

# Subjective social status and neural processing of race in Mexican American adolescents

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## Abstract

Adolescence is a sensitive period for sociocultural development in which facets of social identity, including social status and race, become especially salient. Despite the heightened importance of both social status and race during this developmental period, no known work has examined how individual differences in social status influence perceptions of race in adolescents. Thus, in the present study, we investigated how both subjective social status and objective socioeconomic status (SES) influence neural responses to race. Twenty-three Mexican American adolescents (15 females; mean age = 17.22 years) were scanned using functional magnetic resonance imaging while they viewed Black and White faces in a standard labeling task. Adolescents rated their subjective social status in US society, while their parents responded to questions about their educational background, occupation, and economic strain (objective SES). Results demonstrated a negative association between subjective social status and neural responses in the amygdala, fusiform face area, and medial prefrontal cortex when adolescents viewed Black (relative to White) faces. In other words, adolescents with lower subjective social status showed greater activity in neural regions involved in processing salience, perceptual expertise, and thinking about the minds of others when they viewed images of Black faces, suggesting enhanced salience of race for these youth. There was no relationship between objective SES and neural responses to the faces. Moreover, instructing participants to focus on the gender or emotion expression on the face attenuated the relationship between subjective social status and neural processing of race. Together, these results demonstrate that subjective social status shapes the way the brain responds to race, which may have implications for psychopathology.

Adolescence is a developmental period characterized by profound biological, neural, and social changes that have important implications for mental and physical health. The important changes that occur during this time period have led some to conclude that adolescence may be a sensitive period for sociocultural processing (Blakemore & Mills, 2014; Choudhury, 2009). One element of sociocultural development that becomes increasingly important during adolescence is awareness of and attention to social hierarchies. As youth enter adolescence and begin to form more sophisticated social relationships and engage in more social comparison, feelings about one's standing in the social structure of society are brought to the fore and likely play an important role in influencing the ways in which adolescents navigate their increasingly complex social worlds (O'Brien & Bierman, 1988). This could include awareness of one's objective socioeconomic circumstances (e.g., family wealth, parent education level,

and occupational prestige; objective socioeconomic status [SES]) as well as more subjective feelings about one's standing in society relative to others (i.e., subjective social status; Goodman et al., 2000, 2001). However, to date relatively little is known about how social status in adolescents influences the ways in which they respond to social information. The present study was designed to investigate how subjective social status and objective SES in adolescents influence neural responses to one particularly important aspect of social information: namely, racial group membership. We explore this question in a sample of Latina/o adolescents, given that this ethnic group is largely underrepresented in developmental/social neuroscience, and given the important role that skin tone/race plays in Latina/o culture (Telzer & Garcia, 2009; Uhlmann, Dasgupta, Elgueta, Greenwald, & Swanson, 2002).

Understanding how social status influences race processing (i.e., quick, largely automatic neural responses to faces of different races) may be particularly important in adolescence, as racial and ethnic identity become particularly salient during this period of development (French, Seidman, Allen, & Aber, 2006; Rivas-Drake et al., 2014; Roberts et al., 1999) as youth start to see and organize individuals according to their race (i.e., racial salience; Pauker, Ambady, & Apfelbaum, 2010). Past research has shown that while younger children form and understand concepts of race and ethnicity mostly based on their literal meanings (e.g., some people have darker skin than others), adolescents have much more

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We would like to acknowledge generous support from Andrew Fuligni, Adriana Galvan, and Matthew Lieberman during study conceptualization, design, and data acquisition. Funding for this study was provided, in part, by NICHD Grants R01HD057164-S and R01HD057164 (to AJ Fuligni), NSF Grants SES 1023293 (to AJ Fuligni and EHT) and BCS 1539651 (to EHT), and NIDA Grant R01DA039923 (to EHT).

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abstract and complex notions of race and ethnicity (Quintana, 1994) and are more aware of racial stereotypes and norms (Apfelbaum, Pauker, Ambady, Sommers, & Norton, 2008). Preliminary neuroimaging research suggests that greater amygdala reactivity to Black faces compared to White faces may emerge during adolescence (Telzer, Humphreys, Shapiro, & Tottenham, 2013), consistent with what is seen in adults (Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005). Given that the amygdala plays a key role in responding to stimuli that are motivationally salient in the environment (Cunningham & Brosch, 2012), these functional magnetic resonance imaging (fMRI) data are consistent with the notion that race and racial identity become particularly salient in adolescence. Further, naturalistic peer group diversity (operationalized as parents' reports of the racial makeup of a child's school and friend group; Telzer et al., 2013) and being part of a mixed-race team (Guassi Moreira, Van Bavel, & Telzer, 2017) modulates the extent of amygdala reactivity to Black (vs. White) faces across development, suggesting that individual differences in experience play an important role in influencing neural responses to race. Thus, given the heightened salience of race/ethnicity and social status in adolescence, understanding how social status may influence neural processing of race-related information during this important period of identity development is especially important.

Very little research in either adolescent or adult samples has examined how subjective social status influences racial salience and race processing despite presumed links between the two (Goodwin, Operario, & Fiske, 1998). In one illuminating study of the effects of social status on both self-reported race and other-rated race among youth, those from lower objective SES backgrounds were more likely to self-identify as Black (compared to White) and were more likely to be rated as Black by an interviewer, compared to higher SES youth, who were more likely to identify as and be identified as White (Penner & Saperstein, 2008). This work has been confirmed by experimental research showing that images of individuals who are "racially ambiguous" (i.e., morphs of Black and White faces) are more likely to be categorized as Black when they are paired with low-status attire (e.g., janitor's uniform), while equally ambiguous faces are more likely to be categorized as White when paired with high-status attire (e.g., business suit; Freeman, Penner, Saperstein, Scheutz, & Ambady, 2011). Further, recent experimental work has shown that greater perceptions of economic scarcity cause individuals to view Black faces as more black than during conditions of economic abundance (Krosch & Amodio, 2014). Taken together, this work suggests the possibility of important links between social status and race, such that information about an individual's social status and the broader economic climate in which they are embedded informs perceptions of their race. However, to date, no known work has examined how a perceiver's social status (i.e., individual differences in social status) influences the way he or she responds to individuals from different racial groups, and no

neuroimaging research has explored how social status modulates neural responses to race.

