the study (Trial 1) and at the end of the study (Trial 336). We found no significant difference between ingroup and outgroup at the beginning of the study (Trial 1), $b = -.25$, $z = 1.40$, $p = .16$, 95% CI $[-59, .10]$. However, at the end of the study (Trial 336), the predicted ingroup face N170 amplitude was significantly larger than that of the outgroup face, $b = .40$, $z = 2.27$, $p = .02$, 95% CI $[.06, .75]$. Given this significant difference in N170 amplitudes at the end of the study between ingroup and outgroup, we conducted a more conservative test by examining the differences between ingroup and outgroup for the first 25% of the trials (Block 1) and for the last 25% of the trials (Block 4). We then used MLM to predict N170 amplitudes using group (ingroup, outgroup), block number (first, last), and the interaction between the two as Level 1 predictors. As we did in previous analyses, we averaged N170 amplitudes within the same face identity, and the intercept and slope of group membership were allowed
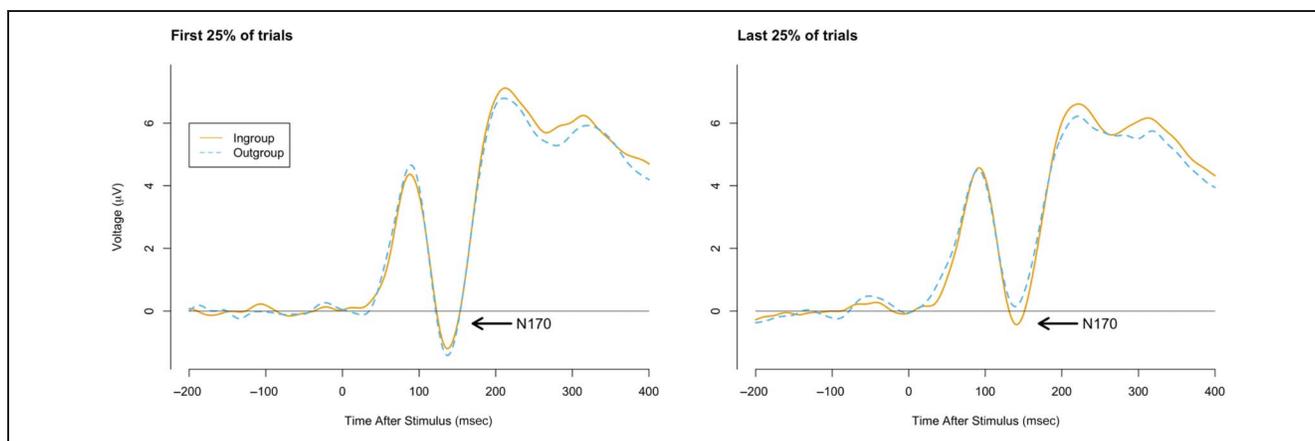
Figure 6. Minimal group effects on N170 amplitudes to faces during the first and last 25% of trials during Study 2. A statistically significant larger peak amplitude for ingroup compared with outgroup faces was only apparent for the last 25% of trials.

to vary by participant. The intercept was also allowed to vary by face identity and channel location. We found no main effect of Group during the first block of the study, indicating that for the first 25% of trials, peak N170 amplitudes (in μV) for ingroup ($M = -7.02$, $SD = 4.29$) and outgroup ($M = -7.15$, $SD = 4.11$) did not significantly differ from each other, $b = -.13$, $z = 0.60$, $p = .55$, 95% CI [$-.54$, .28]. However, this effect was qualified by the interaction between Group Membership and Block Number, $b = .66$, $z = 2.33$, $p = .02$, 95% CI [0.10, 1.22], indicating that the differences between ingroup and outgroup were different for the first 25% and last 25% of trials. Indeed, we found a significant effect of Group during the last block of the study, indicating that for the last 25% of trials, the peak N170 amplitude for ingroup ($M = -7.09$, $SD = 4.38$) was significantly greater than that of the outgroup ($M = -6.55$, $SD = 4.18$), $b = .53$, $z = 2.55$, $p = .01$, 95% CI [.12, .95] (see Figure 6).

We found no significant effect of Group on N170 latency, $b = .39$, $z = 1.13$, $p = .27$, 95% CI [$-.28$, 1.06]. However, we found a significant main effect of Trial Number on N170 latencies for both the ingroup, $b = .01$, $z = 7.48$, $p < .001$, 95% CI [.005, .008], and the outgroup, $b = .01$, $z = 9.07$, $p < .001$, 95% CI [.006, .010], indicating that as the study progressed, the N170 latencies were generally delayed in response to faces. The interaction between Group Membership and Trial Number for N170 latencies was not significant, $p > .05$.

