# Scarcity disrupts neural encoding of Black faces:

# A socio-perceptual pathway to discrimination

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**Abstract**

When economic resources are scarce, racial minorities are often devalued and disenfranchised. We proposed that this pattern extends to visual processing, such that the encoding of minority group faces is impeded under scarcity—an effect that may facilitate discrimination and contribute to racial disparities. Specifically, we used EEG and fMRI to test whether scarce economic conditions induce deficits in neural encoding of Black faces, and we examined whether this effect is associated with discriminatory resource allocation in behavior. In Study 1, framing resources as scarce (vs. neutral) selectively impaired the neural encoding of Black (vs. White) faces, as indexed by a delayed face-related N170 ERP component, and the degree of this encoding deficit predicted anti-Black allocation decisions. In Study 2, we replicated and extended this effect using fMRI: resources framed as scarce (vs. neutral) reduced face-sensitive fusiform activity to Black (vs. White) faces. Furthermore, scarcity-decreased fusiform activity to Black faces corresponded with decreased valuation-related striatum activity to predict anti-Black allocation decisions. These findings suggest that impaired visual processing and devaluation occur selectively for minorities under scarcity—an implicit effect that may promote discrimination and contribute to rising disparities observed during economic stress.

Abstract word count: 192 words

*Keywords:* scarcity, face perception, race, prejudice, fMRI, N170

**Impaired Encoding of Black Faces Under Economic Scarcity:**

**A Socio-perceptual Pathway to Discrimination**

When economic resources are scarce, minorities are often devalued, derogated, and treated as less deserving of those resources. For example, during the *Great Recession* of 2008, minorities were forced to work fewer hours, take more unpaid leave, and switch from full-time to part-time work more often than their White counterparts (Taylor, Kochhar, & Fry, 2011). Indeed, empirical work has shown that threats to resources promote anti-minority attitudes, stereotypes, policy support, and violence (e.g., Bianchi, Hall, & Lee, 2018; Esses, Jackson, & Armstrong, 1998; Hovland & Sears, 1940; Lauritsen & Heimer, 2010; Riek et al., 2006)—a pattern of prejudice and discrimination that appears to reinforce socioeconomic disparities and perpetuate inequality.

Scarcity also affects the social perception of individuals, revealing a point of contact between socioeconomic factors and social cognition. In recent work, even subtle indicators of scarcity led perceivers to view African American faces as “blacker” (Krosch & Amodio, 2014; Rodeheffer, Hill, & Lord, 2012)—a perceptual bias that predicted reduced monetary allocations (Krosch & Amodio, 2014), consistent with research linking the perception of darker skin tone and Afrocentric features to devaluation and discrimination (e.g., Maddox, 2004). Importantly, these effects appear to operate implicitly, without a perceiver’s overt intention or awareness, indicating they may be especially resistant to control.

Collectively, these findings suggest that when resources are scarce, decision makers may actually *see* minority group members as less valuable and less worthy—a perception that may perpetuate deprivation and harm. However, two important assumptions underlying this conclusion remain unsubstantiated. First, because prior research relied on classification judgments, rather than direct assessments of visual processing, it remains unclear whether scarcity-induced changes in face representations relate to visual processes, as opposed to cognitive judgments (e.g., stereotypes). Second, although scarcity has been shown to influence perceptions of facial features (e.g., skin tone, Afrocentricity), prior work has not determined whether scarcity influences a more basic form of perceptual processing: the initial encoding of a racial minority member's *face*, which represents the starting point of a social impression and social interaction. Both issues have important implications for theories of intergroup social cognition and for potential interventions.

The present research addressed these critical assumptions directly: using two different neural indicators of face processing, we asked whether conditions of scarcity impede the configural encoding of minority faces—the initial process through which facial features and configurations are extracted from visual input to form the representation of a face—and, if so, whether this effect was associated with economic deprivation in behavior. We proposed that, under scarcity, decision makers encode minority group member faces less extensively—an effect that may serve to facilitate the behavioral devaluation and unfair treatment of racial minorities in economic decisions.

**Face Encoding and Outgroup Devaluation**

Our impression of another person often begins with the sight of their face, and several recent findings reveal that the initial configural processing of a face has implications for high-level social judgments. For example, Hugenberg et al. (2016) found that participants devalued faces as less thoughtful, empathetic, considerate, creative, and humanlike when configural encoding was impeded—a pattern that characterizes devalued and dehumanized attributions of traits and emotions (e.g., Gray, Gray, & Wegner, 2007; Harris & Fiske, 2006; Hugenberg et al., 2016; Kteily, Bruneau, Waytz, & Cotterill, 2015; Leyens et al., 2000; see also Wilson, Young, Rule, & Hugenberg, 2018). Although these relatively high-level impressions influence many forms of judgment and can facilitate negative treatment of racial and ethnic outgroup members (Opotow, 1990; Haslam & Loughnan, 2014), economic decisions often rely on rapid decisions, with scant information and little time with which to form an impression. Thus, examining initial encoding of a face may be especially useful for understanding the effects of scarcity on decisions made in the face-to-face interactions that characterize much everyday discrimination.

The strong historical and present-day devaluation of Black people in the United States may make them especially vulnerable to perceptual encoding deficits. This devaluation was most overtly seen in the notorious "3/5$^{\text{ths}}$ Compromise," where individual Black Americans were counted as less than a White person in the eyes of the law, and it persists today in stereotypes and prejudiced beliefs, often with grave consequences. For example, Black Americans continue to be represented as ape-like by individuals and in the media, which has been related to capital conviction and state execution (Goff, Eberhardt, Williams, & Jackson, 2008). Black Americans are also believed to feel less pain than White Americans, which leads to racial disparities in pain assessment and treatment (Hoffman, Trawalter, Axt, & Oliver, 2016). Indeed, recent research suggests that such devalued and dehumanized impressions of Black (compared with White) targets are more strongly related to perceptual encoding deficits (Cassidy et al., 2017).

In light of research suggesting widespread devaluation of Black Americans, and links between these devalued social perceptions and visual encoding deficits, we proposed that Black recipients might be especially susceptible to scarcity effects on decision makers' visual processing, such that the encoding of Black faces is impeded when resources are scarce. Moreover, we proposed this perceptual effect would be associated with the deprivation of Black recipients in the allocation of resources, suggesting the possibility that impaired face encoding serves to implicitly facilitate or justify discrimination.

**Intergroup Effects on Face Encoding**

How might scarcity influence the early visual encoding of a face? Although early face perception was once thought to be impenetrable to top-down influences (e.g., Bruce & Young, 1986), recent research suggests that intergroup goals and motivations can influence face encoding. For example, more motivationally-relevant minimal ingroup faces tend to be more extensively encoded, as evidenced by neural and behavioral indices (e.g., Hugenberg & Corneille, 2009; Ratner & Amodio, 2013; Van Bavel et al., 2008, 2011; Young, Bernstein, & Hugenberg, 2010; Young & Hugenberg, 2010), and classic works suggests that motivationally *irrelevant* targets like outgroup members are often afforded fewer processing resources (e.g., Brewer, 1988; Fiske & Neuberg, 1990; Rodin, 1987; Sporer, 2001). Only as outgroup members become more motivationally relevant do they receive prioritized encoding (e.g., Van Bavel & Cunningham, 2012). In the context of race, outgroup faces similarly experience more or less extensive encoding (relative to ingroup faces) depending on participants' social motivations and task goals (Ratner & Amodio, 2013; Kaul, Ratner, & Van Bavel, 2014; Ofan et al., 2011, 2014; Schmid & Amodio, 2017; Senholzi & Ito, 2012; Walker, Slivert, Hewstone, & Nobre, 2008).

An important determinant of intergroup processing resources is the degree of *threat* an outgroup member poses in a particular context (see Chang, Krosch, & Cikara, 2016; Ofan et al., 2011, 2014; Schmid & Amodio, 2017). In economic decisions, the potential threat posed by outgroup members—and subsequent encoding effects—depends on who controls the resources (e.g., Realistic Group Conflict Theory; LeVine & Campbell, 1972), and thus an outgroup member is only threatening to the extent they are able or likely to take resources from the ingroup (e.g., Esses et al., 1998). When minority outgroup members lack decision power and thus pose no direct threat, White decision makers afford them less attention and consideration. Indeed, there is mounting evidence that perceivers with decision power and higher status attend less to faces (e.g., Dietz & Knowles, 2016) and tend to dehumanize lower status others (e.g., Gwinn, Judd, & Park, 2013) and outgroup members, presumably in order to justify harmful treatment (e.g., Lammers & Stapel, 2011). Such encoding deficits (dubbed *perceptual dehumanization*; Cassidy et al., 2017; Fincher & Tetlock, 2016; Hugenberg et al., 2016) have been shown to facilitate harm (Fincher & Tetlock, 2016; Fincher, Tetlock, & Morris, 2017), especially in the case of instrumental harm for personal gain (Rai, Valdesolo, & Graham, 2017).

Thus, in contexts where a White American decision maker controls the allocation of resources, scarcity should impede the decision makers' encoding of racial minority recipient faces relative to White recipients. Furthermore, this effect may then promote devaluation and unfair treatment of minority recipients in the economic decisions.

**Overview of Studies**

To understand how scarcity leads to deficits in the perception of minorities in face-to-face social interactions, we examined the effect of scarcity on decision makers' visual processing of Black faces during economic decisions. We hypothesized that in conditions of resource scarcity, White decision makers would exhibit impaired encoding of Black faces relative to White faces, compared with a neutral decision context. In Study 1, we used electroencephalography (EEG) to examine scarcity-impaired early visual processing of Black relative to White faces, and the association between this impairment and increased discrimination. Using functional magnetic resonance imaging (fMRI) in Study 2, we replicated the effect of scarcity on impaired visual processing and explored whether its effect on discrimination involved neural processes associated with devaluation[1].

## Study 1

[1] Although neither study was formally pre-registered, these hypotheses, procedures, sample sizes, and analyses were proposed in advance in a grant application (NSF BCS 1551826) and dissertation proposal prior to data collection completion.

Study 1 was designed to provide initial evidence for the effect of economic scarcity on impaired visual processing of Black (compared with White) faces and to determine whether this effect predicts behavioral discrimination. To this end, we used an event-related potential (ERP) approach to test whether perceived scarcity selectively interfered with the early visual encoding of Black faces. Specifically, we manipulated scarcity (vs. a neutral context) and examined the N170 component of the ERP to the faces of Black and White recipients in an allocation task.

The N170 component of the ERP is the most direct known index of early configural face processing[2]. Emerging just ~170ms after face onset, the N170 response to a face reflects multiple neural sources, including activation in fusiform, temporo-occipital, and occipital regions (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Herrmann, Ehlis, Muehlberger, & Fallgatter, 2005), with activity in the fusiform most directly supporting the configural encoding process (e.g., Gauthier et al., 2000; Haxby, Hoffman, & Gobbini, 2000; Kanwisher & Yovel, 2006). The N170 response is interpreted as representing the initial encoding of a face in visual processing (e.g., Bentin et al., 1996; Eimer, 2000a)—an obligatory perceptual process that unfolds rapidly and automatically.

Although N170 *amplitude* typically differentiates faces from non-face objects, a disruption to configural processing of faces is most directly evident in the N170 *latency* (e.g., Rossion et al., 2000). This is illustrated by the highly reliable N170 delay to misaligned, scrambled, and eyeless human faces compared with normal human faces, to animal faces compared with human faces, and to inverted compared with upright faces (e.g., Balas &

[2] The N170 and the VPP (vertex positive potential) represent negative and positive dipoles indexing the same brain processes, although the N170 is more commonly studied. The N170 is best observed at the right temporal-occipital electrode site when using an average earlobe or nose reference, whereas the VPP is best observed in frontal sites using a mastoid reference (Joyce & Rossion, 2005). Thus, we focused our analyses on the N170 given our average earlobe reference.

Koldewyn, 2013; Bentin et al., 1996; Eimer, 2000b; George, Evans, Fiori, Davidoff, & Renault, 1996; Itier, Alain, Sedore, & McIntosh, 2007; Jacques & Rossion, 2010).

The N170 delay has been related to reduced activity in the fusiform gyrus (Rossion & Gauthier, 2002). This delay represents a reduced reliance on configural processing, while featural processing is preserved, and it reflects difficulty in resolving a percept as a face (e.g., Itier et al., 2007; Rossion et al., 2000; Latinus & Taylor, 2006; Jacques & Rossion, 2010; Rossion & Jacques, 2012). The delayed N170 sometimes occurs in tandem with a small amplitude increase (e.g., Bentin et al., 1996; Itier et al., 2007; Eimer, 2000b), which reflects signal from inferior occipital gyrus, which supports featural processing, rather than the fusiform (Rossion et al., 2000; Eimer, 2011). Thus, the N170 delay and reduced fusiform activity (used in Study 2) provide the most common and reliable indicators of face encoding impairment (e.g., Balas & Koldewyn, 2013; Bentin et al., 1996; Eimer, 2000b; Gauthier et al., 1999; George et al., 1996; Goffaux et al., 2009; Itier, Alain, Sedore, & McIntosh, 2007; Jacques & Rossion, 2010; Kanwisher et al., 1998; Yovel & Kanwisher, 2005; Zhang, Li, Song, & Liu, 2012).

**Method**

**Participants.** 81 right-handed, native English-speaking undergraduate psychology students from a large private university participated in return for partial course credit. Sample size for this EEG experiment was determined as the maximum number of participants we were able to recruit in the semester; we aimed for $N > 62$ to achieve 90% power to detect a medium interaction effect of interest in our mixed-design, assuming a (conservative) .3 correlation between repeated measurements (calculated using GPower 3.1).

Eight participants were excluded from analysis because their EEG data were unusable due to malfunctioning electrode (which caused either no signal, signal composed of 60 Hz noise, or intermittent signal), failed blink correction, or no discernable ERP response. Two were removed for noncompliant responding (e.g., they pressed the 0 key on each trial). These exclusions yielded seventy-one participants for analysis (mean age = 19.62, *SD* = 1.43; 51 female, 20 male; 67 self-identified as White, one as Asian, and three as Latino; none identified as Black or African American[3]).

**Procedure and materials**. Participants arrived at the lab, provided consent in a manner approved by the Committee on Activities Involving Human Subjects, and were prepared for EEG recording. Participants learned they would be playing a money allocation game in which they would be randomly assigned to either allocate funds ("allocator") or receive funds ("recipient") as in Krosch, Tyler, & Amodio (2017). To ensure that participants believed the game was authentic, with real financial consequences, participants were further told that if they were assigned the role of allocator, they would distribute money to past players who had been assigned the role of recipient. If assigned the role of recipient, participants were told their photo would be entered into our participant database making them eligible to receive funds distributed by future players, and they would move on to perform a different study during the experimental session. In practice, all participants were assigned the role of allocator. Participants were then randomly assigned to a scarce or control condition.

***Scarcity manipulation.*** Although scarcity is associated with a wide range of socioeconomic conditions and psychological experiences, the core construct involves the perception that a resource is limited. Thus, our manipulation focused on the perception of a limited resource. Participants in the scarcity condition were informed that they could have up to $100 to distribute to each recipient, and that the computer would randomly assign them an

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[3] Data patterns and inferences from significance tests are identical when the four non-White participants are excluded (see supplement). See General Discussion for a discussion of the benefits of future studies examining the influence of participant race.

amount to distribute. Participants then viewed an animated pie chart that depicted changing portions of money and ultimately, and ostensibly randomly, assigned them $10 (of $100) to distribute. Participants in the control condition, by contrast, were informed that the computer would randomly assign them a proportion of up to $10 to distribute. These participants watched as the animated pie chart assigned them $10 to distribute (see Supplemental Figure S1). Importantly, participants in both conditions were assigned $10, and thus the actual amount to be allocated never varied between conditions; only the amount participants *could* have been assigned varied. In prior validation studies of this manipulation, $10 out of a possible $100 was perceived as significantly more scarce than $10 out of a possible $10, which was perceived as neither scarce nor abundant (see Krosch & Amodio, 2014; Krosch et al., 2017).