Although no past research has examined how social status influences neural processing of race, the neural systems involved in encoding race-related information are relatively well established (Amodio, 2014; Cikara & Van Bavel, 2014; Eberhardt, 2005; Kubota, Banaji, & Phelps, 2012). Two regions in particular appear to play an important role in the automatic, bottom-up processing of race: the amygdala, a region involved in responding to the salience of environmental cues (Cunningham & Brosch, 2012), and the fusiform face area (FFA), a region involved in processing stimuli about which one has a large amount of expertise (Bukach, Gauthier, & Tarr, 2006), especially faces (Kanwisher & Yovel, 2006). In the context of race processing, greater amygdala activity is often observed during the processing of Black (compared to White) faces (Kubota et al., 2012), which is interpreted as reflecting the greater emotional salience of Black faces, acquired over late childhood and early adolescence as stereotype consciousness, or awareness of broadly held stereotypes of African Americans, develops (McKown & Weinstein, 2003). In contrast, greater FFA activity is often observed during the processing of in-group members relative to out-group members (Golby, Gabrieli, Chiao, & Eberhardt, 2001; Van Bavel, Packer, & Cunningham, 2011), thought to indicate greater expertise for and more enhanced processing of in-group faces. While other areas are also found during race processing, especially when White participants view images of Black faces (e.g., the anterior cingulate cortex and dorsolateral prefrontal cortex), these regions are thought to reflect more higher order cognitive function, including monitoring for potential race bias (i.e., the anterior cingulate cortex) and regulating racial bias when it occurs (i.e., the dorsolateral prefrontal cortex; Kubota et al., 2012). As such, most work indicates that amygdala and FFA are particularly critical for quick, automatic processing of race.

While no studies have investigated how subjective social status influences reactivity in these neural regions that respond to race, some prior work has shown that social status does influence the way in which the brain responds to social information (Mattan, Kubota, & Cloutier, 2017). For example, studies have shown that young adults who rank themselves lower in subjective social status show greater activity in neural regions involved in mentalizing, or thinking about the minds of others, when processing social information, compared to those higher in status (Muscatell et al., 2012, 2016). Further, adolescents from lower objective SES families show greater activity in the dorsomedial prefrontal cortex (DMPFC), a core node of the mentalizing network, and the amygdala, a key region involved in processing the motivational-salience of stimuli in the environment, when viewing images of angry faces (Muscatell et al., 2012). Thus, subjective social status does appear to influence neural responses to social information, though to date, the relationship between subjective social status and neural responses to race is largely unexplored.

225 Finally, although both behavioral and neuroimaging work  
226 suggests that race is encoded relatively quickly and automat-  
227 ically (Blair, Judd, & Fallman, 2004; Ito & Urland, 2003), ad-  
228 ditional research has shown that instructing individuals to fo-  
229 cus on other features of an individual may diminish the  
230 salience of race (Blair, 2002). For instance, automatic activa-  
231 tion of racial stereotypes is diminished when participants are  
232 asked to attend to gender or occupation rather than race  
233 (Mitchell, Nosek, & Banaji, 2003), and racial prejudice is re-  
234 duced when African Americans are labeled as part of an in-  
235 group (i.e., attending the same university as the participant;  
236 Scroggins, Mackie, Allen, & Sherman, 2016). Similarly,  
237 the amygdala response to Black faces is diminished when  
238 participants view famous, positively regarded African Amer-  
239 icans (Phelps et al., 2000), and when African Americans are  
240 labeled as part of an in-group (Van Bavel, Packer, & Cun-  
241 ningham, 2008). Together, these behavioral and fMRI studies  
242 suggest that automatic attention to race can be diminished by  
243 attending to other features of racial out-group members.

244 Simultaneously, other research has shown that labeling the  
245 emotions on a face or the gender of the individual can lead to  
246 reductions in amygdala activity compared to when indi-  
247 viduals simply observe emotional facial expressions (Lieber-  
248 man et al., 2007), again suggesting that labeling salient fea-  
249 tures of stimuli (e.g., emotion expressions) may disrupt  
250 amygdala activity typically associated with processing of af-  
251 fectively laden stimuli. Taken together, this body of work  
252 suggests the possibility that attending to other characteristics  
253 besides race may disrupt automatic neural processing of race-  
254 related information. As such, we sought to examine if direct-  
255 ing adolescents' attention toward features other than race  
256 (e.g., gender or emotion expression) would change patterns  
257 of neural activity observed when they simply observed faces  
258 of individuals from different racial groups.

## 260 The Present Study

261 Thus, in the current study, we examined how social status in-  
262 fluences neural reactivity to race processing in adolescents.  
263 Specifically, we explored three primary research questions:  
264 (a) does objective SES influence neural responses to images  
265 of Black and White faces; (b) does subjective social status in-  
266 fluence neural responses to images of Black and White faces;  
267 and (c) does instructing individuals to attend to other features  
268 of faces (e.g., gender or affect) attenuate the link between so-  
269 cial status and neural processing of race? To investigate these  
270 questions, we recruited a sample of Mexican American ado-  
271 lescents to participate in an fMRI study. Mexican Americans  
272 were selected as our sample of interest due to the important  
273 role that skin tone serves within Latina/o populations (Hunter,  
274 2007). Latina/o individuals are commonly distinguished as ei-  
275 ther "Blancos" (i.e., having a lighter complexion) or "More-  
276 nos" (i.e., having a darker complexion). As such, they are likely  
277 to be acutely aware of racial dynamics between darker skinned  
278 (i.e., Black) and lighter skinned (i.e., White) individuals (Alba,  
279 Jiménez, & Marrow, 2014; Golash-Boza & Darity, 2008).

281 Further, focusing on a Latina/o sample allowed us to move be-  
282 yond previous neuroimaging research on race processing that  
283 has almost exclusively examined neural responses to racial  
284 in-group members compared to out-group members, largely  
285 in White samples (Amodio, 2014). In the case of our Mexican  
286 American sample, both Black and White faces are likely to be  
287 perceived as racial out-group members, as no participants in  
288 the sample self-identified their race as White or Black. As  
289 such, this approach allows us to examine how social status in-  
290 fluences neural responses to different racial out-groups that  
291 vary in their position within the social dynamics of US culture.

292 This study utilizes a developmental cultural neuroscience  
293 approach (Qu & Telzer, 2017), an emerging interdisciplinary  
294 field within cultural and biology interplay (Causadias, Telzer,  
295 & Lee, 2017) that investigates the development of cultural  
296 processes using neuroimaging methods. This approach pro-  
297 vides an important perspective on how culture influences  
298 adolescents' adjustment, broadening our understanding of  
299 cultural transmission and neural plasticity (Qu & Telzer,  
300 2017). This approach also highlights how sociocultural con-  
301 texts (e.g., SES and perceived social hierarchies) shape ado-  
302 lescents' neural processing of culturally based information  
303 (e.g., race perception), which has implications for cultural dif-  
304 ferences in youths' adjustment.