We also examined any interaction effects between Background Color and Target Race and the Number of Trials. We found a significant interaction between Background Color and the Number of Trials on N170 amplitudes, $b = .002$, $z = 2.47$, $p = .01$, 95% CI [.000, .004]. That is, we found no significant main effect of Trial Number for N170 amplitudes to faces presented after green cues, $b = -.00$, $z = 0.25$, $p = .80$, 95% CI [$-.001$, .001]. However, there was a significant main effect of Trial Number for N170 amplitudes to faces presented after blue cues, $b = .002$, $z = 3.25$, $p = .001$, 95% CI [.001, .003], indicating that the relationship

between N170 amplitude and trial number was significantly stronger for faces presented after blue cues than faces presented after green cues. No other significant interaction effects emerged.

Discussion

As with Study 1, the Study 2 results did not indicate any main effect of group membership. This is despite the fact that the perceptual marker of group membership was presented earlier than in Study 1 to allow for more time for participants to process conceptual information before each face appeared. Unlike with Study 1, there was no main effect of background color during Study 2. This lack of a color main effect during Study 2 when background color was presented at least 1500 msec before the face appeared is consistent with the notion that background color modulated the N170 during Study 1 because it was presented concurrently with each face. Interestingly, Study 2 did not replicate the main effect of race that was present during Study 1. Moreover, Study 2 results differed from Study 1 because trial number independently interacted with mere group membership and background color. Over the course of Study 2, N170 peak amplitudes to outgroup (but not ingroup) faces were significantly smaller on later trials. This effect is consistent with a habituation effect to outgroup faces. One possible explanation of this finding that is consistent with existing ERP and fMRI repetition suppression research (see the works of Hughes et al., 2019; Vizioli, Rousselet, & Caldara, 2010) is that the N170 response adapts to the presentation of various outgroup but not ingroup faces over time because ingroup members are seen more as individuals. Separately, there appears to be some evidence of a carryover effect of background color on later face processing as the study progressed. N170 peak amplitudes to faces presented after blue (but not green) backgrounds seemed to have a habituation effect on the later trials during Study 2. It is not clear why

the N170 amplitude would habituate less after presentations of the green background, perhaps this is because of residual bottom–up attentional or sensory effects.

GENERAL DISCUSSION

Fully understanding whether visual perception can be influenced by cognition is not simply an esoteric academic fascination—it has important implications for society (Granot, Balcetis, Schneider, & Tyler, 2014; Eberhardt, Goff, Purdie, & Davies, 2004). For most people, perception is experienced as immediate and incontrovertible, and thus, we assume that what we see is a veridical representation of the external world, no matter how subjective it may actually be (Dunning & Balcetis, 2013). Police officers rely on what they see to guide split second decisions about whether or not to use lethal force. Jurors give considerable weight to eyewitness identifications when determining a defendant's guilt. Subjective visual experience is so powerful that the U.S. Supreme Court has codified "I see it so it must be true" logic as legal precedent (Kahan, Hoffman, & Braman, 2009). If visual representations can be biased by cognitions, then perceptions become a less reliable input for decision-making about the world around us than is commonly believed.

Because faces are rich sources of social information, they attract considerable visual attention (Birmingham et al., 2009). When we encounter another person, we rapidly group them by social category information (Ito & Urland, 2003; Fiske, 1998). Thus, probing whether social biases demonstrated in behavior, beliefs, and evaluations also affect sensory processing of faces provides critical insight into how entrenched prejudice and discrimination are in human information processing. However, investigating group biases in early face processing is complicated by how rapidly visual encoding occurs. Fortunately, cognitive neuroscience research that identified a face-sensitive negative-going ERP called the N170, which peaks approximately 170 msec after a face appears, provides an avenue for examining group categorization bias in early face encoding. In our work, we used the classic minimal group paradigm from social psychology to separate the cognitive aspects of mere group membership from perceptual markers of group membership and test their influences on the N170 response to faces.

Across two preregistered studies, we do not find a main effect of group membership, which goes against the claim that simply being assigned to the same or different group as another person (i.e., the cognitive aspect of mere group membership) influences the structural encoding of their face, as indicated by either the amplitude or latency of the N170. It did not matter whether we followed Ratner and Amodio (2013) and presented the group membership cue simultaneously with each face (Study 1) or the group membership cue preceded each face presentation to allow for more time for top–down group categorization

effects to unfold before bottom–up sensory information appeared (Study 2).