***Resource allocation task.*** Following the scarcity manipulation, participants performed a resource allocation task in which they could allocate from $0 to $10 to each recipient (in $1 increments), in a series of independent choices. Only the recipients' race changed systematically from one trial to the next. Participants were told that people make judgments every day based on very little information, and that they should base their decisions on subtle perceptions of a recipients' deservingness.

Allocation trials began with a fixation cross (2s) and a reminder of the participant's allocation allowance (always $10), accompanied by the pie chart image. Participants then viewed the recipient's face, which remained onscreen until their allocation decision was made via key press. Following 6 practice trials, participants completed 150 critical trials, in which they viewed and responded to a recipient face, in randomized order. Face stimuli included 75 Black and 75 White male faces from the Eberhardt Laboratory Face Database (Eberhardt, Dasgupta, & Banaszynski, 2003), equated for luminance and contrast using the SHINE toolbox for MATLAB (Willenbockel et al., 2010; see Figure 1).

This design ensured that decisions would be based on race and that allocation to one recipient would not affect allocation to any other recipients (i.e., a non-zero-sum choice). This design permitted us to examine relative responses to Black vs. White recipients, in the absence of self-interest. This task was ideally suited for EEG data collection because it permitted multiple trials and an easily-administered pre-trial manipulation, without memory demand or complex calculations.

Following task completion, participants indicated the extent to which the resource pool available to them in the task felt scarce or abundant using a scale anchored from -5 (“extremely scarce) to 5 (“extremely abundant”), with 0 as the midpoint (“neither scarce nor abundant”), as a manipulation check. Participants then completed demographic questionnaires to report their age, race, and gender.

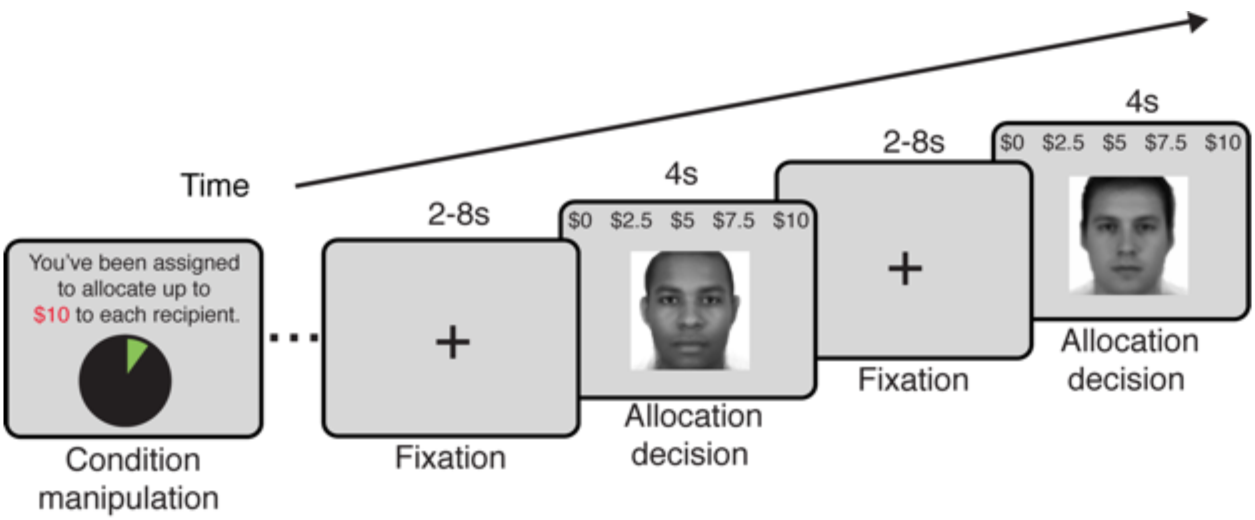


**Figure 1.** Schematic of the experimental task. Participants first saw the scarcity (or neutral) condition manipulation. On each trial, a fixation cross appeared for 2s (Study 1) or 2-8s (Study 2) followed by a White or Black face for 4s, during which time participants registered their allocation choice from $0 to $10.

**EEG recording and processing.** EEG was recorded continuously during task completion from 11 Ag/AgCl electrodes, embedded in a stretch-lycra cap with midline and temporo-occipital channels (Electrode Arrays, El Paso) and referenced to the left earlobe (<5 kΩ)—a widely-used reference shown to be valid for N170 scoring when re-referenced to average ears (e.g., Joyce & Rossion, 2005). Signal was amplified using a Neuroscan Synamps2 amplifier, bandpass-filtered (.15-100 Hz), and digitized at 1000 Hz. Offline, EEG was re-referenced to average earlobes, scored for movement artifact, and submitted to a regression-based eyeblink-correction procedure. This resulted in a rejection of 2.16% of trials (~3.24 of 150 trials per participant, SD = 5.93, range 0-42). EEG was then digitally filtered through a 2-15 Hz bandpass to isolate the N170 component. This bandpass removed low-frequency negative-going pre-baseline activity associated with the manipulation reminder on the fixation slides. ERP waveforms were created by selection of a 900 ms stimulus-locked epoch for each artifact-free trial beginning 100 ms prior to the face onset. Epochs were baseline-corrected (subtracting average pre-stimulus activity) and averaged as a function of trial type.

**ERPs.** ERP amplitudes and latencies were derived from event-related potentials stimulus-locked to face onset. For each subject, N170 latency was determined as the time point at which the area under the curve was equal on both sides (i.e., split-half scored; Luck, 2014), within a 120 and 220 ms window following face onset at temporo-occipital scalp sites (CB1 and CB2, where the N170 effect was maximal). Amplitude was scored as the peak negative amplitude during this window (see Supplement for alternative *area-under-the-curve* analyses using the same time window).

## Results

Our main hypothesis was that under conditions of scarcity, participants would exhibit a delayed N170 to Black relative to White faces. N170 latency was not expected to differ by race in the control condition. Furthermore, we hypothesized that this scarcity-induced N170 delay to Black faces would relate to anti-Black behavior in the allocation task, such that this N170 delay effect would mediate the impact of scarcity on anti-Black allocation decisions.

**Manipulation check.** Participants in the scarcity condition (n = 35) rated resources as more limited (*M* = -1.46, *SD* = 1.69) than subjects in the control condition (n = 36; *M* = 1.02, *SD* = 2.43), $t(69) = 4.97$, $p < .001$; Cohen's $d = 1.18$, thereby validating the manipulation of scarcity.

**N170 validation.** Preliminary analyses were performed to validate inferences of the N170 response by examining its voltage topography (e.g., Joyce & Rossion, 2005; Ofan, Rubin, & Amodio, 2011; Ofan, Rubin, & Amodio, 2014; Ratner & Amodio, 2013). As expected, peak N170 amplitude (μV) was larger in the right hemisphere (CB2; *M* = -3.67, *SD* = 2.24) than left hemisphere (CB1; *M* = -2.71, *SD* = 1.54), $t(70) = 5.87$, $p < .001$. Furthermore, a topographic voltage map indicated peak activation of the N170 over the right temporo-occipital cortex (Figure 2A inset). Thus, as planned, analyses focused on the right hemisphere where the N170 was maximal and where it is commonly scored.

**Scarcity and race effects on N170 latency.** To test our main hypothesis that scarcity selectively impedes the configural processing of Black faces, we tested the interactive effects of scarcity condition and face race on N170 delay scores using repeated measures Analysis of Variance (ANOVA). We predicted a delayed N170 response to Black faces, relative to White faces, in the scarcity condition but not in the control condition. This prediction was supported by a Condition X Race interaction, $F(1,69) = 4.97$, $p = .029$: under scarcity, N170 latency was significantly delayed to Black faces (*M* = 175.26 ms, *SD* = 11.67) relative to White faces (*M* = 172.74 ms, *SD* = 11.60), $F(1,69) = 11.24$, $p = .001$, whereas in the control condition, the latency did not differ between Black faces (*M* = 169.72 ms, *SD* = 11.57) and White faces (*M* = 169.50 ms, *SD* = 12.50), $F(1,69) = 0.05$, $p = .822$ (see Figure 2B).

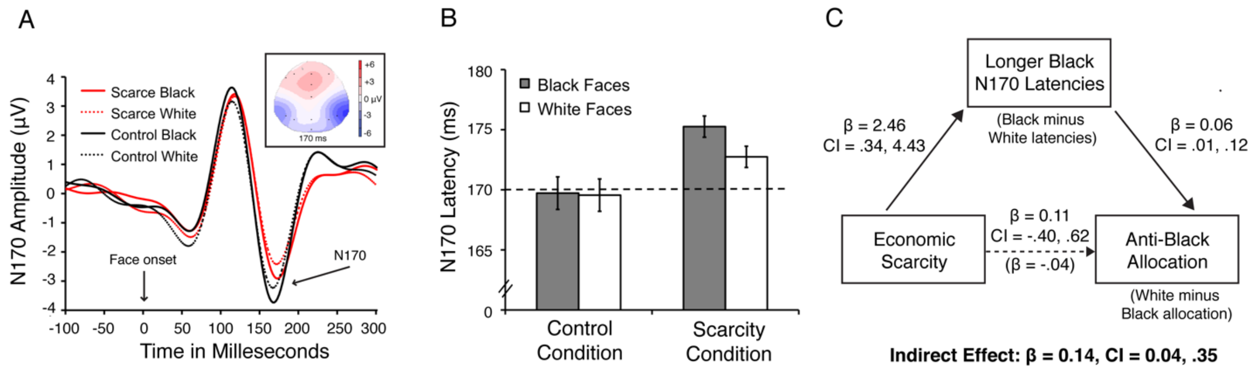


**Figure 2.** Scarcity effects on N170 latency and behavior (n = 71). (A) N170 waveforms for Black and White faces in the scarcity and control conditions, measured at the right temporo-occipital site (CB2) where the N170 was maximal (see inset topographic voltage map). These waveforms validate the N170 component; however, due to individual variability in timing and amplitude, they do not depict reliable individual scores (see scored means in main text). (B) N170 peak latency to Black and White faces as a function of condition (± 1 SE). Dotted line represents 170 ms, the typical latency of the N170 ERP component. (C) Mediation model illustrating the indirect effect of scarcity condition on pro-White/anti-Black allocation through delayed N170 latencies to Black compared with White faces.

This effect was evident in within-race comparisons as well: N170 latency to Black faces was significantly delayed in the scarcity condition compared with the control condition, $F(1,69) = 4.03$, $p = .049$, whereas the latency to White faces did not differ by condition, $F(1,69) = 1.24$, $p = .270$. Together, these results revealed a selective effect of scarcity on Black face encoding. Indeed, only the processing of Black faces under scarcity was significantly delayed beyond the typical latency of 170 ms, $t(34) = 2.66$, $p = .012$, 95% CI = 1.25, 9.27 (all other $p$'s > .171).[4]

**Scarcity and race effects on discrimination.** Previous work indicates that direct effects of scarcity on allocation behavior are moderated by explicit attitudes and more deliberative processing (Krosch, Tyler, & Amodio, 2017), whereas perceptual biases (i.e., implicit processes)

[4] This delay was accompanied by a negative-going amplitude increase for Black faces ($M$ = -3.74 µV, $SD$ = 2.32) compared with White faces ($M$ = -3.21 µV, $SD$ = 1.98) in the scarcity condition, $F(1,69) = 8.12$, $p = .006$, further supporting the interpretation of this effect as an encoding impairment (e.g., Rossion et al., 2000; see Supplement for more detail).

tend to mediate allocation behavior indirectly (Krosch & Amodio, 2014). Thus, we expected the observed effect on face encoding would meditate the effect of scarcity on allocation indirectly and that we may not observe direct effects of scarcity and race on allocation. As expected, a repeated measures Analysis of Variance (ANOVA) suggested no main effect of race, scarcity condition, nor an interaction on allocation amounts (*F*s < 1.06, *p*s > .31. We next tested the indirect relationship between the observed configural processing disruption of Black faces under scarcity and allocation decisions. [5]

**Scarcity and race effects on discrimination mediated by N170 latency.** To test whether scarcity indirectly influenced allocation bias via the N170 latency effect, we created two difference scores: (a) *anti-Black allocation bias* (average amount given to White recipients minus the average amount given to Black recipients; positive scores indicated pro-White allocation bias), and (b) *N170 delay* (average Black N170 latency minus average White N170 latency; positive scores indicate more delayed N170 to Black than White faces). We then used a bootstrapping mediation approach to test effects of scarcity on anti-Black allocation as mediated by the N170 delay difference score (Shrout & Bolger, 2002)

Consistent with our hypotheses, the mediation analysis revealed an indirect effect: The N170 delay for Black relative to White faces significantly mediated the effect of scarcity on anti-Black allocation (A x B cross product = 0.14, *SE* = 0.09, 95% CI = .04, .35, *p* = .039; Figure 2C;

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[5] Tests of indirect effects are recommended in the absence of total effects because they often have greater power, especially when the mediator is more precise than the dependent variable and when the independent variable has more influence on the mediator than the dependent variable (Hayes, 2009; Kenny & Judd, 2014; O'Rourke & MacKinnon, 2015; Preacher & Hayes, 2008; Shrout & Bolger, 2002; Zhao, Lynch, & Chen, 2010). Because visual encoding of faces (our mediator) occurs more rapidly and unconsciously than allocation behavior (our dependent variable) and is indicated by a specific neural signal, it is likely a more reliable measure, less vulnerable to presentational concerns, and more proximally related to our manipulation than allocation behavior.

see supplement for details of the full mediation model).[6] These results support the proposal that the disruption of Black face encoding induced by scarcity may be associated with anti-Black allocation bias in behavior.

**Discussion**

Study 1 tested our main hypothesis that White perceivers' encoding of Black recipient faces is impeded under conditions of scarcity. Consistent with this hypothesis, we found that when resources were framed as scarce (compared with a control condition), participants exhibited a delayed N170 response, characteristic of impaired face encoding, to Black but not White faces. This selective effect, observed under scarcity but not a control condition, suggests that scarcity may prompt White American perceivers to deprioritize the visual processing of Black recipients at this early stage of face processing—a rapidly-occurring and automatic perceptual effect that may represent a form of implicit racial bias. The emergence of this effect in the N170 latency further indicates that it represents a difference in the visual processing of Black compared with White faces, and not merely an attentional effect, and that it is specific to the configural encoding of a face—the first step toward recognizing an object as a human individual.

We further hypothesized that this selective processing deficit may function to facilitate harmful behavior toward the outgroup under scarcity. Consistent with this idea, the degree of the N170 impairment due to manipulated scarcity was associated with greater anti-Black/pro-White allocation bias in behavior. Of course, the relationship between a mediator and outcome in the

[6] Following recent concerns about such use of a single index of mediation and resulting Type I error inflation (Yzerbyt, Muller, Batailler & Judd, 2018), we also used a "component" approach to provide convergent evidence for indirect mediation using the JSmediation R package. Specifically, we found that both the a and b paths were significant (a point estimate = -.77, SE = .09, $t$ = 9.10, $p$ < .001, b point estimate = .19, SE = .03, $t$ = 5.75, $p$ < .001), as was our indirect effect (point estimate = .14, 95% CI = .02, .37, 5000 Monte Carlo iterations).

mediation framework is correlational (Bullock, Green, & Ha, 2010; Fiedler, Schott, & Meiser, 2011), and inferences of putative causality further depend on theoretical and methodological consideration. One such consideration is the possibility of alternative pathways. One alternative is that allocation behavior precedes the visual processing of the recipient—an unlikely path given the very rapid timecourse of visual processing. A second possibility is that perceived scarcity caused both the N170 delay and the bias in allocation behavior, with no causal relationship between the N170 and behavior. However, there was no direct effect of scarcity on behavior; only an indirect effect, via N170 delay, was observed. Finally, existing research has demonstrated a causal effect of configural encoding disruption on social judgments and harm (Fincher & Tetlock, 2016; Hugenberg et al., 2016), which supports the possibility that the relationship between N170 delay and allocation bias observed here is plausible. In light of these considerations, our results are most consistent with the proposal that scarcity effects on face processing may facilitate discriminatory behavior.