## 306 Method

### 308 Participants

309 Twenty-three Mexican-origin adolescents (15 females; mean  
310 age = 17.22 years,  $SD = 0.60$ ) from the Los Angeles metro-  
311 politan area participated in the study. Participants were re-  
312 cruited from a larger longitudinal study, in which inclusion cri-  
313 teria included being of Mexican origin. All participants were  
314 from the same Los Angeles high school and were in the 11th  
315 or 12th grade and residing at home with their family at the  
316 time of the study. The student body of the school was predomi-  
317 nantly Latin American, from lower class to lower middle class  
318 families, and over 70% of students qualified for free or reduced  
319 meals (California Department of Education, 2011).

320 The majority of adolescents in the present sample were  
321 from immigrant families: 4 (17.4%) were of the first genera-  
322 tion (i.e., adolescent and parents were born in Mexico), 18  
323 (78.3%) were of the second generation (i.e., adolescent  
324 born in the United States but at least one parent was born in  
325 Mexico), and 1 (4.3%) was of third generation or greater  
326 (i.e., both the adolescent and parents were born in the United  
327 States). See Table 1 for additional socioeconomic and family  
328 composition information.

329 There were no exclusion criteria based on language, and  
330 all but 1 adolescent completed the measures and scan session  
331 in English. One adolescent and 21 parents completed the  
332 measures in Spanish, which were translated and then back-  
333 translated from English to Spanish by bilingual speakers.  
334 Standard exclusion criteria were implemented for the scan,  
335 including any MRI contraindications (i.e., claustrophobia or  
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**Table 1.** Socioeconomic characteristics of sample

Variable	N (Percent of sample)
Primary caregiver's highest education	
Did not complete high school	19 (82.6)
Completed high school	1 (4.3)
Completed some college	2 (8.7)
Completed 2-year college	1 (4.3)
Completed 4-year college	0 (0.0)
Primary caregiver's employment	
Currently employed	17 (73.9)
Unskilled	6 (26.1)
Semiskilled	9 (39.1)
Skilled	1 (4.3)
Semiprofessional	1 (4.3)
Professional	0 (0.0)
Secondary caregiver's highest education	
Did not complete high school	16 (69.6)
Completed high school	0 (0.0)
Completed some college	1 (4.3)
Completed 2-year college	1 (4.3)
Completed 4-year college	3 (13.0)
Secondary caregiver's employment	
Currently employed	12 (52.2)
Unskilled	3 (13.0)
Semiskilled	4 (17.4)
Skilled	4 (17.4)
Semiprofessional	1 (4.3)
Professional	0 (0.0)
Parents' marital status	
Married	13 (56.5)
Separated or divorced	3 (13.0)
Never married	4 (17.4)
Widowed	3 (13.0)
Dual-parent household	18 (82)

Note: Marital status refers to the primary caregiver's marital status to the biological parent of the child participant. Columns that do not add to 100% indicate missing responses. Dual-parent household represents whether there are at least two adults in the home. Of the 18 dual-parent households, 11 had more than two adults residing in the home.

presence of ferromagnetic implants in the body). Participants were paid for their participation. Participants and their parents completed written consent and assent in accordance with the University of California at Los Angeles's institutional review board.

### Self-report measures

**Subjective social status.** To measure subjective social status, we used the MacArthur Scale of Subjective Social Status (Adler, Epel, Castellazzo, & Ickovics, 2000), which asks participants to rate themselves on a 12-point scale along dimensions of monetary wealth, education, and job status. Participants were presented with a ladder and asked to choose the rung that they felt represented where they stood compared to others in the United States, where the top rung represents those with the most wealth and education and the best jobs, and the bottom rung represents those with the least wealth and education and the worst jobs. Higher scores indicate

higher subjective social status whereas lower scores indicate lower subjective social status. This measure showed skewness of 0.81 and kurtosis of 1.1 in the present sample.

**Objective social status.** We examined objective social status by measuring parents' SES and economic strain, each of which were reported by the adolescent's primary caregiver.

**SES.** The primary caregiver each reported his or her own and his or her child's secondary caregiver's (if applicable; usually the father) highest level of education by responding to a scale that ranged from "elementary/junior high school," "some high school," "graduated from high school," "some college," "graduated from college," to "law, medical, or graduate school." The primary caregiver also reported his or her own and his or her child's secondary caregiver's occupation, which was then coded according to a 5-point scale used in previous studies with a similar population (Telzer & Fuligni, 2009) ranging from 1 (*unskilled level*) to 5 (*professional level*). Examples of unskilled worker included such occupations as furniture mover, gas station attendant, food service worker, and housecleaner; semiskilled worker included baker, cashier, landscaper, and security guard; skilled worker included appraiser, barber, seamstress, and electrician; semi-professional worker included nurse, librarian, optometrist, and office manager; and professional worker included architect, dentist, computer consultant, and physician. If the participant indicated a parent was unemployed, occupational status was not coded. SES was calculated by standardizing and averaging mother's and father's (if applicable) education and occupation. This measure showed a skewness of 1.40 and kurtosis of 1.71 in this sample.

**Economic strain.** The adolescents' primary caregiver completed a measure indicating his or her family's financial well-being with nine items that tapped economic strain over the past 3 months (Conger et al., 2002). The primary caregivers indicated how much difficulty they had paying bills (1 = *no difficulty at all* to 4 = *a great deal of difficulty*), whether they had money left over at the end of each month (1 = *more than enough money left over* to 4 = *very short of money*), and whether they could afford different necessities such as food, medical care, and clothing (1 = *very true* to 4 = *not at all true*). The scale had acceptable internal consistency ( $\alpha = 0.87$ ), and within this sample, showed skewness of  $-0.82$  and kurtosis of  $-0.02$ .

### fMRI paradigm

Similar to prior studies examining neural correlates of race processing in youth (Telzer et al., 2013), adolescents completed a face observation task (Hariri, Bookheimer, & Mazziotta, 2000; Lieberman et al., 2007). During the task, participants were presented with a target face in the center of the screen. Target faces depicted Black and White individuals expressing a negative emotion (fearful or angry). Four condi-

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tions (affect label, gender label, observe, and shape match) were administered across one task run. Each condition was presented in blocks of five trials (5 s each), with a 500-ms fixation between each face. Participants completed two blocks of each condition, one which included only Black faces and one White faces, half of each were male and half female. An instruction screen appeared for 3 s before each block, indicating what condition was next, and a 12-s cross-hair fixation/rest separated each block. Blocks were shown in a randomized order. Faces were selected from a standardized set of face stimuli (Tottenham et al., 2009).