The one piece of evidence that was consistent with an effect of group membership on the N170 was an exploratory analysis that showed larger peak N170 amplitudes to ingroup compared with outgroup faces as Study 2 progressed. This finding raises the possibility that participants in that study perceptually adapted to the presentation of outgroup faces of varying individual identities to a greater degree than they did to ingroup faces of varying identities (see the work of Hughes et al. [2019] and Vizioli et al., [2010] for conceptually similar results using established group distinctions and a standard repetition suppression paradigm). It is possible that this is explained by more individuation of ingroup compared with outgroup faces. We are hesitant to interpret this interaction effect, however, because it was not preregistered and the same interaction was not significant in Study 1. In fact, Study 1 showed evidence of sensitization (not habituation) to face stimuli regardless of group membership over time (i.e., larger N170 amplitudes as Study 1 progressed). This difference in patterns might have resulted from design differences between the two studies, namely, whether the color background and the face were presented simultaneously or sequentially on each trial. Future research could directly investigate this possibility.

Intergroup Bias and the N170

We modeled our work after Ratner and Amodio (2013) because it was the first study to suggest that mere group membership modulates the N170. Unlike their study, our studies were preregistered, our overall sample size was larger, we gender matched our stimuli to our participants, and we used more racially/ethnically diverse face stimuli. We also more carefully considered potential methodological confounds based on how the N170 was calculated, including the number of trials and effects of background color. For these reasons, we view our work as a particularly strong test of whether group membership influences the face-sensitive N170. However, some deviations from Ratner and Amodio's (2013) methods could explain differences between their findings and ours. For instance, it is possible that because fewer faces were used in their study, their participants could have learned which face belonged to each group more easily and did not rely on the background color as much to guide their group classifications. That said, our Study 2 would presumably mitigate this problem by activating the conceptual group knowledge before each face presentation. In addition, Ratner and Amodio (2013) only used White male faces to keep target race and gender constant. We chose to use a more diverse stimulus set because it gave us the flexibility to restrict our analysis to White target faces (as we did in our initial Study 1 N170 analyses to closely match their design) or to make our results more ecologically valid by analyzing the responses to the full set of faces (as we did in our

subsequent analyses). However, it is possible that the presence of racial/ethnic heterogeneity distracted attention away from the mere group membership difference.

Despite no main effect of mere group membership on the N170 response, there was some indication that the N170 response was modulated by the race/ethnicity of the target faces. Study 1 found that the N170 amplitude was smaller and faster in response to Latinx versus White and Asian faces. There were no statistically significant differences between the White and Asian faces. However, Study 2 did not replicate these N170 amplitude or latency effects. It is worth noting that the sample size for Study 2 was about half the sample size of Study 1, so it is possible that Study 2 was not adequately powered to examine the race/ethnicity effects. Assuming that the Study 1 race/ethnicity effects were not spurious, it is an open question as to why White and Asian faces had a larger N170 response than Latinx faces. One possibility is that within American society, White and Asian people are viewed as having higher status than Latinx people and perceivers attend more (and thus process more deeply) faces they view as higher status. However, because race/ethnicity effects on the N170 were not the primary focus of this article and the results were not entirely consistent across studies, any explanations of these effects are speculative.

Our analysis focuses on the N170 given that it is the ERP most closely linked to face encoding, but our raw data are available upon request in case other researchers want to examine our data for group effects on ERPs beyond the N170. We also share our aggregated EEG data and analysis code on the Open Science Framework.

Advice for EEG Researchers Studying Social Group Effects

The senior author of the current work was the first author of the work whose design and analyses we attempted to closely follow and extend. We fully expected to confirm Ratner and Amodio's (2013) results. Although the failure to do so was disappointing, the experience of conducting this research gave us valuable insight that will inform our future EEG research and is relevant to other cognitive and social neuroscientists who are studying similar topics.