Broadly, these results begin to reveal a relationship between very high-level inferences of economic scarcity on the comparatively low-level neural encoding of a face. What explains this relationship? One possibility is that conditions of scarcity guide White decision makers engagement in the task, leading them to deprioritize Black recipients, relative to White recipients, and that this shift in processing strategy leads them to engage a lesser degree of early attentional processing of Black faces (and hence diminished visual encoding). Exploratory post-hoc analyses of our data, reported in the Supplement, appear to support this account: Black faces viewed under scarcity elicited reduced P1 ERP amplitude relative to White faces in Study 1, a component that peaks ~100 ms after face onset and reflects early attention allocation. This result suggests that participants in the scarcity condition showed greater automatic orienting to White compared with Black faces. This rapid shift in attentional processing would likely stunt the visual input from a Black face and thus diminish its visual encoding, consistent with the observed N170 delay. This analysis suggests a plausible explanation for how a high-level factor like scarcity could influence visual face encoding.

Although Study 1 provided evidence for our core hypothesis, features of the ERP method measurement limited our ability to address some questions. First, although the N170 ERP method used in Study 1 provides an established index of face processing, it could not precisely identify the neural source of this effect in fusiform cortex. Our interpretation of the N170 delay, following prior research (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Rossion et al., 2000; Maurer, Le Grand, & Mondloch, 2002; Rossion & Gauthier, 2002), is that it reflects a decrease in configural processing, associated with a reduced contribution of fusiform activity and increased contribution of other neural generators (Rossion & Gauthier, 2002). Because the EEG methods used in Study 1 do not afford the spatial resolution to assess the precise neural source of the N170, our inference regarding the specific role of the fusiform would benefit from additional fMRI evidence.

A second question concerns the psychological processes that may link the process of face encoding to allocation decisions in the context of scarcity. The method used in Study 1 provided a rigorous and circumscribed assessment of early face encoding, but it could not address our extended question of whether encoding effects may relate to devaluation of minority recipients. An exploration of these questions would require other methods, such as fMRI, which can simultaneously assess neural activations in the fusiform and regions associated with the computation of value.

Finally, although we observed the predicted impairment in Black face processing under scarcity, this pattern emerged in the context of a main effect of scarcity. Thus, it is possible that scarcity had a general effect on face encoding across race, such that encoding is impeded for any type of face under scarcity. This inference is ambiguous, however, because scarcity was a between-subjects factor in Study 1, and therefore the main effect of scarcity on N170 delay could represent a true effect of scarcity on face processing *or* a chance effect of variability between subjects assigned (randomly) to each condition. This ambiguity could be resolved using a fully-within-subjects design. To address these issues, we conducted a second study in which brain activity was recorded using fMRI and scarcity was manipulated as a within-subjects variable.

## Study 2

In Study 2, we used fMRI to replicate and extend the findings of Study 1. By using fMRI, we could capitalize on its superior spatial resolution to confirm the selective role of the fusiform cortex, which would further validate our inference regarding configural encoding. By using a within-subjects design, we could also disambiguate the selective effect of scarcity on the encoding of Black faces from a domain-general effect of scarcity on face encoding.

In addition, the use of fMRI in Study 2 permitted us to explore an extension of our hypothesis; that is, whether the effect of scarcity on face encoding and biased decisions is associated with the devaluation of Black recipients, as indicated by decreased activity in the striatum. We were specifically interested in this neural region because of its established role in the encoding of social valuation and the guidance of choice behavior (O'Doherty, 2004; Ruff & Fehr, 2014; Zink et al., 2008). Although the striatum is often implicated in non-social valuation, social perception also involves striatal activity, especially when learning or making decisions about social agents (see Báez-Mendoza & Schultz, 2013; Hackel, Doll, & Amodio, 2015). For example, Zink et al., (2008) found that striatal activity tracks the explicit value of others in a competitive game, with less activity to overtly devalued players—an effect accompanied by reduced fusiform activity. In another study, reduced striatal activity was observed among participants induced to feel poor (as opposed to rich) when they witnessed others receive monetary transfers vs. themselves (Tricomi, Rangel, Camerer, & O'Doherty, 2010). These findings suggest that the striatum supports the encoding of the value of social targets under resource-scarce conditions. In addition, because the striatum is also known to support the translation of value computations into choice decisions (O'Doherty, 2004), its role in scarcity-induced allocation bias would help to explain how early face encoding deficits give rise to discriminatory behavior.

## Method

**Participants.** Thirty-five White-identified subjects were recruited from the undergraduate psychology participant pool of a large private university in return for course credit. Participants were prescreened such that none reported a history of neurological problems, and that all had normal or corrected-to-normal vision, were right-handed, and were native English speakers. Participants completed a metal screening checklist and provided written informed consent before neuroimaging. Our goal was to include at least 22 participants to achieve 80% power to detect a medium interaction effect in this fully within-subject design, assuming a conservative .7 correlation between repeated neural measurements (given a .9 correlation in Study 1).

Two participants were excluded from analysis because their imaging data could not be recovered from the servers; two were excluded because they lacked detectable Face > Fixation fusiform activity and thus regions of interest (ROIs) could not be drawn; one was excluded for failing to complete more than 10% of trials. These exclusions yielded 30 participants for analysis (mean age = 19.63, SD = 1.40; 16 self-identified as female, 14 as male).

**Procedure and materials**. As in Study 1, participants were recruited for a study described as an economic game in which they would allocate funds to others based on perceptions of their deservingness, inferred from pictures of peoples' faces. In order to compare effects of scarcity and control conditions within subjects, participants were further told that we were interested in the way that people allocate different amounts of money, and that their task would be divided into two blocks of trials, one with larger and one with smaller dollar amounts. Participants then performed the multi-trial decision task twice, once in the scarcity condition and once in the control condition, in counterbalanced order. During scarcity trials, participants learned they could have up to $100 to allocate; during control trials, participants learned they could have up to $10 to allocate. Importantly, all participants believed they would have $10 to allocate on each trial in both blocks, thereby holding the actual amount constant across trials. To determine the success of this manipulation, participants were thoroughly probed for suspicion prior to debriefing.[7]

On each trial of the allocation task, a fixation cross appeared for 2-8 seconds (jittered; *M* = 3.67; 50% of trials were 2s, 25% were 4s, 16.7% were 6s, and 8.3% were 8s), followed by a face for 4s, during which time participants registered their allocation decision. Again, participants' task was to simply indicate the portion of $10 they believed the recipient deserved, this time in $2.50 increments, on a five button scanner-friendly controller. Participants were assured their choices were confidential in order to avoid reputation or reciprocity concerns. Participants completed a total of 72 trials in each condition. Assignment of individual faces to condition was counterbalanced and their order of appearance within condition was randomized. No face stimuli were repeated throughout the task. Participants were reminded of their allocation allowance every 24 trials. Upon each block completion, participants indicated the extent to

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[7] Three participants expressed some suspicion regarding whether the $10 assignment in each condition was truly random. However, they did not report the hypothesis, role of race, nor role of scarcity. Results are nearly identical if these participants are excluded from analysis. No other participants reported suspicion, and most reported using the same decision strategy in each condition. See Supplement for funneled debriefing questions and participants' responses, and for results excluding suspicious participants.

which their allocation allowance felt limited, using a scale anchored from 1 ("extremely limited) to 5 ("Not at all limited"), as a manipulation check. When both conditions were complete, participants exited the scanner and completed demographic questionnaires assessing their age, race, and gender.

**Scanning parameters and fMRI preprocessing.** fMRI data were collected using the 3T Siemens Allegra head-only scanner at a university brain imaging center with the Siemens standard head coil. Anatomical images were acquired using a T1-weighted protocol (256 × 256 matrix, 176 1-mm sagittal slices), along with a field map and short TE EPI scan to improve functional-to-anatomical coregistration. Functional images were acquired using a multi-echo EPI sequence (TR time = 2000 ms; echo time = 15 ms; field of view = 240 mm, flip angle = 82 degrees, bandwidth = 4,166 Hz/Px, and echo spacing = 0.31 ms), obtaining 34 contiguous oblique-axial slices (3 x 3 x 3-mm voxels) + 20 degrees parallel to the anterior commissure–posterior commissure line. Fixation scans acquired at the start of each run were dropped from analysis to allow for magnet equilibrium. Data were preprocessed and analyzed in SPM8 (Wellcome Department of Cognitive Neurology, London, United Kingdom), co-registered to structural images, corrected for slice acquisition time and motion, transformed to conform to the default EPI Montreal Neurological Institute (MNI) brain interpolated to 3 x 3 x 3mm, smoothed using a 6-mm full-width/half-maximum kernel, corrected for artifacts, and detrended.

**fMRI data analysis.** Individual participants' blood-oxygenation-level-dependent (BOLD) responses to face presentations (4s) were modeled at the first-level as a function of a canonical hemodynamic response function (HRF) with a 128s high-pass filter, using a general linear model (GLM) with four predictors (Scarcity-Black, Scarcity-White, Control-Black, Control-White). We then submitted these first-level GLM analyses conducted on individual subjects' BOLD signal to a second-level random effects analysis treating subjects as a random factor, to examine the interactive effect of scarcity condition and face race on neural activity.

***Region of interest (ROI) creation.*** To isolate the effects of face encoding in the fusiform region, we created bilateral fusiform maps based on peak activity in a functional Face > Fixation contrast, collapsing across conditions. Importantly, because this localizer was based on activity to faces across condition and face race, it remained independent from the analysis comparing activity to faces in this region by condition and race (i.e., the sum of the localizer contrast [1 1 1 1] x interaction contrast [1 -1 -1 1] = 0; eliminating concerns about the use of non-independent data for ROI selection and analysis). Specifically, we defined the bilateral fusiform maps as 10 mm spheres around the location of peak activity in the Face > Fixation contrast for the right and left side (MNI coordinates: 30, -66, -12, and -36, -60, -18), following previous research (Ratner, Kaul, & Van Bavel, 2013; see Figure S2). Given our interest in right FFA activity and given consistent evidence for right-lateralized FFA effects in right-handed participants such as ours (e.g., Kanwisher, McDermott, & Chun, 1997), we then extracted mean parameter estimates (β values) from the right FFA maps and submitted them to a repeated-measures analysis of variance as a function of scarcity and race conditions.

Because an additional aim of this study was to understand the relationship between diminished face encoding and devaluation under scarcity, and because of the well-established role of the striatum in valuation (Ariely & Berns, 2010; Poldrack, 2011) and the guiding of action in decision tasks (O'Doherty, 2004), we examined functional connectivity between the fusiform ROI and an anatomically-defined striatum ROI. The striatum ROI was generated from the caudate and putamen AAL atlas regions (which includes nucleus accumbens). The inference of reward processing from striatum activity is based on extensive prior research in humans and animals (Ariely & Berns, 2010; Poldrack, 2011); moreover, a NeuroSynth analysis revealed that the terms “reward” and “value” had an 89% and 79% probability, respectively, of appearing in published reports of striatal activation (MNI coordinates -12, 4, -10; Yarkoni et al., 2011). In the present research, all ROIs were selected prior to any data analysis on the basis of our theoretical hypotheses and prior findings in cognitive neuroscience[8].

***Psychophysiological interactions (PPIs).*** We examined connectivity between the fusiform and striatum ROI with a psychophysiological interaction model (PPI). This PPI analysis allowed us to test our a priori questions about whether scarcity jointly reduces fusiform and striatum activity, and whether this joint activity gives rise to anti-Black allocation. Whereas a Race x Condition effect on striatum activity only reveals whether fusiform and striatum activity are independently less active on scarce-Black trials (see supplement), the PPI analysis determined whether fusiform and striatum respond in tandem on scarce-Black trials, perhaps because dampened fusiform activity decreased striatal activity. We used the generalized PPI SPM8 toolbox to manage the repeated-measures nature of the data (McLaren, Ries, Xu, & Johnson, 2012). Participants’ data were entered in a second-level random effects model with regressors for (a) each trial type (Scarcity/Control x Black/White faces; i.e., the psychological regressors), (b) the timecourse from the Face > Fixation functionally defined fusiform ROI (i.e., the physiological regressor), and (c) the interaction of this timecourse with each trial type. We then examined the interaction of the four conditions x fusiform timecourse regressors within the anatomical striatum ROI to identify regions in which the strength of connectivity with the fusiform seed varied by trial type, using a voxel-wise threshold of $p < .001$ and SPM’s small-volume correction procedure, $p_{FWE} < .05$. To interpret interaction patterns, we extracted mean

[8] Though striatum was our a priori hypothesized region of interest given our interest in devaluation, we also performed whole-brain analyses and exploratory ROI analyses to examine secondary hypotheses about additional psychological mechanisms that might support our effects (see supplement).

parameter estimates (beta values) from within significant ROIs and submitted them to a 2 (Race: Black face vs. White face) x 2 (Condition: Scarcity vs. Control) repeated-measures ANOVA (for descriptive purposes only; significance was determined by the random effects model). See Supplement for whole-brain methods and analysis.

**Results**

**Manipulation check.** Participants rated resources in the scarcity condition as more limited (*M* = 2.80, *SD* = 1.19) than resources in the control condition (*M* = 3.23, *SD* = 1.14), *t*(29) = -2.09, *p* = .045, Cohen's *d* = 0.38. Thus, despite the use of a within-subjects manipulation in this experiment the manipulation of scarcity was validated.

**Scarcity and race effects on fusiform activity.** Our main hypothesis was that scarcity would impede the encoding of Black faces but not White faces, replicating Study 1. Based on our theorizing and Study 1 results, we expected to observe a selective reduction in right fusiform activity to Black faces viewed under scarcity (e.g., Bentin et al., 1996). This prediction was supported by a Condition X Race interaction, *F*(1,28) = 7.16, *p* = .012 (Figure 3). In the scarcity condition, activity in the right fusiform was significantly reduced to Black faces (*M* = 2.85, *SD* = 1.20) relative to White faces (*M* = 3.28, *SD* = 1.21), *F*(1,28) = 13.05, *p* = .001, whereas in the control condition, right fusiform activity to Black faces (*M* = 3.14, *SD* = 1.20) and White faces (*M* = 3.10, *SD* = 1.25) did not differ, *F*(1,28) = 0.07, *p* = .798. Within-race comparisons further revealed that the effect of scarcity involved both a reduction in activity to Black faces, *F*(1,28) = 2.11, *p* = .157, and enhancement to White faces, *F*(1,28) = 0.96, *p* = .335—trends that jointly contributed to the significant effect of scarcity on Black vs. White face processing.[9] This pattern

[9] The fusiform ROI contrast (Faces > Fixation) was orthogonal to the Condition x Race contrast. However, to ensure our results were robust to the ROI selection method, we replicated them using a right fusiform anatomical ROI which yielded a significant cluster of 28 voxels at $p < .005$ (uncorrected), which survived small-volume correction (SVC), $P_{FWE} < 0.03$ (see Supplement).

replicated Study 1, further demonstrating Black face encoding impairments under conditions of economic scarcity.