During the affect label condition, participants saw a target face in the middle of the screen depicting either a fearful or an angry expression. Participants were instructed to choose one of two label options presented on the screen that best described the facial emotion (e.g., “scared,” “furious,” “angry,” “fearful,” or “worried”). Two affect labels were paired together, one with the target emotion and a second with a different negative emotion. During the gender label condition, participants saw the same target faces as in the affect label condition, but were instructed to match the gender of the face to a name (e.g., “Manuel” or “Maria”). Two names were paired together, one with a male name and one with a female name. Names were selected that were common names in Spanish and English, with the male and female names being similar in terms of number of letters, syllables, and the first letter. During the observe condition, participants were instructed to passively view the target face, and no emotion labels or names were presented. Finally, during the shape match condition, participants saw a trio of shapes and were instructed to select the shape on the bottom that matched the target shape on top. Only the data from the affect label, gender label, and observe conditions are used for this study.

### *fMRI data acquisition*

Imaging data were collected using a 3 Tesla Siemens Trio MRI scanner. The task was presented on a computer screen, which was projected through scanner-compatible goggles. Data acquired during the face observation task consisted of T2\*-weighted echoplanar images (slice thickness, 4 mm; 34 slices; repetition time = 2 s; echo time = 30 ms; flip angle = 90 degrees; matrix =  $64 \times 64$ ; field of view = 200 mm; voxel size  $3 \times 3 \times 4 \text{ mm}^3$ ) for blood oxygen level dependent (BOLD) imaging. A T2\*-weighted, matched-bandwidth, high-resolution, anatomical scan and magnetization-prepared rapid-acquisition gradient echo scan were acquired for registration purposes (repetition time = 2.3 s; echo time = 21 ms; field of view = 256; matrix =  $192 \times 192$ ; sagittal plane; slice thickness = 1 mm; 160 slices). The orientation for the matched-bandwidth and echoplanar images scans was oblique axial to maximize brain coverage.

### *fMRI data preprocessing and analysis*

Neuroimaging data were preprocessed and analyzed using Statistical Parametric Mapping (SPM8; Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK).

Preprocessing for each participant’s images included spatial realignment to correct for head motion. Images showing more than 2.5 mm or degrees of image-to-image motion or rotation in any direction were removed from analyses. The realigned functional data were coregistered to the high-resolution magnetization-prepared rapid-acquisition gradient echo scan, which was then segmented into cerebrospinal fluid, gray matter, and white matter. The normalization transformation matrix from the segmentation step was then applied to the functional and structural images, thus transforming them into standard stereotactic space as defined by the Montreal Neurological Institute and the International Consortium for Brain Mapping. The normalized functional data were smoothed using an 8-mm Gaussian kernel, full width at half maximum, to increase the signal-to-noise ratio.

Whole-brain statistical analyses were performed using the general linear model in SPM8. Each trial was convolved with the canonical hemodynamic response function. High-pass temporal filtering with a cutoff of 128 s was applied to remove low-frequency drift in the time series. Serial autocorrelations were estimated with a restricted maximum likelihood algorithm with an autoregressive model order of 1. The task was modeled as a block design. The 12-s fixation preceding each block was not modeled and therefore served as the implicit baseline. The following contrasts were computed at the individual level for Black and White faces separately: affect label, gender label, and observe. In addition, shape match was modeled as a separate regressor but not examined further.

The individual subject contrasts were submitted to random-effects, group-level analyses. At the group level, analyses were conducted using GLMflex (McLaren, Schultz, Locascio, Sperling, & Atri, 2011), which removes outliers and sudden activation changes in the brain, partitions error terms, analyzes all voxels containing data, and corrects for variance–covariance inequality. Whole-brain regression analyses were run to examine how subjective social status correlates with neural activation when viewing Black relative to White faces. Separate analyses examined the conditions of interest (i.e., affect label, gender label, and observe). To correct for multiple comparisons, we conducted a Monte Carlo simulation implemented using 3dClustSim in the software package AFNI (updated version April 2017) and the `-acf` option in 3dFWHMx to estimate the smoothness. Results of 3dClustSim indicated a voxel-wise threshold of  $p < .001$  combined with a minimum cluster size of 26 voxels for the whole brain, corresponding to  $p < .05$ , false discovery rate corrected.

## **Results**

### *Behavioral results*

We examined the correlations between objective SES indicators (i.e., composite of parent education and occupation; family financial strain) and subjective social status in this sample of adolescents. There was no significant association between

subjective social status and the parent education/occupation composite ( $r = -.04, p = .86$ ), or with financial strain ( $r = -.17, p = .44$ ) in this sample of adolescents. Further, the parent education/occupation composite was not significantly correlated with self-reported economic strain ( $r = -.22, p = .33$ ).

### fMRI results

*Association between subjective social status and neural responses to race.* To explore the association between subjective social status and neural responses to race processing, we conducted a whole-brain regression analysis in which we examined neural responses to observing Black faces compared to White faces, and searched for regions that showed an association with subjective social status. Results of this analysis revealed a negative correlation between subjective social status and BOLD signal in the amygdala, hippocampus, and temporal poles bilaterally, left fusiform gyrus (encompassing the FFA), medial prefrontal cortex (BA10), dorsomedial prefrontal cortex (BA9), and left ventrolateral prefrontal cortex (VLPFC; BA 11), among other regions (see Table 2 for a complete list of activations and Figure 1 for scatter plots of the associations). Activation in many of these regions (i.e., amygdala, hippocampus, temporal poles, fusiform, and VLPFC) remained negatively associated with subjective social status after controlling for the objective SES indicators, suggesting that the results are not driven by variability in parental education, occupation, or family economic strain (see Table 2). No activity was positively associated with subjective social status in the contrast of observing Black faces versus White faces.