Background color in Study 1 significantly modulated the N170 response to faces. This indicates that cognitive and social neuroscientists should pay very careful attention to the low-level visual cues that they manipulate to signify novel group membership to make sure any conclusions about high-level cognition influencing perception are not because of sensory or attentional confounds. This is especially the case because research outside of the face processing literature finds that an early negative-going ERP called the visual N1 is associated with attention and color discrimination (Vogel & Luck, 2000). This ERP is detectable in the same window and at the same channels

as those that are typically used to assess the N170. It is notable, however, that although Ratner and Amodio (2013) did not model background color effects, they did counterbalance background color, so a background color confound is not an easy explanation of their findings. Beyond methodological considerations, researchers interested in the formation of intergroup biases should take note of this strong background color effect. In the real world, groups may choose bright clothing and other vivid artifacts to demarcate themselves from others and might use such effects to their strategic advantage (Hill & Barton, 2005). Future research could expand on how the perceptual qualities of these symbols may bias face processing and other aspects of social perception.

To our knowledge, our work is the first research on group membership effects on face perception to preregister our sample sizes. One of the reasons that sample size preregistration is important is that stopping data collection after finding a statistically significant result (i.e., optional stopping) can inadvertently take advantage of fluctuations in p values in a way that leads to false positives (Simmons, Nelson, & Simonsohn, 2011). For the Study 1 preregistration, we landed on a target of 100 participants by doubling the 45 participant sample size of Ratner and Amodio (2013) and then rounding up. We reasoned a priori that this preregistered sample size would likely account for any overestimation of effect size by Ratner and Amodio (2013). By committing to our preregistered sample size, we were free to conduct interim analyses with the knowledge that we would not stop data collection early based on significant effects. These interim analyses were instructive because they proved to us the instability of p values and the importance of not relying on optional stopping. At one point, the results of an interim analysis suggested to us that we would actually replicate Ratner and Amodio's (2013) finding, but this turned out to be illusory after subsequent analyses further along in data collection consistently revealed null main effects. Although determining a preregistered sample size can be very challenging when conducting a new study because one might not feel confident that effect sizes calculated from past research can be relied upon for power analyses or there is a lack of comparable past research to estimate effect sizes, ERP research should not underestimate the extent to which optional stopping can undermine the validity of hypothesis testing.

Another difficulty with ERP research is that there is a lot of flexibility in how researchers can choose to analyze their data (Luck & Gaspelin, 2017). For instance, initially when we created our multilevel models, we chose to model random intercepts but fixed slopes for ingroup and outgroup for each participant. This appeared to show a statistically significant effect of group membership on the N170. However, this modeling choice was incorrect because it did not account for variability between participants[7] (Volpert-Esmond et al., 2018, 2021). Because of how slight variation in modeling choices can lead to differing conclusions, we

recommend that ERP researchers attempt to model their data with competing approaches to ensure that one approach does not lead them astray.

Implications for Understanding Cognition Effects on Perception

Our preregistered results suggest that previous reports of mere group membership effects on the N170 should not be relied upon to support broader claims that cognition influences early visual perception. That said, it should not be overlooked that Study 2 seemed to show N170 adaptation to outgroup but not ingroup faces. Although we did not predict this finding a priori, in hindsight, this effect is consistent with some existing ERP and fMRI research examining social group effects on repetition suppression to outgroup faces (Hughes et al., 2019; Vizioli et al., 2010). In that work, adaptation is operationalized as a smaller neural response following a face presentation that directly follows one of the same group identity. The apparent adaptation in Study 2 was different in that it was general adaption to outgroup more than ingroup faces across randomized, intermixed trials over time. Past research had shown general N170 habituation to faces over time (Mercure et al., 2011), but moderation by group had not been explored.

If future studies provide support for this intergroup N170 habituation effect, careful consideration of the theoretical implications would be necessary. Claims about top–down effects of group membership on visual perception typically assume that they occur at the initial time a person is encountered. Top–down effects during an interaction with a single individual could result from conceptual group membership shaping the representational structure of the visual code or differential attention to ingroup versus outgroup faces. What appears to be greater habituation to outgroup versus ingroup faces in a long experimental session with many intermixed trial types could actually result from participants focusing less on the outgroup faces over time as overall attention wanes. A reason for this is that past research suggests that, in a minimal group context, outgroups are viewed as less relevant to the perceiver and less worthy of deep encoding (Bernstein, Young, & Hugenberg, 2007). Such an attentional explanation seems especially likely when the perceptual marker of group membership is presented before the face so participants can anticipate whether an ingroup or outgroup face is likely to appear (as was the case in our Study 2) and plan their attentional allocation accordingly. Thus, apparent N170 habituation to outgroup faces more so than ingroup faces toward the end of an experimental session might be less about the structure of the sensory representation in the most direct sense and more about an upstream decision by the participant (perhaps non-consciously) to attend to ingroup and outgroup faces differently. Beyond theory development, disambiguating top–down effects on attention and representation could

inform the creation of applied interventions to prevent bias from influencing visual processing.