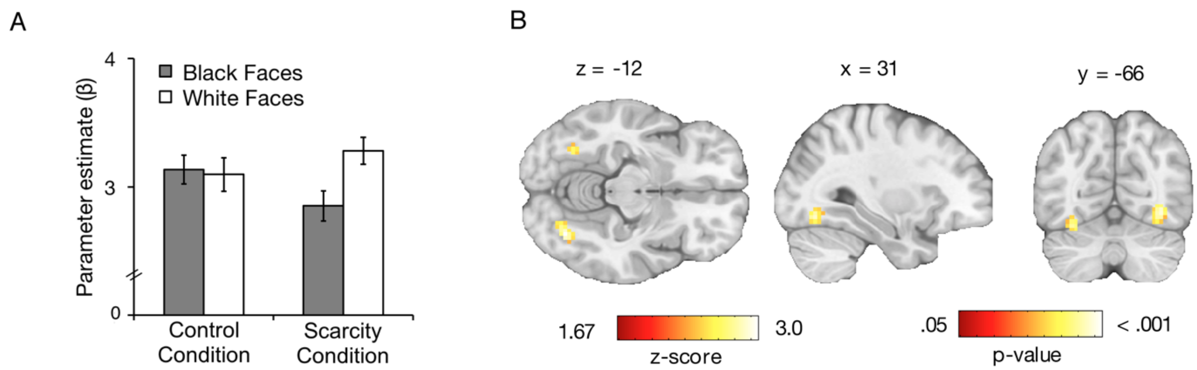


**Figure 3.** Scarcity effects on race in fusiform gyrus ROI (N = 30). (A) Average parameter estimates of each trial type across the right fusiform ROI compared to fixation. Error bars represent within-subject +/- 1 SE. (B) Activity within the fusiform gyrus as a result of a second-level 2 (Race: Black vs. White) x 2 (Condition: Scarcity vs. Control) repeated-measures ANOVA, which treated subjects as a random factor (the image is shown at a voxel-wise threshold of $p < .05$).

**Scarcity and race effects on fusiform-striatum connectivity.** A secondary hypothesis was that the scarcity-decreased fusiform activity to Black faces would be related to a reduction in valuation-related activity in the striatum; that is, to the extent that participants' encoding of Black faces was impaired, they should also "devalue" those faces. To explore devaluation effects associated with the reduction in fusiform response to Black faces, we conducted an *a priori* psychophysiological interaction (PPI) analysis (O'Reilly, Woolrich, Behrens, Smith, & Johansen-Berg, 2012) with the right fusiform ROI as the seed region, searching for coactivation in the predetermined striatum ROI. That is, we examined the strength of connectivity between the fusiform and striatum ROI as a function of trial type (condition x race), in order to determine whether decreased fusiform response corresponded most strongly with decreased valuation-related striatum activity on Scarcity-Black trials.

This contrast revealed a significant positive relationship between the fusiform and striatum ROI, which was strongest on Scarce-Black trials, $p < .001$ (uncorrected), small-volume correction within striatum anatomical mask, $P_{\text{FWE}} < .0001$, $k = 70$ (Fig 4A-B)[10,11]. This finding suggests that neural activity related to face encoding and valuation was most tightly coupled on Scarce-Black trials, such that diminished face encoding was associated with diminished valuation.

**Scarcity and race effects on discrimination.** As in Study 1, and based on previous research (Krosch & Amodio, 2014; Krosch, Tyler, Amodio, & 2017), we did not expect a direct effect of scarcity and race on behavior. Using a mixed-measure ANOVA, we confirmed this was the case: the critical Scarcity x Race interaction on allocation bias was not significant, $F(1,28) = 0.27$, $p = .62$.

**Scarcity and race effects on discrimination mediated by fusiform-striatum connectivity.** We did however predict that the strength of the relationship between diminished face processing and devaluation would be associated with behavioral discrimination, such that participants who showed the greatest scarcity-driven connectivity between decreased fusiform and decreased striatum activations would show the largest anti-Black bias. That is, scarcity would induce greater anti-Black allocation through the combination of reduced fusiform and striatum response to Black faces. To test this prediction, we created an index of anti-Black allocation bias on scarcity trials (a contrast comparing the average amount allocated on Scarce-

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[10] An additional analysis using an 8mm sphere around the nucleus accumbens yielded similar results with a cluster of 17 voxels at $p < .001$ (uncorrected), SVC, $P_{\text{FWE}} < .03$, suggesting our results are robust to the method of defining the striatum (see Supplement).

[11] This pattern of fusiform-striatum connectivity was unique; additional PPI analyses involving a set of exploratory ROIs were not significant (see supplement)."

Black trials to all other trial types) and fusiform-striatum connectivity (a contrast comparing the strength of fusiform-striatum connectivity on Scarce-Black trials to other trial types). As expected, a within-subjects mediation analysis (Judd, Kenny, McClelland, & 2001) revealed a significant indirect effect of scarcity, such that it increased anti-Black allocation through enhanced functional connectivity between the fusiform and striatum on Scarce-Black trials, $B$ = 0.43, $SE$ = 0.17, $\beta$ = 0.56, $t$ = 2.64, $p$ = .014 (Figure 4C; see supplement for details of the full mediation model and additional analyses).

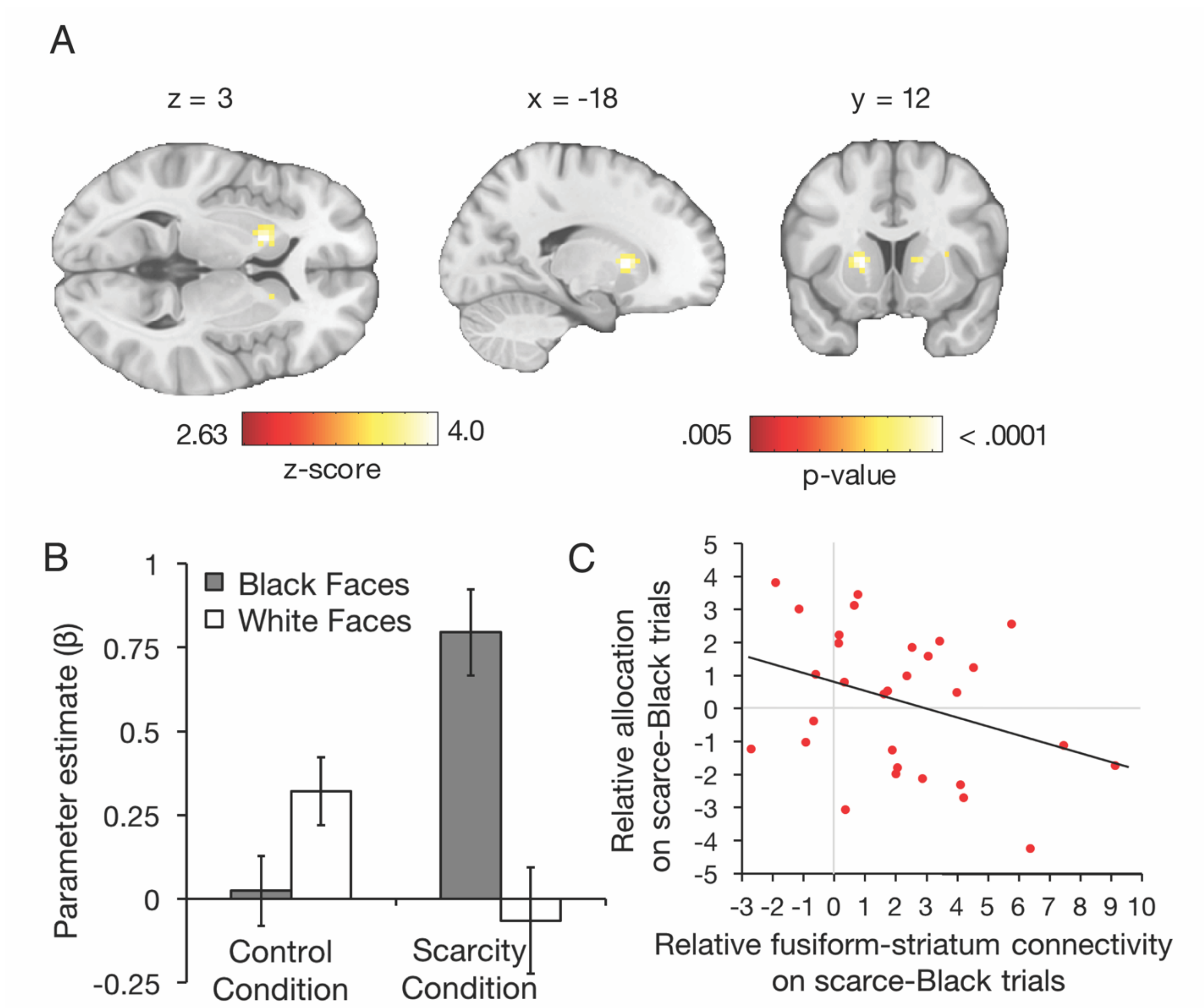


**Figure 4.** Results of functional connectivity analysis (N = 30). We examined functional connectivity between the right fusiform seed region and the striatum ROI by trial type (Scarcity

x Race). (A) The Scarcity x Race contrast revealed significant fusiform-striatum connectivity as a function of trial type, $p < .001$ (uncorr.), small-volume corrected, $P_{FWE} < .0001$ (activation illustrated at $p < .005$ uncorrected). (B) Average parameter estimates of connectivity between the striatum and fusiform ROIs for each trial type (for descriptive purposes). Error bars represent within-subject +/- 1 SE. Decreased fusiform activity on Scarce-Black trials was most strongly coupled with decreased striatum activity. (C) Subjects who exhibited the strongest fusiform-striatum connectivity on Scarce-Black trials (compared to other trial types) allocated fewer resources on Scarce-Black trials (compared to other trial types).

**Discussion**

Study 2 provided additional evidence for the reduced encoding of Black faces under scarcity, as indicated by fusiform cortex activity—a conceptual replication of Study 1 using a different method of neuroimaging. This result again revealed a selective effect, such that fusiform activity was lower in response to Black than White faces in the scarcity condition but did not differ in the control condition. This pattern was consistent with our inference, in Study 1, that N170 results reflected a reduction in configural encoding of Black faces under scarcity, underpinned by activity in the fusiform cortex. Again, our results suggest that under conditions of scarcity, White perceivers exhibit a reduced visual encoding of Black faces as human faces.

Importantly, by utilizing a within-subjects design, we were able to clarify the pattern observed in Study 1 and more definitively determine that scarcity-related processing deficits were race-specific. In Study 2, participants experienced both scarcity and control conditions in a within-subject design. This design controlled for individual differences and thus permitted a more precise test of the hypothesis—that is, whether scarcity alone can influence face processing or whether the effect of scarcity is truly selective for Black faces. Consistent with our hypothesis, the drop in fusiform activity was selective for Black faces. A main effect of scarcity on fusiform activity did not emerge, suggesting the main effect on latency in Study 1 was likely driven by random between-subject variation rather than by a general effect of scarcity.

In addition, Study 2 examined the role of valuation in the effect of scarcity-altered face encoding on decision making. Results of the PPI analysis revealed that the scarcity effect on fusiform activity to Black faces related to valuation-related activity in the striatum. In other words, the disruption in face encoding was associated with a reduction in valuation of Black faces under scarcity. Furthermore, a novel contribution of Study 2 was to identify devaluation as a possible mechanism through which face encoding deficits give rise to discriminatory behavior. Specifically, our fMRI results suggested complementary roles of visual processing (associated with fusiform activity) and reward processing (associated with striatal activity) in intergroup social perception. Striatal activity has long been implicated in valuation (Ariely & Berns, 2010; Poldrack, 2011) and supports goal-directed action (O'Doherty, 2004), and our results appear to link perceptual biases with neural signatures of devaluation in the prediction of biased economic decision making.

Because PPI analysis is correlational, and given the slow timecourse of BOLD signal, the sequence of these effects cannot be directly inferred; hence, it is possible that striatum activity preceded fusiform activity or, alternatively, that their responses are parallel and complementary, but not causally related. However, we know from Study 1 that the effects of scarcity on face processing occurs as early as 170 ms following presentation of a face—a timeframe that likely precedes valuation-related activity in the striatum. Although contemporary non-invasive neuroimaging methods cannot provide a clear test of causality, our results are consistent with such a pathway. More broadly, Study 2 provided further evidence that impeded visual encoding of Black faces under scarcity relates to discriminatory behavior.

## General Discussion

Minorities are often derogated and disenfranchised when resources become scarce—a pattern that leads to heightened discrimination and perpetuated disparities (Bianchi, Hall, & Lee, 2018; Esses, Jackson, & Armstrong, 1998; Hovland & Sears, 1940; Lauritsen & Heimer, 2010; Riek et al., 2006). We asked whether this pattern of devaluation under scarcity is reflected in the visual perception of faces, such that minority group member faces are less readily encoded under scarcity, and whether this tendency is associated with economic discrimination. This research yielded three major findings:

First, our main hypothesis that scarcity impedes processing of Black faces was supported in two studies with converging evidence from complementary approaches. Specifically, we found that when economic resources were perceived to be scarce (vs. neutral), decision makers showed marked deficits in the encoding of Black recipients' faces, as indicated by a delay in the face-sensitive N170 ERP component in Study 1 and by reduced neural activity in face-sensitive fusiform gyrus revealed by fMRI in Study 2. The combination of these effects provides particularly strong support for our hypothesis: The N170 index revealed that the effect occurs very rapidly, at approximately 170 ms after face onset. Furthermore, based on the extensive N170 face processing literature, the observed N170 delay effect specifically suggests a decrement in configural face processing—a pattern previously observed for inverted human faces and allospecific (e.g., ape) faces. By using fMRI, in Study 2, we were able to locate the effect in the participants' face-selective regions of the fusiform (i.e., their fusiform face areas), consistent with the putative neural source of the N170. Together, these findings provide strong evidence that economic scarcity influences the early visual processing of minority group member faces. Importantly, these findings move beyond prior work that examined how scarcity influences judgements of racial group membership (e.g., Krosch & Amodio, 2014; Rodeheffer, Hill, & Lord, 2012) to demonstrate its effect on the degree to which a Black face is initially registered in the mind as a representing a conspecific (i.e., human) face.

Second, we found that perceptual encoding deficits for Black faces under scarcity were related to a decrease in neural activity associated with valuation. That is, to the extent that participants exhibited diminished Black face encoding under scarcity (compared to other conditions), they showed a complementary reduction in valuation-related striatum activity. These findings suggest that, as proposed, faces seen as less face-like are also seen as less valuable under resource scarcity.

Finally, these studies collectively demonstrated that the degree of Black face encoding impairment under scarcity was associated, directly or through devaluation, with discrimination in monetary allocations. In Study 1, the extent to which participants showed delays in the N170 to Black (compared with White) faces was related to the extent to which they favored White (compared with Black) recipients in allocation decisions. Study 2 expanded on this proposed pathway to identify a potential mechanism through which a bias in perception can lead to bias in behavior. Specifically, we showed that behavioral discrimination under scarcity was related to the degree of coupling between face encoding deficits and neural signatures of devaluation; that is, participants who showed the tightest link between face encoding deficits and devaluation under scarcity showed the strongest behavioral bias. Together these results support a perceptual account of scarcity effects on discrimination: When resources are scarce, decision makers perceptually devalue Black recipients, which in turn is associated with discriminatory allocation decisions.