In an effort to further explore and clarify if the results were driven by individuals lower in subjective social status showing more activity to Black faces or individuals higher in subjective social status showing more activity to White faces, we ran follow-up regression analyses. Specifically, we regressed subjective social status separately onto the contrasts of Black faces compared to baseline, and White faces compared to baseline. For Black faces, we again saw a negative association between subjective social status and BOLD signal in the amygdala, hippocampus, and VLPFC (BA10/BA46; all bilaterally), the left temporal pole, and the left fusiform gyrus, among other regions (see Table 2 for a complete list of activations and Figure 2 for scatter plots of associations). No activity was positively correlated with subjective social status when observing Black faces (vs. baseline). There were no regions that were negatively correlated with subjective social status while observing White faces (vs. baseline). However, a number of regions showed a *positive* correlation when observing White faces (vs. baseline), including the ventromedial prefrontal cortex (BA10), bilateral ventral striatum, and occipital cortex (Table 2 for a complete list of activations and Figure 3 for scatter plots of associations).

*Association between objective SES and neural responses to race.* Next, we examined if there was a relationship between

the objective SES indicators and neural responses to race processing. We explored the associations between SES as measured by the combination of parental education and occupation and neural responses to viewing Black faces compared to White faces. This analysis did not reveal any significant clusters of activity that were either negatively or positively correlated with parental education and occupation. Next, we examined the association between SES as measured by family economic strain and neural responses to viewing Black faces compared to White faces. There were again no significant activations that correlated negatively or positively with SES as conceptualized as economic strain. Thus, it appears that, in this sample, there is no association between more objective indicators of SES (i.e., parent education/occupation; economic strain) and neural responses to observing faces of different races.

*Relationship between subjective social status and neural responses to labeling gender and emotion.* Finally, we explored if shifting the focus from automatic processing of race in faces (as in the observe condition) to non-race-related information (i.e., labeling gender or emotion) changed the pattern of associations with subjective social status. We examined if there was an association between subjective social status and neural responses to gender labeling for Black faces versus White faces. No significant activations were either positively or negatively correlated with subjective social status when the task was shifted to labeling gender rather than passively observing the faces. A similar pattern emerged when we examined the association between subjective social status and neural responses to emotion labeling for Black versus White faces: again, there was no association (in either a negative or a positive direction) between subjective social status and activity in response to labeling the emotion on faces of different races. Finally, we examined the relationship between subjective social status and neural responses to labeling the emotions on Black faces compared to simply observing Black faces. This comparison again revealed that there was no significant association between subjective social status and neural responses to labeling the emotions on Black faces (compared to just observing Black faces). Taken together, these results suggest that instructing adolescents to focus on features of the face besides race (i.e., those that signal gender or emotion) eliminates the associations between subjective social status and neural responses to different races.

### Discussion

Adolescence is a sensitive period for sociocultural development (Blakemore & Mills, 2014), wherein different facets of social identity, including perceptions of social status in society and racial/ethnic identity, become particularly salient (Apfelbaum et al., 2008; French et al., 2006; Roberts et al., 1999; Rowley, Kurtz-Costes, Mistry, & Faegans, 2007). While research in adults has begun to focus on how social status influences social information processing (Mattan et al.,

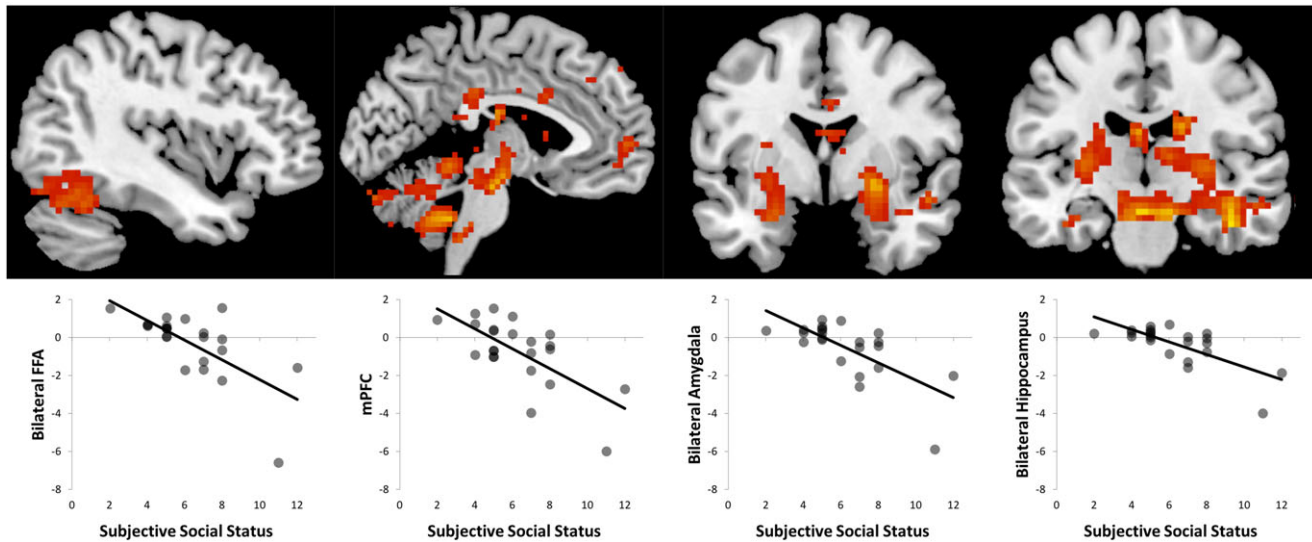
**Table 2.** Neural regions showing significant associations with subjective social status