Conclusion

The temporal resolution of EEG makes it a powerful tool to study higher-order cognitive effects on early stages of face encoding. Some past research suggests that group categorization could influence the face-sensitive N170 response whereas other research does not support a link. Our two preregistered results find no main effect of mere group membership on face perception. Instead of finding a clear top–down conceptual effect of group membership on face processing, we observed bottom–up effects of race/ethnicity and background color on the N170 response in one of our studies and some evidence for differential habituation to ingroup and outgroup faces in our second study.

Acknowledgments

Data Availability Statement

All code and aggregated data will be available on the Open Science Framework. Raw data will be available by request.

Author Contributions

Youngki Hong: Conceptualization; Data curation; Formal analysis; Funding acquisition; Project administration; Software; Writing—Original draft; Writing—Review & editing. Matthew S. Mayes: Conceptualization; Data curation; Formal analysis; Funding acquisition; Project administration; Writing—Original draft; Writing—Review & editing. Anudhi P. Munasinghe: Data curation; Project administration; Writing—Review & editing. Kyle G. Ratner: Conceptualization; Formal analysis; Funding acquisition; Resources; Supervision; Writing—Original draft; Writing—Review & editing.

Diversity in Citation Practices

Retrospective analysis of the citations in every article published in this journal from 2010 to 2021 reveals a persistent

pattern of gender imbalance: Although the proportions of authorship teams (categorized by estimated gender identification of first author/last author) publishing in the *Journal of Cognitive Neuroscience* (*JoCN*) during this period were M(an)/M = .407, W(oman)/M = .32, M/W = .115, and W/W = .159, the comparable proportions for the articles that these authorship teams cited were M/M = .549, W/M = .257, M/W = .109, and W/W = .085 (Postle and Fulvio, *JoCN*, 34:1, pp. 1–3). Consequently, *JoCN* encourages all authors to consider gender balance explicitly when selecting which articles to cite and gives them the opportunity to report their article's gender citation balance. The authors of this article report its proportions of citations by gender category to be as follows: M/M = .675; W/M = .2; M/W = .1; W/W = .025.

Notes

1. Latinx is a nongendered term that encompasses both Latino and Latina identity. We use this term because many of our student participants voice preference for it; however, we acknowledge that other people with roots in Latin America might prefer Latino or Hispanic as the relevant pan-ethnic classifier of men and women (Noe-Bustamante, Mora, & Hugo Lopez, 2020).
2. The specific CFD stimuli were as follows: WF006, LF217, LF213, WF017, AF219, LF208, AF225, WF005, LF212, WF001, AF240, AF201, WM200, LM243, AM228, AM229, AM250, WM209, LM211, LM207, WM031, AM238, WM230, and LM216.
3. In PsychoPy (Python 2.7), the colors used in this task were *lime* (green) and *deepskyblue* (blue).
4. Results did not change if we selected the first 30 ingroup and outgroup faces regardless of target race/ethnicity.
5. Please note that because we used a more diverse set of faces (Asian, Latinx, and White and gender matched face stimuli to the participants) than did Ratner and Amodio (2013) (only White male faces) and equated the faces for trustworthiness (not done by Ratner and Amodio), Study 1 is not an exact replication of their work.
6. It is likely that mean RT was longer in our study than in the work of Ratner and Amodio (2013) because we included a jittered fixation cross so participants could not predict exactly when a face would appear. Their study had a fixed amount of time between trials, and a look at the baseline portion of their ERP epoch suggests that participants were anticipating each face onset and preparing their response accordingly.
7. We thank Hannah Volpert-Esmond for pointing this out to us during a conversation at the 2020 meeting of the Society for Personality and Social Psychology.