**Scarcity Effects on Racial Bias**

It is well-documented that minorities suffer disproportionately when resources are scarce (Bianchi, Hall, & Lee, 2018; Esses, Jackson, & Armstrong, 1998; Hovland & Sears, 1940; Lauritsen & Heimer, 2010; Quillan, 1995; Riek et al., 2006; Taylor, Kochhar, & Fry, 2011), yet the sociocognitive mechanisms through which scarcity gives rise to behavioral discrimination have remained obscure. To this end, recent research has identified processes such as biased race categorization (e.g., of mixed-race faces as Black) and representation (of faces as darker and more Afrocentric), as well as moderating factors (e.g., egalitarian motivations, social dominance orientation), that begin to explain the psychology of scarcity-induced discrimination (Ho, Sidanius, Cuddy, & Banaji, 2013; Krosch & Amodio, 2014; Krosch, Tyler, & Amodio, 2017; Rodeheffer, Hill, & Lord, 2012). However, these effects do not fully capture the mechanisms that drive discrimination under conditions of scarcity. By linking economic scarcity to early and automatic visual face encoding processes, the present research represents an advance toward understanding *why* scarcity gives rise to discrimination in individual social exchanges and *how* we might mitigate these effects (see "Implications for Interventions" below).

These experimental findings also offer new insights into how scarcity may contribute to a broader—and more extreme—range of racial disparities. Although we focused on the effects of scarcity-induced encoding deficits on small monetary allocations, it is possible that the same pathway may also produce more serious forms of minority group oppression associated with devaluation, such as upticks in physical violence that emerge during economic recession (e.g., Hovland & Sears, 1940; Lauritsen, Heimer, 2010; but see Green, Glaser, & Rich, 1998). Such extreme forms of harm are not easily predicted from cognitive explanations that emphasize biased racial categorization or representation. Yet the perceptual mechanisms of devaluation proposed here may provide an important link between these cognitive explanations and real-world racial injustices.

Our findings also raise new questions regarding the roles of status, race, and group membership in the observed effects of scarcity. Our focus on White Americans' perceptions of Black recipients was guided by historical and contemporary social issues of racial prejudice and discrimination in the United States. However, it is notable that, in this American context, Black recipients in our task are simultaneously racial minorities, members of a low status social group, and members of White participants' outgroup (e.g., Axt, Ebersole, & Nosek, 2014; Sidanius & Pratto, 1999). Although these experiments were not designed to distinguish between these factors, we can speculate on their likely contributions. In light of our study designs, findings, and prior research, our results appear most consistent with an effect of status, which may have been exacerbated by race. In our studies, the participant was a member of a higher-status racial group, placed in a position of power (as allocator), making allocations to same-group and lower-status group members in a non-threatening context. In addition, differences in appearance associated with race may have exacerbated the visual encoding effects, given that these particular groups—Black and White Americans—are often distinguishable by skin tone and facial features.

It appears less likely that these findings could reflect group membership effects (i.e., ingroup vs outgroup effects). Research on minimal group effects typically observed ingroup favoritism in the absence of outgroup derogation (e.g., Brewer, 1999). In the present studies, allocation decisions were non-zero-sum, and thus a mere group effect should produce enhanced processing of ingroup members under scarcity but no changes in the processing of outgroup members. We did not observe this pattern, however. Rather, we observed decrements in face processing specific to outgroup members—a pattern consistent with selective anti-Black allocation biases under scarcity reported by Krosch et al. (2017). These findings suggest that our findings more likely reflect effects of status and race than of group membership. Future research on this issue may disentangle these accounts by manipulating these factors independently.

**Scarcity Effects on Early Visual Processing: Potential Mechanisms**

Our findings raise new questions regarding the psychological experience of scarcity and how it may produce the visual changes observed in the present research. One possibility is that scarcity increases sensitivity to outgroup cues (e.g., darker skin tone), which facilitates the categorical processing of a face (e.g., as Black) and, as a consequence, shifts attention away from configural cues—an effect that known to produce the *own race bias* (Hugenberg, Young, Bernstein, & Sacco, 2010; Sporer, 2001). That is, according to this account, faces are typically processed according to a "default route," involving configural encoding that supports individual identification. However, if an outgroup membership cue is detected, the face is processed more categorically according to that cue (e.g., skin tone) and less configurally (Sporer, 2001). Hence, scarcity might interfere with configural encoding by increasing sensitivity to outgroup cues and enhancing categorical processing—a process connected to behavioral biases (e.g., Fincher & Tetlock, 2016). Although the present studies did not assess race categorization, prior evidence that scarcity affects race categorization is consistent with this account (e.g., Krosch & Amodio, 2014; Rodeheffer, Hill, & Lord, 2012).

Other research suggests that scarcity enhances the experience of intergroup competition (e.g., Sherif & Sherif, 1953), which may lead White perceivers to discount the value of Black individuals in economic contexts. That is, scarcity may have implicitly reduced attention to, and thus visual processing of, Black faces relative to White faces. As noted above, Study 1 provided data consistent with this account, such that Black faces viewed under scarcity elicited reduced P1 ERP amplitude relative to White faces (reflecting early attentional preferences for White faces). This automatic orienting and shift in covert attentional processing of White compared with Black faces would, in theory, cascade into Black face visual encoding deficits consistent with the observed N170 delay. These additional results provide clues about the mechanisms through which high-level socioeconomic factors (i.e., scarcity-driven sensitivity to outgroup cues or feelings of intergroup competition) can influence relatively low-level, rapidly-unfolding visual processes involved in social cognition.

**Impaired Face Processing, Discrimination, and Dehumanization**

The deficits in face processing observed in this research, which were specific to Black faces viewed under conditions of scarcity, may represent a very literal form of dehumanization. In prior research, "perceptual dehumanization"—defined as disruption to configural processing—has been shown using face inversion manipulations known to impair configural face encoding (e.g., Cassidy et al., 2017; Hugenberg et al., 2016; Fincher & Tetlock, 2016, Wilson, Young, Rule, & Hugenberg, 2018). However, viewing upside-down faces can be ecologically peculiar, as we rarely encounter them in the real world. The N170 delay used here offers an alternative assessment of configural face encoding in response to upright faces. N170 latency has long been implicated in face encoding deficits, and a large body of research demonstrates longer N170 latencies to a variety of "less human" faces, including misaligned, scrambled, eyeless, inverted, and animal faces (Balas & Koldewyn, 2013; Carmel & Bentin, 2002; De Haan, Pascalis, Johnson, & 2002; Eimer, 2000a; George, Evans, Fiori, Davidoff, & Renault, 1996; Itier, Latinus, Taylor, & 2006; Itier, Alain, Sedore, & McIntosh, 2007; Letourneau & Mitchell, 2008; Rousselet, Macé, & Fabre-Thorpe, 2004; Stahl, Wiese, & Schweinberger, 2008). Importantly, this N170 delay has been observed in response to great ape faces (with clear human-like facial features) relative to human faces, illustrating its sensitivity to perceived *humanity* (Carmel & Bentin, 2002; De Haan, Pascalis, & Johnson, 2002; Eimer, 2000b; Gajewski & Stoerig, 2011; George, Evans, Fiori, Davidoff, & Renault, 1996; Letourneau & Mitchell, 2008). These findings suggest that the N170 delay effect observed in Study 1 may represent a literal form of "perceptual dehumanization"—a deficit in encoding a face percept as a human face.

By *measuring* configural processing deficits in response to scarcity, as opposed to manipulating it, we provide evidence of perceptual dehumanization in an ecologically valid face-to-face decision task. Future research on perceptual dehumanization effects and downstream behavioral implications could implement this method to allow for more naturalistic tasks and less demand susceptible tasks (given the N170 occurs at a very early stage of visual perception, ~170ms after seeing a target face). In addition, future research could further validate the interpretation of N170 delays as a perceptual component of dehumanization by examining its relationship to higher-level constructions of dehumanization (e.g., trait impressions of targeted individuals that minimize their degree of human experience and agency, their ability to feel secondary emotions, and their connection with humanity; Gray, Gray, & Wegner, 2007; Harris & Fiske, 2006; Kteily, Bruneau, Waytz, & Cotterill, 2015; Leyens et al., 2000), as previous researchers have done with manipulated forms of encoding disruption (e.g., inversion; Hugenberg et al., 2016; Wilson, Young, Rule, & Hugenberg, 2018). If we accept encoding deficits as "perceptual dehumanization," as have previous authors (Cassidy et al., 2017; Fincher & Tetlock, 2016; Hugenberg et al., 2016; Wilson, Young, Rule, & Hugenberg, 2018), our results suggest that racial minorities may not be seen as fully human when resources are scarce and are consequently perceived as less deserving of resources.

In identifying a perceptual component of dehumanization, our findings suggest a unique perceptual mechanism to explain how human aversion to violence (e.g., Crockett, Kurth-Nelson, Siegel, Dayan, & Dolan, 2014) has been overcome in historical and present-day brutality against Black Americans. Black people were historically considered less than human via the "3/5$^{ths}$ Compromise" in America and still face dehumanizing representations, often with harmful and violent consequences (e.g., Goff, Eberhardt, Williams, & Jackson, 2008; Hoffman, Trawalter, Axt, & Oliver, 2016; Waytz, Hoffman, & Trawalter, 2015; Wilson, Hugenberg, & Rule, 2017). The present research suggests one way through which Black Americans may be treated as less than a person—by literally being *seen* that way.

Finally, although much recent research has established that intergroup goals and motivations influence early face processing (e.g., Hugenberg & Corneille, 2009; Freeman et al., 2011; Ofan et al., 2011, 2014; Ratner & Amodio, 2013; Van Bavel et al., 2011; Young, Bernstein, & Hugenberg, 2010; Young & Hugenberg, 2010), to our knowledge this study is the first to link situationally-induced encoding deficits to behavioral discrimination. Furthermore, while research has shown that artificially disrupting configural face processing (i.e., through inversion) can give rise to blunted ascriptions of humanity (e.g., Cassidy et al., 2017; Hugenberg et al., 2016; Wilson, Young, Rule, & Hugenberg, 2018) and lead to greater punishment behaviors (e.g., Fincher & Tetlock, 2016), the current study assessed naturally-occurring disruptions in individuals' configural face processing, as a function of their task goals during the course of decision making, and linked those differences to bias in allocation behaviors.

**Stimulus and Sample Diversity**

The current research was inspired by real-world observations that racial minorities suffer the greatest consequences of economic downturns, and thus we chose to focus on racial discrimination perpetrated by non-Black decision makers. However, future research may consider whether similar results would be found with other groups. For example, use of a minimal group paradigm, “model” minority group recipients, or Black perceivers could illuminate whether our findings hinge on the status of recipient groups, broad anti-Black perceptions, or more general intergroup mechanisms that promote discrimination. Previous research suggests that scarcity effects on attitudes are strongest for low status minority groups, yet they exist for other groups as well (Riek et al., 2006). The current investigation may have been a particularly strong test of our hypothesis (given the relatively low status of Black Americans and their historical discrimination), but other groups might still be susceptible. Indeed, we propose perceptual dehumanization as a general mechanism that may apply in any case where perceivers are motivated to see outgroup members as less deserving, regardless of their race. Future research should probe this speculation.

Due to the relatively difficult and immobile nature of EEG and fMRI data collection, our samples were limited to undergraduate psychology student participants at a large private university in a major metropolitan area. Given this population, we cannot gauge the degree to which our effects generalize to less educated people, those from rural areas, or those from non-industrialized, poor, and non-democratic societies. Indeed, such samples may differ even on "low-level" processes such as visual perception (Henrich, Heine, & Norenzayan, 2010; Miyamoto, Yoshikawa, & Kitayama, 2011). Future research should capitalize on the growing push toward interlab replication (e.g., StudySwap) to investigate the generalizability of these effects.

**Implications for Interventions**

By identifying the sociocognitive processes through which economic scarcity operates on behavioral discrimination, our results help to identify points of intervention as well as potential limitations. For example, our results suggest that interventions designed to improve encoding, "rehumanize," and individuate minority outgroup members, originally developed to alter trait impressions (Harris & Fiske, 2009), may also enhance perceptual encoding of outgroup faces (e.g., Hugenberg, Young, Bernstein, & Sacco, 2010), thus buffering the harmful effects of economic scarcity on racial disparities.

At the same time, the implicit nature of encoding deficits suggests a potential limitation to some intervention approaches. An implication is that the effects of impaired encoding on judgment and behavior may be especially difficult to detect and respond to, making them impervious to control. Indeed, the visual process identified in the present research may represent a very durable, resistant pathway through which system-level inequalities perpetuate themselves in individual-level judgments and behaviors. Thus, they may not be easily changed by current interventions and present a challenge for new approaches. For example, *proactive* intervention strategies that do not rely on the detection of biased perception (see Amodio & Swencionis, 2018) may prove more effective at reducing biasing effects in visual perception. If interventions can be developed to reduce these perceptual biases in individual decision makers, they may lessen the impact of institutional forces that drive disparities and facilitate progress to more egalitarian systems.

## Data Availability

We report all data exclusions, manipulations, conditions, and measures in both experiments. Neither experiment was formally preregistered, but the hypotheses, method, and analysis plan for Study 1 was described in the initial grant proposal submitted to NSF, which was awarded to support this work. The hypotheses, method, and analysis plan for Study 2 were outlined in the first authors' dissertation proposal before data were collected. De-identified summary data, analysis code, and materials will be made available at osf.io/jkdw5 upon reasonable request and according to IRB restrictions regarding participant privacy/consent.

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## Supplemental Online Materials

### Supplemental Analyses – Study 1

**Response latency.** Log-transformed response latencies were submitted to a 2 (Race: Black vs. White) x 2 (Condition: Scarcity vs. Control) mixed-factorial ANOVA. This analysis revealed a trending but non-significant main effect of race, such that participants made slower decisions for White targets (mean raw latency $M$ = 2462.30 ms, $SD$ = 881.55) compared with Black targets ($M$ = 2428.29 ms, $SD$ = 869.97), $F(1,69) = 2.35$, $p = .130$. There was no main effect of condition or interaction, $F$'s < 1.73, $P$'s > .192.

**Scarcity effects on N170 amplitude**. Disruption to configural processing of faces is most directly evident in N170 latency (e.g., Balas & Koldewyn, 2013; Bentin et al., 1996; Eimer, 2000b; George, et al., 1996; Itier et al., 2017; Jacques & Rossion, 2010), which is why our main focus was on delay. However, this delay often occurs in tandem with increased amplitude (e.g., Bentin et al., 1996; Itier et al., 2007; Eimer, 2000b), and together this pattern is thought to signify difficulty resolving the percept as a face and trouble processing it configurally (e.g., Itier et al., 2007; Rossion et al., 2000; Latinus & Taylor, 2006; Jacques & Rossion, 2010).
Thus, to bolster our interpretation of the Black N170 delay under scarcity as a decrease in configural processing, we submitted peak N170 amplitude scores in the right hemisphere to a 2 (Race: White vs. Black) x 2 (Condition: scarcity vs. control) mixed-factorial ANOVA.[12]

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[12] One criticism of peak amplitude measures is insensitivity to multiple peaks within a given time window. Although all of our participants exhibited a single peaked waveform within our window of interest, we also conducted tests on the area under the curve as a complementary approach that is less vulnerable to multiple peaks. This analysis produced the same pattern of N170 amplitude results, such that there was no main effect of condition, $F(1,69) = 0.05$, $p$ =

Although the interaction effect was not significant, $F(1,69) = 0.39$, $p = .537$, the key predicted effect of race within the scarcity condition was significant, $F(1,69) = 8.12$, $p = .006$, indicating greater negative amplitudes to Black (*M* = -3.74, *SD* = 2.31) compared with White faces (*M* = -3.21, *SD* = 1.98). Thus, Black faces in the scarcity condition exhibited a pattern characteristic of decreased configural processing (i.e., delayed peak combined with increased amplitude). Participants in the control condition also exhibited greater N170 amplitudes to Black (*M* = -4.05, *SD* = 2.45) compared with White faces (*M* = -3.68, *SD* = 2.46), $F(1,69) = 4.02$, $p = .049$. However, without an accompanying latency difference, this pattern (i.e., no delay combined with greater amplitudes) suggests, if anything, a processing *advantage* for Black faces in the neutral control condition.