Anatomical region	+/-	BA	x	y	z	t	k
<i>Black observe &gt; White observe</i>							
R cerebellum <sup>a*</sup>	-		-49	-38	-38	-6.65	3445
L cerebellum <sup>*a</sup>	-		-33	-64	-35	-4.89	
Medial cerebellum <sup>a</sup>	-		0	-46	-38	-5.83	
L fusiform <sup>*a</sup>	-		-33	-67	-14	-4.93	
R fusiform <sup>a</sup>	-		48	-70	-23	-5.02	
L brainstem <sup>*a</sup>	-		-9	-13	-14	-5.12	
R brainstem <sup>*a</sup>	-		12	-16	-17	-5.91	
L hippocampus <sup>*a</sup>	-		-24	-7	-20	-4.88	
R hippocampus <sup>*a</sup>	-		27	-19	-14	-5.66	
L putamen <sup>*a</sup>	-		-27	2	-5	-4.03	
R putamen <sup>*a</sup>	-		24	-1	-5	-5.44	
L amygdala <sup>*a</sup>	-		-24	-7	-20	-4.88	
R amygdala <sup>*a</sup>	-		24	-1	-20	-4.05	
mPFC	-		0	59	4	-4.44	57
R MFG*	-		42	44	13	-4.81	50
L VLPFC*	-		-18	56	-8	-4.69	45
L SFG	-		-30	41	43	-4.21	44
<i>Black observe &gt; baseline</i>							
R calcarine gyrus <sup>b</sup>	-		18	-79	13	6.59	1820
L dorsal cerebellum <sup>b</sup>	-		-24	-67	-26	6.30	
L ventral cerebellum <sup>b</sup>	-		-24	-73	-44	6.28	
L dorsal cerebellum <sup>b</sup>	-		18	-67	-44	4.82	
R ventral cerebellum <sup>b</sup>	-		3	-61	-50	5.43	
R hippocampus <sup>c</sup>	-		27	-10	-20	6.09	905
L hippocampus <sup>c</sup>	-		-27	-10	-20	5.31	
Pons <sup>c</sup>	-		9	-25	-20	5.36	
R amygdala <sup>c</sup>	-		27	-4	-20	4.91	
L amygdala <sup>c</sup>	-		-27	-4	-20	4.64	
Mid-cingulate	-		-15	17	34	4.80	60
L MFG	-		-30	53	22	4.41	49
R MFG	-		39	41	13	4.47	29
Posterior SFG	-		-15	17	67	5.84	29
<i>White observe &gt; baseline</i>							
R calcarine gyrus	+		21	-88	7	-7.86	126
L IOG	+		-21	-97	-5	-4.95	50
L MOG	+		-21	-94	10	-4.45	27
L FFA	+		-42	-64	-20	-5.87	55
Mid-cingulate	+		-9	5	28	-5.76	48
R VS	+		12	5	-2	-5.35	52
R thalamus	+		12	-19	13	-5.30	104
L VS	+		-18	17	-2	-5.29	98
L thalamus	+		-24	-22	13	-4.59	191
L vmPFC	+		-9	59	-14	-5.29	50
R aMPFC	+		9	65	-2	-5.18	46

Note: Parametric map thresholded at  $p < .001$ , with a minimum cluster size  $k = 26$ . L and R refer to left and right hemispheres; + and - refer to positive or negative association with subjective social status; BA refers to Brodmann Area of peak voxel;  $k$  refers to the number of voxels in each significant cluster;  $t$  refers to peak activation level in each cluster;  $x$ ,  $y$ , and  $z$  refer to MNI coordinates; voxel size =  $3 \text{ mm}^3$ . Superscripts (e.g., a, b, etc.) indicate that peak voxels are part of a contiguous cluster; \* indicates regions that survive controlling for objective socioeconomic status, which is only investigated in the Black observe versus White observe contrast. mPFC, medial prefrontal cortex. MFG, middle frontal gyrus, VLPFC, ventrolateral prefrontal cortex. SFG, superior frontal gyrus. IOG, inferior occipital gyrus. MOG, middle occipital gyrus. FFA, fusiform face area. VS, ventral striatum. vmPFC, ventromedial prefrontal cortex. aMPFC, anterior medial prefrontal cortex.

2017), much less work has focused on understanding the relationship between social status and neural responses to social information in adolescents, and no known studies have examined how social status (in either adolescents or adults) influences neural processing of race, one particularly important facet of social identity. To help fill this gap in our knowledge,

we present the first known data to explore how individual differences in subjective social status influence neural responses during race perception. Specifically, we used fMRI to index Mexican American adolescents' neural responses to Black and White faces, both while they passively observed the faces, and while they attended to specific features of the

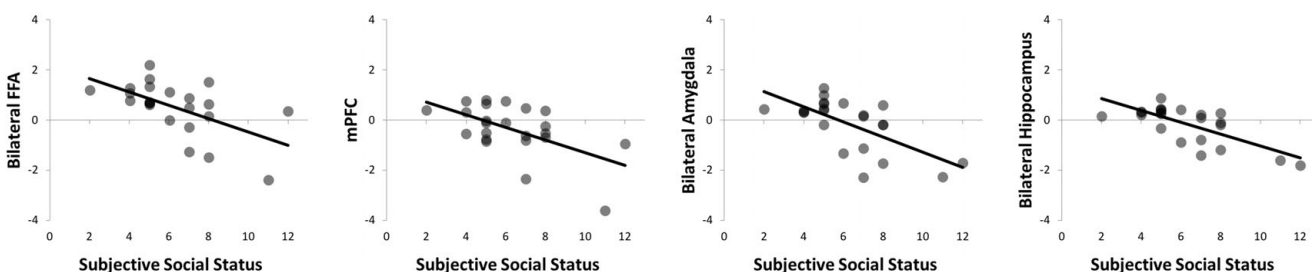


**Figure 1.** Negative association between subjective social status and neural responses to observing Black faces versus observing White faces.

face unrelated to race (e.g., gender or emotion expression). Results indicated that adolescents lower in subjective social status showed greater activity in neural regions known to respond quickly and automatically to stimuli with motivational salience (including race; e.g., the amygdala) and to stimuli with which one has expertise (e.g., the FFA), specifically when viewing images of Black faces (relative to White faces or baseline). No such pattern emerged for higher subjective status adolescents; if anything, these individuals showed greater neural responses to White faces (relative to baseline). Instructing adolescents to focus on features of the stimuli other than race attenuated the association between subjective social status and enhanced neural activity in salience-related regions in response to Black faces. Together, this pattern of results suggests that youth with lower subjective social status may be more automatically attentive to race, specifically to the race of other groups with lower social standing in society (i.e., African Americans). Below, we provide more extensive discussion of these results and their potential implications for psychopathology.

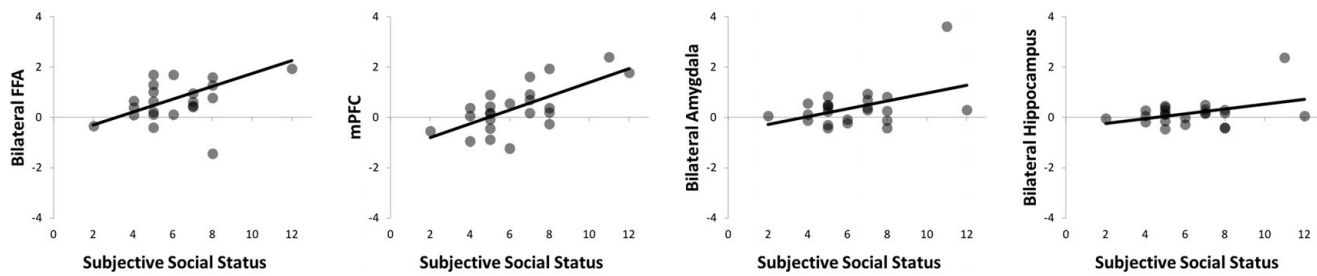
In exploring the association between social status and neural responses to Black (vs. White) faces, we found a negative association between subjective social status and