REFERENCES

Amodio, D. M., & Cikara, M. (2021). The social neuroscience of prejudice. *Annual Review of Psychology*, 72, 439–469. https://doi.org/10.1146/annurev-psych-010419-050928, PubMed: 32946320

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience*, 8, 551–565. https://doi.org/10.1162/jocn.1996.8.6.551, PubMed: 20740065

Bernstein, M. J., Young, S. G., & Hugenberg, K. (2007). The cross-category effect: Mere social categorization is sufficient to elicit an own-group bias in face recognition. *Psychological Science*, 18, 706–712. https://doi.org/10.1111/j.1467-9280.2007.01964.x, PubMed: 17680942

Birmingham, E., Bischof, W. F., & Kingstone, A. (2009). Get real! Resolving the debate about equivalent social stimuli. *Visual Cognition*, 17, 904–924. https://doi.org/10.1080/13506280902758044

Cassidy, K. D., Boutsen, L., Humphreys, G. W., & Quinn, K. A. (2014). Ingroup categorization affects the structural encoding of other-race faces: Evidence from the N170 event-related potential. *Social Neuroscience*, 9, 235–248. https://doi.org/10.1080/17470919.2014.884981, PubMed: 24506512

Churchland, P. M. (1988). Perceptual plasticity and theoretical neutrality: A reply to Jerry Fodor. *Philosophy of Science*, 55, 167–187. https://doi.org/10.1086/289425, PubMed: 28073940

Dijkstra, N., Bosch, S. E., & van Gerven, M. A. (2017). Vividness of visual imagery depends on the neural overlap with perception in visual areas. *Journal of Neuroscience*, 37, 1367–1373. https://doi.org/10.1523/JNEUROSCI.3022-16.2016, PubMed: 28073940

Dunning, D., & Balcetis, E. (2013). Wishful seeing. *Current Directions in Psychological Science*, 22, 33–37. https://doi.org/10.1177/0963721412463693

Eberhardt, J. L., Goff, P. A., Purdie, V. J., & Davies, P. G. (2004). Seeing black: Race, crime, and visual processing. *Journal of Personality and Social Psychology*, 87, 876–893. https://doi.org/10.1037/0022-3514.87.6.876, PubMed: 15598112

Firestone, C., & Scholl, B. J. (2016). Cognition does not affect perception: Evaluating the evidence for "top–down" effects. *Behavioral and Brain Sciences*, 39, e229. https://doi.org/10.1017/s0140525x15000965, PubMed: 26189677

Fiske, S. T. (1998). Stereotyping, prejudice, and discrimination. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (pp. 357–411). McGraw-Hill.

Fodor, J. A. (1983). *The modularity of mind: An essay on faculty psychology*. Cambridge, MA: MIT Press. https://doi.org/10.7551/mitpress/4737.001.0001

Gamond, L., Vilarem, E., Safra, L., Conty, L., & Grèzes, J. (2017). Minimal group membership biases early neural processing of emotional expressions. *European Journal of Neuroscience*, 46, 2584–2595. https://doi.org/10.1111/ejn.13735, PubMed: 28976039

Gauthier, I., & Curby, K. M. (2005). A perceptual traffic jam on highway N170. *Current Directions in Psychological Science*, 14, 30–33. https://doi.org/10.1111/j.0963-7214.2005.00329.x

Goldstone, R. L., & Barsalou, L. W. (1998). Reuniting perception and conception. *Cognition*, 65, 231–262. https://doi.org/10.1016/s0010-0277(97)00047-4, PubMed: 9557384

Gramfort, A., Luessi, M., Larson, E., Engemann, D. A., Strohmeier, D., Brodbeck, C., et al. (2013). MEG and EEG data analysis with MNE-Python. *Frontiers in Neuroscience*, 7, 267. https://doi.org/10.3389/fnins.2013.00267, PubMed: 24431986

Granot, Y., Balcetis, E., Schneider, K. E., & Tyler, T. R. (2014). Justice is not blind: Visual attention exaggerates effects of group identification on legal punishment. *Journal of Experimental Psychology: General*, 143, 2196–2208. https://doi.org/10.1037/a0037893, PubMed: 25222261

Haxby, J. V., Hoffman, E. A., & Gobbini, M. (2000). The distributed human neural system for face perception. *Trends in Cognitive Sciences*, 4, 223–233. https://doi.org/10.1016/s1364-6613(00)01482-0, PubMed: 10827445

Herzmann, G., & Curran, T. (2013). Neural correlates of the in-group memory advantage on the encoding and recognition of faces. *PLoS One*, 8, e82797. https://doi.org/10.1371/journal.pone.0082797, PubMed: 24358226

Hill, R. A., & Barton, R. A. (2005). Red enhances human performance in contests. *Nature*, 435, 293–293. https://doi.org/10.1038/435293a, PubMed: 15902246

Hong, Y., & Ratner, K. G. (2021). Minimal but not meaningless: Seemingly arbitrary category labels can imply more than group membership. *Journal of Personality and Social Psychology*, 120, 576–600. https://doi.org/10.1037/pspa0000255, PubMed: 32816512