**Scarcity and Race effects on P1 and P2.** The high temporal resolution of ERP methodology allowed us to test secondary questions about where in the processing stream scarcity effects first arise and what psychological processes are affected by scarcity. In two exploratory analyses, we tested the effects of scarcity, race, and their interaction on the P1 and P2 ERP components, which are believed to reflect early orienting and anticipatory attention, respectively. P1 and P2 components were scored as the peak positive amplitude between 60 and 140ms at Pz, and the peak positive amplitude between 150 and 210ms at Cz, where they were maximal, respectively. The P1 amplitude analysis revealed no main effect of scarcity condition, $F(1,69) = 1.01$, $p = 0.32$ and a marginal effect of race, $F(1,69) = 3.18$, $p = .079$, such that P1 amplitudes were greater for White (*M* = 2.39, *SD* = 2.21) than Black faces (*M* = 2.08, *SD* =

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.824, but a significant main effect of race, $F(1,69) = 13.27$, $p = .001$, such that area under the curve was greater for Black faces than White faces. Again, there was no interaction between race and condition, $F(1,69) = 1.28$, $p = .262$.

2.06), possibly reflecting low level visual differences that remain even after adjusting Black and White faces for luminance differences (e.g., Firestone & Scholl, 2015). Although the Condition by Race interaction did not reach significance, $F(1,69) = 1.01$ $p = .317$, the pattern of this interaction mirrored the N170 latency findings: Participants in the scarcity condition exhibited smaller P1 amplitudes to Black faces ($M = 1.80$, $SD = 2.07$) compared with White faces ($M = 2.29$, $SD = 2.32$), $F(1,69) = 3.84$, $p = .054$, whereas participants in the control condition did not exhibit this difference, $F(1,69) = 0.31$, $p = .582$. Together these findings tentatively suggest a very early reduction in attentional orienting to Black faces when resources are scarce, which may give rise to downstream configural processing impairments seen in the N170. During scarcity, these White subjects may have implicitly prioritized the processing of White over Black faces, reducing their covert attention to and, thus, visual processing of Black faces. This suggests perhaps the possibility of a pattern of multi-stage mediation, where scarcity influences P1 to influence N170 to influence allocation decisions. Indeed, greater attention to White vs. Black faces marginally predicted longer latencies to Black vs. White faces (r = .20, p = .09) which predict anti-Black allocation decisions (r = .26, p = .30. However, the strength of this effect did not differ between conditions, and we were far underpowered to detect such moderated mediation. Future research designed to directly test this question with sufficient power could test the plausibility of this model.

Analysis of P2 latency revealed no main effects or interactions, $F$'s < .53, $p$'s > .470, suggesting that scarcity effects on Black face processing were limited to the interruption of configural processing and possibly early attentional orienting, and did not influence later attentional processes.

**Scarcity and Race on Allocation through N170 delay (full mediation model).** Scarcity did not directly predict participants' degree of anti-Black allocation ($B = 0.11$, $SE = .26$, $\beta = 0.05$, *t* = 0.43, *p* = .67, 95% CI = -0.40, 0.62; c path). Scarcity did directly influence N170 delay for Black relative to White faces, *B* = -.77, SE = .09, *t* = 9.10, *p* < .001 (a path), and that delay was related to Scarce-Black allocation, *B* = .19, SE = .03, *t* = 5.75, *p* < .001 (b path). A bootstrapped mediation analysis revealed an indirect effect such that the N170 delay for Black relative to White faces significantly mediated the effect of scarcity on anti-Black allocation (A x B cross product = 0.14, *SE* = 0.09, 95% CI = .04, .35, *p* = .039.

**Scarcity and Race on N170 delay (four non-White participants removed).** Condition X Race interaction, F(1,65) = 6.34, p = .014: under scarcity, N170 latency was significantly delayed to Black faces (M = 175.33 ms, SD = 12.03) relative to White faces (M = 172.66 ms, SD = 11.95), F(1,65) = 12.49, p = .001, whereas in the control condition, the latency did not differ between Black faces (M = 169.47 ms, SD = 11.48) and White faces (M = 169.47 ms, SD = 11.99), F(1,65) < 0.01, p > .99. N170 latency to Black faces was significantly delayed in the scarcity condition compared with the control condition, F(1,65) = 4.17, p = .045, whereas the latency to White faces did not differ by condition, F(1,65) = 1.19, p = .279. Again, only the processing of Black faces under scarcity was significantly delayed beyond the typical latency of 170 ms, t(32) = 2.55, p = .016, 95% CI = 1.07, 9.59 (all other p's > .209).

**Supplemental Methods – Study 2**

**Alternative ROIs.** To ensure our results were robust to the ROI selection method, we examined activity in the whole fusiform gyrus using an Automated Anatomical Labeling (AAL) atlas anatomical mask of the right fusiform gyrus and activity in the striatum as defined by 8mm spheres around the nucleus accumbens (-11,11,-2 and 11,11,-2), as in Knutson et al. (2005) and Tricomi, Rangel, Camerer, & O'Doherty (2010).

**Exploratory ROI creation and PPI analyses.** Although the primary aim of this study was to understand the relationships between face encoding and higher-level valuation under scarcity, we also examined possible connectivity between the fusiform ROI and OFC and MPFC ROIs to explore additional regions implicated in valuation and mentalizing. We created these anatomical regions of interest by defining masks for the MPFC as Brodmann's Area (BA) 9 and 10 (which includes lateral portions) as well as by using the Dorsal Default Mode Network atlas, which excludes lateral regions (Richiardi et al., 2015). We defined the OFC as BA 11 and 12, and alternatively using the OFC regions of the AAL2 atlas (Rolls, Joliot, & Tzourio-Mazoyer, 2015).

We examined connectivity between the fusiform ROI and the striatum, MPFC, and OFC ROIs with a psychophysiological interaction model (PPI), using the generalized PPI SPM8 toolbox to manage the repeated-measures nature of our data. Participants' data was remodeled in a second-level random effects model with regressors for each trial type (Scarcity/Control x Black/White faces; i.e., the psychological regressors), the timecourse from the Face > Fixation functionally defined fusiform ROI (i.e., the physiological regressor), and the interaction of this timecourse with each trial type. We then examined the interaction of the four condition x fusiform timecourse regressors within each anatomical ROI to identify regions in which the strength of connectivity with the fusiform seed varied by trial type, using a voxel-wise threshold of $P < .005$ and SPM's small-volume correction procedure, $P_{FWE} < .05$. To interpret interaction patterns, we extracted mean parameter estimates (beta values) from within significant ROIs and submitted them to a 2 (Race: Black face vs. White face) x 2 (Condition: Scarcity vs. Control) repeated-measures ANOVA (for descriptive purposes only; significance was determined by the random effects model).

**Whole-brain analyses.** We also performed a whole-brain analysis to examine neural activity beyond the scope of our primary hypotheses. For the main analyses, we set the family-wise error (FWE) rate at $p < .05$ to correct for multiple comparisons using a voxel-wise threshold of $p < .001$ (uncorrected) and an extent threshold of 33 voxels, as determined by Monte Carlo simulation accounting for spatial correlation among neighboring voxels and implemented in AlphaSim with a smoothing kernel estimated from the data at 3.2 mm. We also performed an exploratory whole-brain analysis with a $p < .005$ voxel-wise threshold (uncorrected) and a more liberal extent threshold of 20 voxels, a widely-used exploratory approach in fMRI research. For whole-brain PPI analyses, we examined results with a voxel-wise threshold of $p < .001$ (uncorrected) and an extent threshold of 86 voxels that were determined by Monte Carlo simulations to set the family-wise error (FWE) rate at $p < .05$.

**Supplemental Analyses – Study 2**

**Response latency.** Log-transformed response latencies were submitted to a 2 (Race: Black vs. White) x 2 (Condition: Scarcity vs. Control) repeated-measures ANOVA. As in Study 1, this analysis revealed a main effect of race, such that participants made slower decisions for White targets (mean raw latency $M$ = 2166.07 ms, $SD$ = 394.48) compared with Black targets ($M$ = 2111.25 ms, $SD$ = 380.45), $F(1,28) = 4.43$, $p = .044$. There was no main effect of condition or interaction, $P$'s > .322.

**Scarcity and race effects on fusiform activity (whole fusiform mask, small-volume corrected.** Replicating the results of the main text, this supplemental analysis revealed a significant cluster (k = 15) in the fusiform gyrus (x = 33, y = -69, z = −12), $p < .005$ (uncorrected), which survived small-volume correction (SVC), $P_{FWE} < 0.03$, suggesting the fusiform results are highly robust and not the spurious result of ROI construction.

**Scarcity and Race effects on Fusiform-striatum Connectivity (8-mm spheres centered on NaCC).** Replicating the results of the main text, this supplemental analysis revealed a significant cluster (k = 17) in the nucleus accumbens, $p < .001$ (uncorrected), which survived small-volume correction (SVC), $P_{FWE} < 0.03$, suggesting our results are robust to the method of striatum definition.

**Scarcity and Race effects on Striatum Activity.** We also explored a Condition x Race contrast on striatum activity, $p < .001$ (uncorrected) revealed a significant cluster (k = 12) in the striatum, $P_{FWE} < 0.05$, small-volume corrected. We next extracted activity in these voxels to determine their pattern: As expected, the Condition X Race interaction on striatum was significant, $F(1,28) = 5.42$, $p < .03$, as this test is redundant with the SVC analysis. Furthermore, we found that mirroring the effect in the fusiform, in the scarcity condition, activity in the striatum was marginally reduced to Black faces ($M = -0.64$, $SD = 1.42$) relative to White faces ($M = 0.03$, $SD = 1.37$), $F(1,28) = 3.80$, p = .06, whereas in the control condition, striatum activity to Black faces ($M = -0.28$, $SD = 1.44$) and White faces ($M = -0.38$, $SD = 1.32$) did not differ, $F(1,28) = 0.07$, $p = .78$. Within-race comparisons further revealed that the effect of scarcity involved both a reduction in activity to Black faces, $F(1,28) = 2.53$, $p = .12$, and enhancement to White faces, $F(1,28) = 4.91$, $p = .04$ (See Figure S3). Although this task did not recruit strong striatum activity overall, it produced meaningful variability, suggesting that valuation of White faces was especially enhanced under scarcity.

**Exploratory ROIs.** No voxels in the MPFC or OFC survived the small volume correction at the $P_{FWE} < .05$ level.

**Whole-brain Condition x Race analyses.** No voxels survived the whole-brain analysis with a voxelwise threshold of $p < .001$ (uncorrected) and an extent threshold of 33 voxels. Results of the exploratory analysis with a voxelwise threshold of $p < .005$ (uncorrected) and an extent threshold of 20 voxels are presented in Table S1.

**Whole-brain PPI analyses.** Whole-brain results with a voxelwise threshold of $p < .001$ (uncorrected) and an extent threshold of 86 voxels are presented in Table S2.

**Scarcity and Race on Allocation through FFA activity (Full mediation model).** Scarcity did not directly influence allocation to Black recipients on average, as the Scarce-Black allocation contrast did not differ from zero, $t(29) = 0.55$, $p = .59$, CI = -1.02, .59 (c path). Within-subjects mediation analysis revealed a significant indirect effect of scarcity, such that it increased anti-Black allocation through enhanced functional connectivity between the fusiform and striatum on Scarce-Black trials, $B = 0.43$, $SE = 0.17$, $\beta = 0.56$, $t = 2.64$, $p = .014$.

**Main analyses with suspicious participants excluded.** The Condition X Race interaction remained marginally significant when excluding three participants who voiced some suspicion at our manipulation, $F(1,28) = 7.16$, $p = .06$ (Figure 3). In the scarcity condition, activity in the right fusiform was significantly reduced to Black faces ($M = 2.85$, $SD = 1.26$) relative to White faces ($M = 3.23$, $SD = 1.27$), $t(26) = 3.03$, $p = .005$, whereas in the control condition, right fusiform activity to Black faces ($M = 3.04$, $SD = 1.19$) and White faces ($M = 3.08$, $SD = 1.30$) did not differ, $t(26) = 0.21$, $p = .834$. According to a within-subjects mediation analysis (Judd, Kenny, McClelland, & 2001), scarcity significantly indirectly increased anti-Black allocation through enhanced connectivity between fusiform and striatum on Scarce-Black trials, $B = 0.41$, $SE = 0.18$, $\beta = 0.53$, $t = 2.35$, $p = .028$.

**Scarcity effects on discrimination through fusiform activity**. The primary aim of Study 2 was to replicate Scarcity x Race effects on neural encoding using the FFA. The secondary aim was to understand the relationship between diminished face encoding and devaluation under scarcity and to test an extension of the hypothesized pathway in which scarcity influences allocation through face processing effects on valuation. However, readers may be interested in the indirect effects of Scarcity on Allocation through FFA.

A within-subjects mediation analysis (Judd, Kenny, McClelland, & 2001) revealed a non-significant indirect effect of scarcity on allocation through FFA, but the pattern was such that scarcity increased anti-Black allocation through *reduced* FFA activity to Black faces, $B = 0.15$, $SE = 0.13$, $\beta = 0.21$, $t = 1.15$, $p = .28$, as expected. This weaker pattern is likely because FFA activation provides a relatively less direct and more temporally-imprecise index of configural face encoding than the N170.

## Supplemental Supporting Text

**Scarcity manipulation: The role of perceived importance.** Although we are confident in our manipulation of perceived scarcity (see manipulation checks), it is possible that our scarcity manipulation also reduced perceived task importance, which combined with reduced attention to low status outgroup members, reduced attention to Black faces. Because we focused on perceived scarcity—and found that participants in the scarce condition interpreted their resources as more scarce and more limited than participants in the control condition—we did not ask any questions about the perceived importance of the task. However, there are a few reasons to believe task importance does not drive our scarcity effects:

First, some research suggests that people may actually put *more* effort into a task when they believe resources are limited. For example, when allocating scarce resources, decision makers undertake more complex attributional analyses about recipients (Skitka & Tetlock, 1992), spend more time making decisions (Krosch, Tyler, Amodio, & 2017), and increase attention to scarcity-related concerns (e.g., Fernbach, Kan, & Lynch Jr., 2015; Shah, Shafir, & Mullainathan, 2015), and put extra effort into resource allocation tasks (Gersick, 1988; Mullainathan & Shafir, 2013; Shah et al., 2012).

Second, our supplemental reaction time data fail to support this alternative hypothesis—in neither study was there a response latency interaction (see this supplement). If the alternative hypothesis were true, we would expect participants to be fastest in the scarcity condition when allocating to Black recipients. The only significant effect in either study was a main effect of race on response latency in Study 2, such that participants made slower decisions for White targets compared with Black targets. This may suggest that overall participants felt the Black recipient trials to be less consequential but does not support the hypothesis that scarcity diminishes the perceived importance of the task or of Black trials, specifically.

Finally, as predicted by a "perceptions of scarcity" vs. a "perception of unimportance" account, we found that in the scarcity condition, participants' beliefs about the limited nature of their resources was marginally correlated with greater anti-Black N170 latencies ($r = .28$, $p = .11$), while in the control condition these were unrelated ($r = .04$, $p = .81$). That is, to the extent that participants experienced scarcity following our manipulation, they showed longer latencies to Black than White faces. In the control condition, there was no relationship between perceived scarcity and anti-Black N170 latencies. Although this test cannot speak to the perceived importance of the task, it does corroborate our interpretation that the *psychological* experience of \$10/\$100 as more scarce drives our perceptual effects.

**Scarcity manipulation: Psychologically similar to real-life conflict?** Although scarcity is associated with a wide range of socioeconomic conditions and psychological experiences, the core construct involves the perception that a resource is limited, which is what we aimed to manipulate. Thus, it isn't clear from these studies whether the present scarcity manipulation induces identical psychological states induced by absolute resource scarcity or realistic conflict in the real world. However, evidence from previous research suggests that very different and overt manipulations (i.e., telling participants they have less to allocate than others on account of the recession) result in similar intergroup behavioral effects as the present manipulation (Krosch, Tyler, Amodio, & 2017).