neural activity in a number of regions, including a large cluster of activation in the medial temporal lobe, extending from the amygdala through the hippocampus to the putamen. We also found evidence for a negative association between subjective social status and activity in the FFA, an area important for face processing and responding to stimuli about which one has a high level of expertise. These two regions (i.e., the amygdala and FFA) are observed in many fMRI studies of race processing, with the amygdala often found to be more active in response to Black faces (regardless of the race of the participant; Kubota et al., 2012; Lieberman et al., 2005) and the FFA more active in response to in-group members, likely reflecting deeper perceptual processing of the faces of in-group members (Van Bavel et al., 2008, 2011). In light of this past research, one interpretation of the present findings is that race may be more salient for adolescents who perceive themselves as lower in social status, and they may engage in deeper perceptual processing of race. Further, though speculative, it is possible that Latina/o adolescents with lower subjective social status may see African Americans as more a part of their in-group, perhaps due to the fact that African Americans are also often seen as a group with lower social standing in society. However, in light



**Figure 2.** Negative association between subjective social status and neural responses to observing Black faces versus baseline.





**Figure 3.** Positive association between subjective social status and neural responses to observing White faces versus baseline.

of the fact that we do not have behavioral or self-report data to substantiate this interpretation of the neural data, these conclusions are presented with caution. More research examining how subjective social status influences perceptions of race (in both adolescent and adult samples) is needed to fully unpack the relationship between social status and race processing. Further, meta-analyses of the neural systems involved in processing race (in both adult and adolescent samples) that attempt to quantify the consistency (or lack thereof) in the spatial patterns of activation and magnitude of association between neural responses to faces of different races (i.e., Black individuals and White individuals) are needed to help move this area of work forward.

Beyond the medial temporal lobe (i.e., the amygdala) and FFA activity discussed above, we also found a negative association between subjective social status and activity in the DMPFC and more ventral aspects of the medial prefrontal cortex (MPFC), as well as lateral portions of the prefrontal cortex (the left VLPFC) in response to Black (vs. White) faces. We saw a *positive* association between subjective social status and activity in the MPFC and DMPFC in response to White faces (vs. baseline), such that individuals who rated themselves higher in subjective social status showed greater activity in these regions when viewing White faces. Given that the DMPFC and MPFC are often active during tasks that involve thinking about the mental states of others (Adolphs, 2009; Frith, 2007), it may be the case that lower subjective status individuals are more likely to automatically think about the minds of individuals from lower status groups (i.e., African Americans), while higher subjective status individuals may focus more on individuals from high-status groups (i.e., Whites). This is consistent with past research demonstrating that individuals who rate themselves as lower in subjective social status are more likely to activate regions involved in thinking about others, or mentalizing, when processing social information (Muscatell et al., 2012, 2016), as well as other work showing that individuals who are lower in social standing respond to both high- and low-status others, while individuals higher in social standing respond only to other higher status individuals (Zerubavel, Bearman, Weber, & Ochsner, 2015). Here, we extend this prior work to show that subjective social status also influences neural processing of race, suggesting that individuals who are lower in per-

ceived social status may be especially attentive to the minds of individuals from lower status racial groups (e.g., African Americans), while higher subjective status individuals may selectively focus on the minds of people from higher status groups (e.g., Whites).

We found also that instructing adolescents to focus on characteristics of individuals other than race disrupted the association between subjective social status and neural processing of race. More specifically, when participants were asked to label either the gender of the person pictured or the emotion expression on the person's face (i.e., rather than just passively viewing the faces), we no longer saw associations between subjective social status and neural activity in any region. This pattern is consistent with other research showing that drawing attention to features of individuals besides race disrupts stereotypes (Mitchell et al., 2003) and reduces amygdala activation (Phelps et al., 2000). Thus, while adolescents with lower subjective social status may automatically process race as a more salient feature of identity than higher subjective status adolescents, these responses are malleable and can be diminished if individuals focus on characteristics besides race.

It is interesting to note that while other studies in adults have found a significant, positive association between subjective social status ratings and more objective indicators of SES (e.g., income, education, and occupation; Adler et al., 2000), subjective status ratings and objective SES indicators were not correlated in this sample of Mexican American adolescents. This could be due to a lack of statistical power to detect the association (due to a small sample size), and/or a restricted range of scores on the objective SES measures. However, this lack of correlation between objective SES indicators and subjective social status may also be meaningful, as it has also been observed in other studies of adolescents (Goodman et al., 2000), including those in predominantly low-income, Mexican communities (Ritterman et al., 2009), suggesting that adolescents may be using information other than objective SES to rate their subjective social standing. This may be especially true among adolescents from racial/ethnic minority groups, as associations between objective and subjective SES indicators may be weaker in these populations compared to the associations observed in White-majority groups (Cundiff & Matthews, 2017). Further, recent research has pointed

1009 to the critical role that relative deprivation and economic ine- 1065  
 1010 equality (rather than objective indicators of SES) play in influ- 1066  
 1011encing important outcomes (Luttmer, 2005; Payne, 1067  
 1012 Brown-Iannuzzi, & Hannay, 2017), suggesting that one's per- 1068  
 1013ception of their economic standing *relative to others* is par- 1069  
 1014ticularly important. Further, the fact that subjective social sta- 1070  
 1015tus was related to neural processing of race whereas objective 1071  
 1016SES measures were not points to the utility of using subjective 1072  
 1017measures to index social status, perhaps particularly 1073  
 1018within samples that are relatively homogenous in their objec- 1074  
 1019tive SES, such as the sample employed here. 1075