Hughes, B. L., Camp, N. P., Gomez, J., Natu, V. S., Grill-Spector, K., & Eberhardt, J. L. (2019). Neural adaptation to faces reveals racial outgroup homogeneity effects in early perception. *Proceedings of the National Academy of Sciences, U.S.A.*, 116, 14532–14537. https://doi.org/10.1073/pnas.1822084116, PubMed: 31262811

Itier, R. J., & Taylor, M. J. (2004). N170 or N1? Spatiotemporal differences between object and face processing using ERPs. *Cerebral Cortex*, 14, 132–142. https://doi.org/10.1093/cercor/bhg111, PubMed: 14704210

Ito, T. A., & Bartholow, B. D. (2009). The neural correlates of race. *Trends in Cognitive Sciences*, 13, 524–531. https://doi.org/10.1016/j.tics.2009.10.002, PubMed: 19896410

Ito, T., & Urland, G. (2003). Race and gender on the brain: Electrocortical measures of attention to the race and gender of multiply categorizable individuals. *Journal of Personality and Social Psychology*, 85, 616–626. https://doi.org/10.1037/0022-3514.85.4.616, PubMed: 14561116

Kahan, D. M., Hoffman, D. A., & Braman, D. (2009). *Whose eyes are you going to believe? Scott v. Harris and the perils of cognitive illiberalism* Harvard Law Review. https://harvardlawreview.org/2009/04/whose-eyes-are-you-going-to-believe-scott-v-harris-and-the-perils-of-cognitive-illiberalism/.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human Extrastriate cortex specialized for face perception. *Journal of Neuroscience*, 17, 4302–4311. https://doi.org/10.1523/jneurosci.17-11-04302.1997, PubMed: 9151747

Koenig-Robert, R., & Pearson, J. (2019). Decoding the contents and strength of imagery before volitional engagement. *Scientific Reports*, 9, 3504. https://doi.org/10.1038/s41598-019-39813-y, PubMed: 30837493

Kosslyn, S. M. (2005). Mental images and the brain. *Cognitive Neuropsychology*, 22, 333–347. https://doi.org/10.1080/02643290442000130, PubMed: 21038254

Kosslyn, S. M., Thompson, W. L., Kim, I. J., & Alpert, N. M. (1995). Topographical representations of mental images in primary visual cortex. *Nature*, 378, 496–498. https://doi.org/10.1038/378496a0, PubMed: 7477406

Luck, S. J., & Gaspelin, N. (2017). How to get statistically significant effects in any ERP experiment (and why you shouldn't). *Psychophysiology*, 54, 146–157. https://doi.org/10.1111/psyp.12639, PubMed: 28000253

Lupyan, G., Thompson-Schill, S. L., & Swingley, D. (2010). Conceptual penetration of visual processing. *Psychological Science*, 21, 682–691. https://doi.org/10.1177/0956797610366099, PubMed: 20483847

Ma, D. S., Correll, J., & Wittenbrink, B. (2015). The Chicago face database: A free stimulus set of faces and norming data. *Behavior Research Methods*, 47, 1122–1135. https://doi.org/10.3758/s13428-014-0532-5, PubMed: 25582810

Mercure, E., Cohen Kadosh, K., & Johnson, M. H. (2011). The N170 shows differential repetition effects for faces, objects, and orthographic stimuli. *Frontiers in Human Neuroscience*, 5, 6. https://doi.org/10.3389/fnhum.2011.00006, PubMed: 21283529

Naselaris, T., Olman, C. A., Stansbury, D. E., Ugurbil, K., & Gallant, J. L. (2015). A voxel-wise encoding model for early visual areas decodes mental images of remembered scenes. *Neuroimage*, 105, 215–228. https://doi.org/10.1016/j.neuroimage.2014.10.018, PubMed: 25451480

Nguyen, V. T., Breakspear, M., & Cunnington, R. (2014). Fusing concurrent EEG–fMRI with dynamic causal modeling: Application to effective connectivity during face perception. *Neuroimage*, 102, 60–70. https://doi.org/10.1016/j.neuroimage.2013.06.083, PubMed: 23850464

Noe-Bustamante, L., Mora, L., & Hugo Lopez, M. (2020). *About one-in-four U.S. Hispanics have heard of Latinx, but just 3% use it*. Pew Research Center. https://www.pewresearch.org/hispanic/2020/08/11/about-one-in-four-u-s-hispanics-have-heard-of-latinx-but-just-3-use-it/.