Based on years of research in social identity theory on symbolic and realistic threat we believe this manipulation induces a valid form of perceived scarcity. “Real-life” scarcity may take other forms, but this fact does not change the validity of our manipulation or the fact that it is likely to represent important aspects of scarcity effects in society. Thus, while this manipulation may not induce the same experience of scarcity as losing ones’ job or going underwater on a mortgage due to the recession, it is still relevant and reflective of real-world decision contexts. For example, consider a manager that expects to distribute $10K in end of year bonus funds but only has $1K. They are likely to experience more resource scarcity than one who expects to distribute $1K and then receives $1K. Our findings suggest this manager might perceptually devalue outgroup employees during a bonus review which could result in biased decision making.

The above manager scenario elucidates the decision to eliminate the role of self-interested decision making and the direct effects of competition: There are real-world scenarios of great importance in which scarcity might drive intergroup allocation behavior in the absence of self-interest, and it is important to investigate scarcity and race effects without the influence of desire for personal financial gain and direct competition.

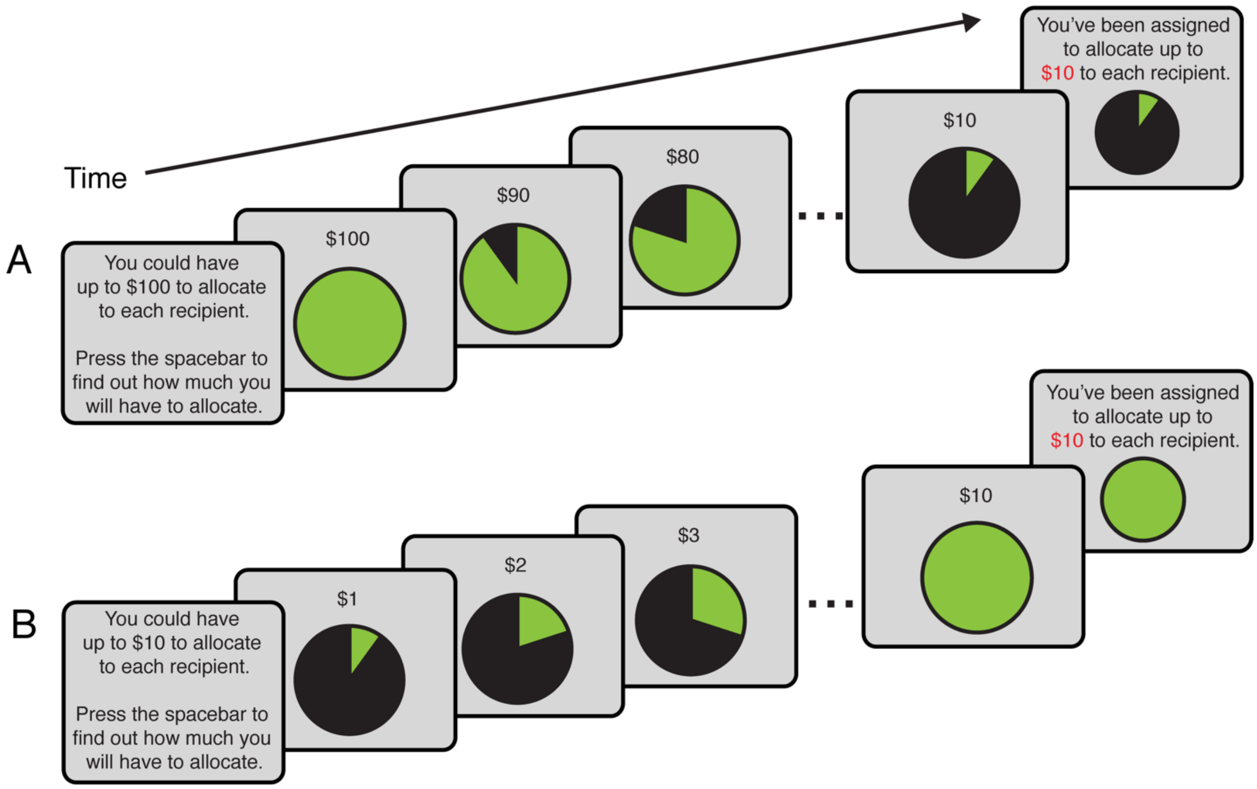


**Figure S1. Scarcity manipulation.** Participants believed they could have up to $100 to allocate to each recipient in the scarcity condition (A) or up to $10 to allocate to each recipient in the control condition (B). Every participant was ostensibly randomly chosen to allocate up to $10 to allocate to each recipient – only the total *possible* amount changed between conditions.

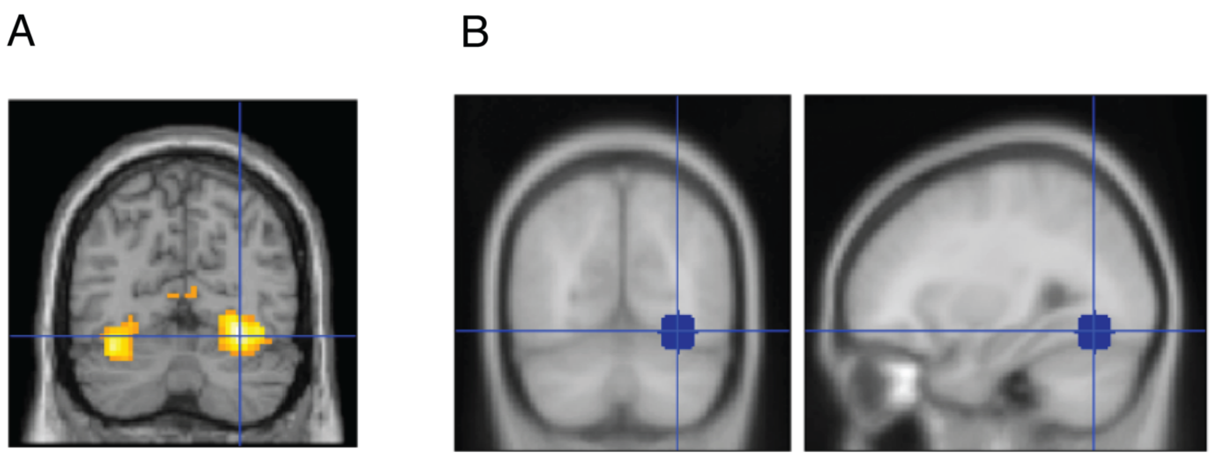


**Figure S2.** Fusiform ROI creation. We created face-sensitive fusiform regions of interest by (A) identifying the location of peak activity that was greater to faces than fixation (represented at $p <$ .00001) and (B) drawing a 10 mm sphere around that point.

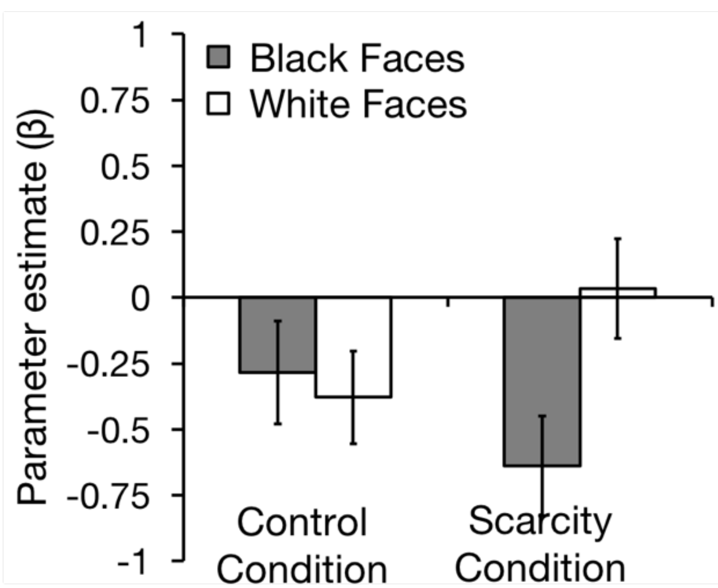


**Figure S3.** Scarcity effects on race in striatum (N = 30). Average parameter estimates of each trial type across in a significant 12 voxel striatum cluster, compared to fixation. Error bars represent within-subject +/- 1 SE.

Supplementary Table 1. **Results of whole-brain Scarcity x Race analysis.**

*Neural Activity*

| Region | t-Value | MNI Coordinates | | | # Voxels |
|---|---|---|---|---|---|
| | | x | y | z | |
| **Black > White** | | | | | |
| Calcarine/Lingual | 3.96 | -15 | -54 | 9 | 49 |
| Right Frontal Mid | 4.45 | 33 | 30 | 42 | 22 |
| Left Frontal Mid | 3.80 | -39 | 27 | 42 | 22 |
| **White > Black** | | | | | |
| Fusiform/Lingual | 4.27 | 36 | -57 | -3 | 34 |
| **Scarce > Control** | | | | | |
| **Control > Scarce** | | | | | |
| Putamen/NAcc | 3.50 | 18 | 12 | 0 | 21 |
| **Interaction** | | | | | |
| Left Cingulum Mid | -4.20 | -15 | -21 | 48 | 39 |
| Right Anterior Insula | -3.46 | 42 | 9 | 6 | 27 |
| Left Postcentral | -3.74 | -20 | -36 | 48 | 23 |
| Left Frontal Sup Medial | 3.71 | -9 | 69 | 24 | 25 |
| Bilateral Caudate | 3.75 | 3 | 18 | 0 | 23 |

*Note*. Thresholded at $p < .005$, k > 20

**Supplementary Table 2.** Results of whole-brain PPI analysis with right Fusiform ROI as seed region.

*Neural Activity*

| Region | t-Value | MNI Coordinates | | | # Voxels |
|---|---|---|---|---|---|
| | | x | y | z | |
| **Black > White** | | | | | |
| **White > Black** | | | | | |
| Left Hippocampus/Para | 4.18 | -15 | -15 | -6 | 99 |
| Cingulum/Lingual/Calc. | 3.99 | -6 | -39 | 18 | 187 |
| Right Hippocampus/Para | 3.93 | 12 | -21 | -12 | 120 |
| **Scarce > Control** | | | | | |
| dACC/pre-SMA | 3.67 | -6 | 15 | 45 | 92 |
| **Control > Scarce** | | | | | |
| Posterior Left Insula | 3.88 | -30 | -9 | 15 | 88 |
| **Interaction** | | | | | |
| Postcentral/Precentral | -4.63 | -33 | -33 | 51 | 186 |
| Supp. Motor Area | -4.17 | -6 | 24 | 45 | 110 |
| Left Precentral | -3.85 | -60 | 9 | 36 | 93 |
| Left Mid Temporal | 3.85 | -45 | -15 | -18 | 136 |
| Left Fusiform/Lingual | 3.72 | -24 | -45 | -15 | 88 |

*Note*. Thresholded at $p < .001$, $k > 86$

**Supplementary Table 3. Study 2 Debriefing Questions**

*Q1: What do you think the purpose of the experiment was?*

| Pp | Response |
|---|---|
| 1 | I believe that the purpose of this experiment was to see how we naturally react to certain images and how different that is from what we actually put down for a certain answer. Many people change their answers to various things depending on how they might be viewed, but by seeing the brain as it's working it allows for a true understanding of the thought process of a person. |
| 2 | I believe the purpose of this experiment was to research and learn how different demographics (race, ethnicity, gender) affect how people make decisions in their everyday lives. |
| 3 | To see how looks or first impressions affect people's reaction to them |
| 4 | To see different facial features and their positive/negative impacts on subject's ideas surrounding them. This could differentiate between race, attractiveness, gender, and/or other facial features. Also to test ideas surrounding amounts of money. |
| 5 | Study the brain when making decisions based on ethnicity, race, and gender. |
| 7 | I think it was to assign a monetary value to a demographic (black vs white) by using black and white people making all sorts of different facial expressions (sad, angry, cheerful, etc.). |
| 8 | I believe that the purpose of this experiment was to see what features determine deservingness. This is what I was told, anyway, but I'm also starting to think that this experiment wanted to see how the allocation/perception of money would change if participants were told that they would be allocating large or small sums. I don't know if that makes any sense. |
| 9 | I think the purpose was to determine how much money I would give to certain demographics, ages, and beauty, to see if I was bias towards one race or age or attractive people. |
| 10 | To see how our impressions of people were affected based on just looks. How we determine deservingness by just one's attractiveness, race, gender, and expression. |
| 11 | The purpose of the experiment was to measure how deserving/trusting I found certain individuals to be, with the intention of giving (or not giving) those people money. |
| 12 | To study which brain areas are pertinent to decision-making vis-a-vis monetary allocation. I imagine that there was a racial component in the study as well -- how biased reactions look as opposed to non-bias perhaps. |
| 13 | Perhaps the purpose of the experiment was to see the regions of high brain activity during racial classification, retrieving biases, and/or performing basic reasoning to decide how much money to allocate per person. |
| 14 | to see if the race of an individual has any effect on whether or not they are deserving of a certain amount of money |
| 15 | To examine racial/gender/beauty prejudices and whether/how they affect money |
| 16 | To determine the arbitrary allocation of resources to a random set of faces |
| 17 | To examine how different parts of the brain are activated when making first impressions / To examine neural/psychological responses to race/gender/age differences / To examine neural/psychological responses to slight differences in expression / To examine |

| | |
|---|---|
| | how the brain is activated when asked to complete sociologically uncomfortable tasks (dealing with money allocation and deservedness) |
| 18 | To understand how race/ethnicity as well as gender affect how we perceive the worthiness of people, to test if physical factors of appearance play a part in how we perceive others. |
| 20 | To determine how race and facial cues influence how a person judges another. |
| 22 | to see how people reacted to certain races and ethnicities and facial expressions and based off of those pre-conceived biases how to give money accordingly |
| 24 | I think the purpose of this experiment was to discover a correlation between how much money I allotted someone and their physical appearance. ie. gender, race expression etc |
| 25 | to see how much a person's opinion affects their decision making when it comes to other people. |
| 26 | To see how different areas of the brain work when allocating money to people. |
| 27 | The purpose was to observe what facial features determined how much money was given to each person by the participant. |
| 28 | To determine how much money people deserved based on their facial characteristics and ethnicity. For example, an upset and visibly worn minority would make me feel like they deserved more money. |
| 29 | I think the purpose of the experiment was to study the response of the brain to the task of deciding deservingness via the process of allocation. |
| 30 | To determine what thought processes were involved in judging worthiness. |
| 31 | I think the purpose of this experiment was to determine what motivates people to decide someone is deserving of something or what (eye) cues/what people look at to determine how much someone else deserves. |
| 32 | to see if there were innate differences in our allocation responses |
| 33 | To determine the way in which people decide to trust others to make good use of money based on physical features. |
| 34 | To see how we judge people's character, beliefs, etc. based solely upon their face. Some were less attractive, some had sores or pock marks, some were smiling, and you wanted to see how all these factors may affect my perception of them. |

*Q2: Did you feel like you understood the tasks well? Did you know what to do? Please name one thing, at minimum, that was confusing.*

| Pp | Response |
|---|---|
| 1 | I believe that the tasks were pretty clear and straight forward. My only issue with the experiment is that I felt like I had no true basis to judge how much money I should give to the people; I only had their skin color and facial expression. This is truly not enough in deciding how much money to give out because there is no foundation or reasoning to it. |
| 2 | Yes. There wasn't really anything that was confusing. I guess the most confusing part was that there wasn't any information given about the people that we were allocating money too, it was solely based on appearance. |
| 3 | It was very self-explanatory. If anything, I probably had the most trouble deciding where to put my arms once in the machine. |

4 Yes, the instructions were very clear. At first I thought that we only had $10 in total to allocate to a random number of people, but it made sense.