1020 In sum, results from the present study highlight the impor- 1076  
 1021tant role that individual differences in adolescents' percep- 1077  
 1022tions of their social status play in influencing the way the 1078  
 1023brain responds to race. While we did not directly measure 1079  
 1024symptoms of psychopathology in this sample, it will be 1080  
 1025important for future research to examine if the relationship be- 1081  
 1026tween social status and race processing influences mental 1082  
 1027health in youth. For example, other research has shown that 1083  
 1028perceptions of one's family's social standing are associated 1084  
 1029with risk for depression in adolescence, such that individuals 1085  
 1030who perceive themselves as lower in social status exhibit 1086  
 1031greater depressive symptoms than those who rate themselves 1087  
 1032higher in status (Åslund, Leppert, Starrin, & Nilsson, 2009). 1088  
 1033Further, greater activation in the amygdala and the DMPFC 1089  
 1034during social interactions, two regions that were associated 1090  
 1035with subjective social status in the present study, has been as- 1091  
 1036sociated with physiological responses that may, over time, 1092  
 1037lead to the development of negative mental health outcomes 1093  
 1038(Muscatell et al., 2015, 2016; Muscatell & Eisenberger, 1094  
 10392012). In other words, the tendency of individuals with lower 1095  
 1040subjective social status to engage neural systems involved in 1096  
 1041processing social information may lead to increased physio- 1097  
 1042logical activation that could ultimately contribute to the de- 1098  
 1043velopment of psychopathology (Manczak, Basu, & Chen, 1099  
 10442016; Manczak, DeLongis, & Chen, 2016). It will be impor- 1100  
 1045tant for future work in this area to examine how the height- 1101  
 1046ened salience of race (and corresponding neural activation) 1102  
 1047among lower status individuals may be linked to mental 1103  
 1048health. 1104

1049 It is also important to consider how the findings presented 1105  
 1050here fit within the cultural development and psychopathology 1106  
 1051framework (Causadias, 2013) and the area of culture-biology 1107  
 1052interplay more broadly (Causadias et al., 2017), and can be 1108  
 1053used to inform future work moving forward. With regard to 1109  
 1054cultural development and psychopathology, results from the 1110  
 1055current study point to the utility in considering how, within 1111  
 1056a group of individuals from one ethnic background (i.e., La- 1112  
 1057tina/Latinos), variability in individual-level self-perceptions 1113  
 1058(i.e., subjective social status) can influence neural responding 1114  
 1059to social information, particularly, race processing. This ap- 1115  
 1060proach highlights the need to consider both how group-level 1116  
 1061factors like ethnicity and culture interact with individual-level 1117  
 1062perceptions to contribute to intergroup relations (Causadias, 1118  
 10632013). Further, the results presented here are consistent with a 1119  
 1064developmental cultural neuroscience perspective (Qu & Tel- 1120

1065 zer, 2017) that emphasizes the important ways in which cul- 1066  
 1067ture can shape neural plasticity across development. More 1068  
 1069specifically, we show that a broad societal construct (i.e., sub- 1070  
 1071jective social status) varies among individuals from a similar 1071  
 1072ethnic background and influences neural responsivity. It will 1072  
 1073be important for future work in this area to examine how cul- 1073  
 1074ture influences development of neural processing of race over 1074  
 1075time (emphasizing cultural, developmental, and neural plas- 1075  
 1076ticity), and to explore how the development of trajectories 1076  
 1077of patterns of neural responding may confer both risk and re- 1077  
 1078silience among youth. It will also be critical for future studies 1078  
 1079to explore the role of racial/ethnic identity development 1079  
 1080(Umaña-Taylor et al., 2014) and its socialization by parents 1080  
 1081in influencing neural responses to different racial groups. Un- 1081  
 1082der a developmental cultural neuroscience approach, it is pos- 1082  
 1083sible that racial and ethnic identity development may influ- 1083  
 1084ence the way the brain responds to faces of different races, 1084  
 1085in ways that may contribute to both risk and resilience for psy- 1085  
 1086chopathology among those from different cultural, racial, and 1086  
 1087ethnic backgrounds. This idea is largely unexplored in neuro- 1087  
 1088imaging research to date and is an important direction moving 1088  
 1089forward. 1089

1090 Results from the present study should be interpreted in 1090  
 1091light of some important limitations. First and foremost, like 1091  
 1092many neuroimaging studies, the sample size is relatively 1092  
 1093small, particularly for examining individual differences and 1093  
 1094associations between self-report measures (e.g., subjective 1094  
 1095social status and objective SES). Future research with larger 1095  
 1096samples that attempts to replicate the effects reported here 1096  
 1097is critical. Second, all participants in the present sample 1097  
 1098were Mexican American, and thus it is not clear if the results 1098  
 1099extend to individuals from other racial and ethnic groups, or 1099  
 1100to other Latina/o groups (e.g., individuals from other Central 1100  
 1101or South American countries). However, given the underre- 1101  
 1102presentation of Mexican Americans in neuroimaging re- 1102  
 1103search, our results are an important step in broadening the de- 1103  
 1104velopmental and social neuroscience literature to include 1104  
 1105non-White samples. Further, while we selected a Latina/o 1105  
 1106sample due to the enhanced salience of skin color in this 1106  
 1107group, we unfortunately do not know if perceptions of subjec- 1107  
 1108tive social status track with skin color (i.e., "Blancos" or 1108  
 1109lighter skinned individuals having higher status compared 1109  
 1110to "Morenos" or darker skinned individuals having lower so- 1110  
 1111cial status) in this specific sample of Latina/o youth, as has 1111  
 1112been reported in other samples (Telzer & Garcia, 2009; Uhl- 1112  
 1113mann et al., 2002). Along similar lines, all faces used as stim- 1113  
 1114uli in this study depicted Black or White individuals, which 1114  
 1115limits the knowledge that can be gained from these stimuli. 1115  
 1116It will be important for future work to investigate neural re- 1116  
 1117sponses to brown and multiracial faces to explore if a similar 1117  
 1118(or different) pattern may occur. A third limitation is that the 1118  
 1119names used in the gender-labeling version of the fMRI task 1119  
 1120have not been normed for the extent to which they likely 1120  
 1121describe one gender face versus another. As such, future stud- 1121  
 1122ies utilizing these stimuli could provide important validation 1122  
 1123data on these names. Fourth and finally, due to the nature of 1123

the fMRI task employed here, we do not know if the observed neural responses translate into differences in behavior toward different racial groups (e.g., implicit attitudes toward Black and White Americans). It will be important for future work to explore if the enhanced neural processing of race for lower status individuals is associated with biases (or lack thereof) toward these groups.

In conclusion, we report results from the first known study to examine how subjective social status influences neural processing of race. We focused on adolescents, given that both social status and racial/ethnic identity are particularly salient during this important developmental period. Our results show that individuals who perceive themselves

as having lower social status in society show greater activity in neural regions involved in processing salience (i.e., the amygdala), expertise and deeper perceptual encoding of faces (i.e., the FFA), and in thinking about the minds of others (i.e., the DMPFC and MPFC) when viewing Black faces relative to White faces. This association is attenuated when individuals are asked to focus on features of faces other than race, including gender and emotion expression. These findings are important for advancing our knowledge of how social status influences the way in which the brain responds to social information, and future research should explore if this enhanced processing of race is related to mental health outcomes.

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