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., et al. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods*, 51, 195–203. https://doi.org/10.3758/s13428-018-01193-y, PubMed: 30734206

Puce, A., Allison, T., Gore, J. C., & McCarthy, G. (1995). Face-sensitive regions in human extrastriate cortex studied by functional MRI. *Journal of Neurophysiology*, 74, 1192–1199. https://doi.org/10.1152/jn.1995.74.3.1192 PubMed: 7500143

Pylyshyn, Z. (1999). Is vision continuous with cognition?: The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences*, 22, 341–365. https://doi.org/10.1017/s0140525x99002022, PubMed: 11301517

Ratner, K. G., & Amodio, D. M. (2013). Seeing "us vs. them": Minimal group effects on the neural encoding of faces. *Journal of Experimental Social Psychology*, 49, 298–301. https://doi.org/10.1016/j.jesp.2012.10.017

Ratner, K. G., Dotsch, R., Wigboldus, D. H. J., van Kippenberg, A., & Amodio, D. M. (2014). Visualizing minimal ingroup and outgroup faces: Implications for impressions, attitudes, and behavior. *Journal of Personality and Social Psychology*, 106, 897–911. https://doi.org/10.1037/a0036498, PubMed: 24841095

Rossion, B., & Jacques, C. (2008). Does physical interstimulus variance account for early electrophysiological face sensitive responses in the human brain? Ten lessons on the N170. *Neuroimage*, 39, 1959–1979. https://doi.org/10.1016/j.neuroimage.2007.10.011, PubMed: 18055223

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, 22, 1359–1366. https://doi.org/10.1177/0956797611417632, PubMed: 22006061

Tajfel, H., Billig, M. G., Bundy, R. P., & Flament, C. (1971). Social categorization and intergroup behaviour. *European Journal of Social Psychology*, 1, 149–178. https://doi.org/10.1002/ejsp.2420010202

Tanaka, J. W., & Curran, T. (2001). A neural basis for expert object recognition. *Psychological Science*, 12, 43–47. https://doi.org/10.1111/1467-9280.00308, PubMed: 11294227

Thierry, G., Martin, C. D., Downing, P., & Pegna, A. J. (2007). Controlling for interstimulus perceptual variance abolishes N170 face selectivity. *Nature Neuroscience*, 10, 505–511. https://doi.org/10.1038/nn1864, PubMed: 17334361

Van Bavel, J. J., Packer, D. J., & Cunningham, W. A. (2008). The neural substrates of in-group bias. *Psychological Science*, 19, 1131–1139. https://doi.org/10.1111/j.1467-9280.2008.02214.x, PubMed: 19076485

Van Bavel, J. J., Packer, D. J., & Cunningham, W. A. (2011). Modulation of the fusiform face area following minimal exposure to motivationally relevant faces: Evidence of in-group enhancement (not out-group disregard). *Journal of Cognitive Neuroscience*, 23, 3343–3354. https://doi.org/10.1162/jocn_a_00016, PubMed: 21452952

Vizioli, L., Rousselet, G. A., & Caldara, R. (2010). Neural repetition suppression to identity is abolished by other-race faces. *Proceedings of the National Academy of Sciences, U.S.A.*, 107, 20081–20086. https://doi.org/10.1073/pnas.1005751107, PubMed: 21041643

Vogel, E. K., & Luck, S. J. (2000). The visual N1 component as an index of a discrimination process. *Psychophysiology*, *37*, 190–203. https://doi.org/10.1111/1469-8986.3720190, PubMed: 10731769

Volpert-Esmond, H. I., Merkle, E. C., Levsen, M. P., Ito, T. A., & Bartholow, B. D. (2018). Using trial-level data and multilevel modeling to investigate within-task change in event-related potentials. *Psychophysiology*, *55*, e13044. https://doi.org/10.1111/psyp.13044, PubMed: 29226966

Volpert-Esmond, H. I., Page-Gould, E., & Bartholow, B. D. (2021). Using multilevel models for the analysis of event-related potentials. *International Journal of Psychophysiology*, *162*, 145–156. https://doi.org/10.1016/j.ijpsycho.2021.02.006, PubMed: 33600841

Zheng, X., & Segalowitz, S. J. (2014). Putting a face in its place: In- and out-group membership alters the N170 response. *Social Cognitive and Affective Neuroscience*, *9*, 961–968. https://doi.org/10.1093/scan/nst069, PubMed: 23677488