5 I did feel like I understood the tasks well and knew what to do. I think the most confusing part was having ten dollars twice, as I wasn't sure whether that was what was expected to happen from the computer. I think that is more situational though.

7 I didn't know that I would be randomly assigned a monetary value for the large and small blocks, it was a little confusing with the wheel but by the second time around I understood what was going on and that the value assigned to me was arbitrary.

8 I feel that I understood the task fairly well and knew what to do. Instructions were fairly clear. The only thing I found initially confusing was how the tasks themselves were to work, but that was cleared up pretty quickly.

9 I understood the task well, just allot a certain amount of money to each person. Before it started I had to make sure that I was given the $10 for each person, opposed to I only had $10 to give total and it would have to add up to $10 after everyone.

10 Yes, I felt like I understood them well. At first, I was slightly confused by which finger corresponded to which amount.

11 I feel like I understood the task pretty well. Personally, I wasn't sure why I was giving people money in the first place (for example, if they were homeless, in distress, emergency, going to buy something illegal..). Social background would have made it a little bit easier but I think I understand what the experimenter was trying to do.

12 I was not sure if there was a maximum amount overall that I could allocate. It was unclear whether I had to be conservative in my allocation or if I could just be generous according to my own criteria-based judgments.

13 The tasks were fairly easy to comprehend, no worries there. I knew what to do throughout. At first when I was handed the button controller, the buttons were labeled from greatest to least. During the experiment, however, the dollar amounts went from least to greatest. There was really only minor confusion during the instructions portion outside of the machine. Once inside, I couldn't see the buttons so it wasn't an issue.

14 Yes. The only confusing part was that I received $10 for both my large and small amounts, but I understand that happened randomly.

15 I was a bit confused when it said I could have $100 per person and then only had $10

16 I feel like I understood the task; I had trouble understanding what the real-world version of this would be, whether it was money coming out of my pocket or money that would go to waste if I didn't allocate it, etc.

17 Yes, it was well explained. I was confused by the fact that I was allotted the same amount to give both times. I wonder if thinking that the $10 dollars was a maximum and then being told the same number was a minimum changed how I perceived the task. I wasn't consciously sure if it did.

18 I think I understood everything. I know several faces came up more than once and that was a bit confusing because after a certain sequence of faces I found myself allocating them a different sum of money.

20 I think so. I felt pressured to make sure i was using all 5 keys and i often had to remind myself not to save the extremes for what i thought where the most extreme scenarios...

22 I felt like I understood the tasks well and I knew what to do. One thing that was confusing was how to consider allocating the amount of money to different types of faces.

| | |
|---|---|
| 24 | Yes I understood the task well but I was unsure of how to create the parameters of how to allot the money. I tried different tactics in deciding what type of person gets no money and who gets the full amount of money. |
| 25 | yes, and yes. The most confusing thing to me was the click any key to pick what amount of money you're going to have part. I kept clicking my clicker but it always just landed on a number randomly, not when I would click a key. |
| 26 | I think I understood what I was supposed to do pretty well. The only thing I found kind of confusing was that I wasn't totally sure what I should be basing my decisions on since all I had to go on was a picture of each person. |
| 27 | Yes. Yes. Nothing. |
| 28 | The tasks were pretty straight forward, the only question that I felt was lingering or subjective was whether the I hypothetically had $10 and had to determine how much I would give (which I assumed), or if hypothetically I was to dish out an amount out of $10 that I didn't own to the subject I was being shown. |
| 29 | I feel that I understood the tasks well. One thing that was confusing was the scale that asked me to rate how limited I felt after the first and second blocks. I was unsure whether to refer to the numbers on the hand control or the numbers presented on the screen. |
| 30 | I felt like I understood everything fairly well. The fact that the first and second amount of money were the same was a bit confusing. |
| 31 | I felt like I understood the task well. I knew what to do. The only slightly confusing thing was how at first it was out of $100 and then $10, I am not sure what the difference was supposed to be or if it was supposed to have an impact. |
| 32 | yes. why was the amount $10 for both parts? |
| 33 | I feel like I understood the task well. Although one thing that was confusing was that at it took me a minute to realize that, in the first block, I was giving 10$ out of the 100$ I had, whereas I thought I was just giving a bit of a random 10 dollars, but I understood in the end. |
| 34 | I understood the tasks well. I felt like I knew what to do. I wasn't sure what I was allocating the money for though. Was it a hypothetical reward for a task? A gesture of good will? |

*Q3: Did your approach to allocation change depending on which block you were in (larger or smaller amounts)?*

| Pp | Response |
|---|---|
| 1 | My block stayed the same both times ($10) so I approached both the same way. |
| 2 | In both the larger and smaller amounts, I was given the same amount of money. However, I do believe my approach in the larger amount differed slightly from the smaller amount, as I felt that I had lost a chance at allocating money. |
| 3 | My amount was the same for both blocks, so yes I approached it the same. |
| 4 | Yes, when in the larger amount I felt that I was more restricted money-wise at first and felt that I should give larger amounts. |
| 5 | Because I had the same value for both larger and smaller amounts, my approach to the allocation did not change much. However, I do remember at times thinking that if I had 100 dollars instead of 10 I would be more reluctant to give out the higher amounts of money. |

| | |
|---|---|
| 7 | It didn't for me because I was assigned $10 for both the large and small blocks so it just seemed like a continuation. |
| 8 | I think that I saw the $10 in the large sum block as a far less significant amount of money than the $10 in the small sum block. I kind of feel as if I didn't change my method of allocation too significantly, though. |
| 9 | I was given $10 for both the small and large amounts, however I believe my mindset did change. For the first $10 I allotted money based on 1-10 my initial reaction. I rarely gave the full $10, because I was waiting for someone to really wow me. For the second $10 (larger amount) I used a do they need $10 philosophy. If the person looked like they could use $10, I would give it to them. Usually they fell under this category if they were young (they could use the money) or a parent (usually a mother) or sad. If the person seemed angry or gave me a bad vibe, I usually gave them $5 or less. There were a few cases that I gave $0, only I believe if they were a man that I thought didn't need the money, or if they gave me a REALLY bad vibe. |
| 10 | No because I received the same amount for both blocks ($10) |
| 11 | Both of my blocks were the same amount of money (the most minimal amount: $10). Because my amount was so low, I felt pretty limited in my funds and didn't really see how such a little amount of money could really help someone if they really needed the financial support. |
| 12 | Not by much -- the second block I had gotten more used to the task at hand. |
| 13 | No not really, because I was tasked with allocating $10 for both the larger and smaller amount blocks. |
| 14 | No i had $10 for both blocks |
| 15 | no, I had same $10 both rounds |
| 16 | Both of my blocks were for the same amount of money. |
| 17 | I didn't think so. I had the same number both times. |
| 18 | Actually, both of my blocks involved the same exact sum, so there was no difference in my approach. |
| 20 | This is a bit hard to answer given that i had the same $10 to allocate in each block. That said, as the blocks went on i think i was able to get outside of my own head when arbitrarily judging people and switch over from will they think im racist mode? to alright who gets what mode. |
| 22 | No because I had the same amount of money in each block |
| 24 | My block stayed the same both times. In both blocks I was asked to allocate 10 dollars. |
| 25 | My amounts were the same, so no. |
| 26 | Not really, but then again I had 10 dollars to allocate each time so there wasn't really any difference. |
| 27 | No |
| 28 | Not really because I had the same amount for each, but over time I became increasingly strict with how much I would give to people and the reasoning behind it. |
| 29 | Since I was given the same amount of money to allocate during both blocks ($10), I don't think my approach changed much. |
| 30 | Not that I particularly noticed. |
| 31 | No. |
| 32 | no |
| 33 | Yes. |
| 34 | My approach did not change since the random amount was the same both times. |

*Q4: Did anything in the experiment strike you as strange? Confusing? Untrue?*

| Pp | Response |
|---|---|
| 1 | Just the fact that we did not have much of a basis to use for our results. |
| 2 | No, I quite enjoyed the experiment. |
| 3 | I don't think there was enough difference in the appearance of the people, although I suppose that was probably the point. It made it hard to decide the amount to allocate though! |
| 4 | There was a point where I couldn't tell if I was seeing the same face throughout or if the two subjects just had similar features. When this happened I couldn't remember if I was changing my monetary amount and became worried that I was being inconsistent. |
| 5 | It was a bit strange that I had the same amount of money for both the smaller and larger block, but I didn't think that was intentional. I also wasn't sure if the people I was giving money to were real people or not, but otherwise nothing really caught my attention. |
| 7 | no |
| **8** | **I'm pretty sure that the dollar amounts weren't random and that the experimenter wanted to see how people would allocate the same amount of money under different pretenses.** |
| 9 | It struck me as strange that I usually had a pretty good idea of how much I wanted to give each person. I also found myself giving more money to black people, probably because I subconsciously attribute them to be poorer or in need. |
| 10 | I found it strange and a bit confusing that I received the $10 amount twice. |
| 11 | Some of the poses felt staged. For example, two men and one woman were completely wide-eyed and looked as like they were high on cocaine, stimulated, or just plain neurotic. Also, I'm pretty sure the only races involved were blacks and whites. That was curious. I felt like I was being tested on how stereotypical I was, and how easily I would give to a black person versus a white person. Also, I felt like I was being shown women and men in separate series of photographs. |
| **12** | **The fact that both blocks allowed for the same amount of allocation -- 10$. Also, what would have prevented me from giving everyone 10$? I wasn't sure if the test was supposed to merit-based.** |
| 13 | Nothing out of the ordinary, confusing, or untrue. |
| 14 | nope. |
| 15 | did I see some faces multiple times?? |
| 16 | The motivation behind it seemed odd. It didn't seem like I had a complete picture of what was happening, as far as where the money had been before. |
| 17 | Not specifically. My being in that sort of position of economic authority seemed unrealistic however. Or at the very least uncomfortable. |
| 18 | Having to judge the same face multiple times out of sequence was a bit confusing and strange, but I understand how that might be a research tactic. |
| 20 | It felt very arbitrary to assign values on faces alone. For some reason i thought I would be getting a bit more information to synthesize alongside the face |
| 22 | It just struck me that I was supposed to allocate money to people based solely off of their facial features and expressions. |
| 24 | No |
| 25 | Some of the pictures started to look like they had similar features after a while.. not sure if that was just me though. |

| | |
|---|---|
| 26 | The only thing I found strange was that I was choosing how much money to give people based solely on one picture of them. |
| **27** | **I got 10 dollars both times.** |
| 28 | There were, as I recalled, some distorted facial features that I thought were strange and made it a little more difficult to assess the emotional state of the person. Also, I felt there were many more unfortunate looking minorities than whites, I feel if there were more not-well-off white people they would have deserved more money. |
| 29 | It felt a little strange to me to have to decide and change how much money I gave to each person. I think in a normal situation, I would have given the same amount of money to each individual. |
| 30 | Judging how much to allocate to people based solely on pictures was rather odd. |
| 31 | No. |
| 32 | i thought i saw a few repeated faces |
| 33 | No. |
| 34 | I never saw someone that was exceptionally attractive. It was also a bit odd that all the faces were in black and white. |

*Q5: Do you think the experimenter wanted you to do anything specific in today's session? If so, what?*

| Pp | Response |
|---|---|
| 1 | No. |
| 2 | They stressed the importance of making sure I used the full range of buttons, allocating different amounts. |
| 3 | The experimenter wanted me to allocate specific amounts of money to the photos I saw. |
| 4 | I think she wanted me to use all different monetary amount equally. |
| 5 | I think that she wanted me to fall asleep or begin to fall asleep during the last scan. |
| 7 | I think they wanted me to use all the buttons so that there was variety in my responses. I think they wanted to see if I would assign less money to african americans. |
| 8 | I imagine that the experimenter wanted me to be honest with my answers, does that count? I can't think of anything else. |
| 9 | I assume that the data they wanted was that I would give more money to one specific type of person, and I assume they wanted it to be black people. |
| 10 | Not particularly, I think it was more to just observe what effects our perceptions of people. I think expressions/race/attractiveness might be especially interesting to the experimenter. |
| 11 | Yes. I think the experimenter wanted me to choose to give money to those who I trusted, or found that if given to them, the money would be spent well. The experimenter probably assumed I would give more money to those I felt calm, safe, and familiar with. That was pretty much the case, but I found myself giving more to people not only whom I sympathized with, but also whom I pitied or felt the need to assist; that included people separate from my age, race, or gender. |
| 12 | Not to freak out in the MRI machine. |
| 13 | Allocate money along the spectrum, not just choosing one value in particular to expedite the experiment. |
| 14 | not anything specific other than just doing the experiment |

| | |
|---|---|
| 15 | just to choose from all across the increments, which I think I did, except I only gave out $0 once |
| 16 | I think the experimenter wanted to study my reaction to stress. I think it's likely that there was some kind of measurement of my allocation of the money with regard to various demographics (gender, age, race, etc.), but I'm not convinced that was the primary goal of the exercise. |
| 17 | Not pick the same amount for everyone, despite my being inclined to just arbitrarily throw money at everyone. I don't like to consider people undeserving of anything, nor do I enjoy the fact that I am capable of that thought in the first place. |
| 18 | I don't think so. |
| 20 | nope. |
| 22 | Wanted to see if we had any inherent race biases perhaps |
| 24 | I think the experimenter wanted me to be consistent in my choices of allotting people money in terms of the parameter set up for myself. |
| 25 | no |
| 26 | I think the experimenter wanted me to choose how much money to give different people. |
| 27 | Maybe it was expected I would favor a specific demographic or show preference against certain demographics. |
| 28 | Do my best to determine how deserving people were of my money given a set amount. |
| 29 | The experimenter wanted me to vary the amounts of money I gave to each individual based on the photo of the individual. This felt a little strange; I think I would normally just give each person the same amount of money. |
| 30 | Look at pictures and press buttons? |
| 31 | Not really, just to press different buttons and not continue to allocate the same amount to everyone. |
| 32 | see how race gender or physical attractiveness can play a roll |
| 33 | Use the whole range of money available to me. Also, perhaps have some kind of correlation between some facial feature or physical feature and amount of money allocated. |
| 34 | Allocate more money to more attractive people and white people and allocate less to less attractive people and black people. |

*Q6: Is there anything relevant that we haven't asked about, but should know regarding what happened in the study or what you did today?*

| **Pp** | **Response** |
|---|---|
| 1 | I don't believe so. |
| 2 | I believe that the request to allocate all of the amounts at some point slightly influenced my decisions. |
| 3 | No. |
| 4 | Nope. |
| 5 | The only thing is that a few times during the allocation of the larger block I would occasionally react as though I had 100 dollars instead of 10. |
| 7 | no |
| 8 | There's nothing that I can think of. |
| 9 | Nope. |

10 Nope
11 Maybe the role of the participant, like why am I giving away money (ie: charity, I owe you favor). But that might taint the experiment because it would be another variable regarding who to give money to and how much money to give to that person.
12 No.
13 Nope.
14 nope.
15 i was in a good mood
16 I was falling asleep a little at the end (when the screensavers came up) and I twitched a little. It definitely didn't affect the block tasks, but it might've affected the final scan.
17 It was interesting how I became more comfortable with making arbitrary judgements as the experiment progressed. I became less concerned with whatever demonstrations of unconscious racism/misangyny I was making.
18 No, I don't think so.
20 was all good fun. thanks much!
22 no
24 No
25 no
26 Not that I can think of.
27 No
28 Not that I can think of
29 Nothing comes to mind.
30 Is this study related to race in some way?
31 No. All good!
32 no
33 No.
34 Nope. I think that covers just about everything

*Note*. Highlighted portions indicate mention of our manipulation. Bolded portions indicate potential suspicion at our manipulation.