Original Research Article

Skin Pigmentation, Self-Perceived Color, and Arterial Blood Pressure in Puerto Rico

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ABSTRACT   Darker skin color has been associated with higher average blood pressure in several African-derived populations in the Americas. This pattern has been interpreted as evidence of genetic, physiologic, or sociocultural mechanisms, but existing evidence does not provide an adequate means of evaluating these alternatives. This paper introduces a measurement strategy to isolate the cultural and biological dimensions of skin color, and it develops a specific hypothesis regarding the cultural significance of skin color in Puerto Rico and its relationship to arterial blood pressure. Data come from a face-to-face survey in southeastern Puerto Rico ($N = 100$). There is no association between blood pressure and skin pigmentation, as measured by reflectance spectrophotometry. However, the discrepancy between self-perceived color and skin pigmentation, a measure we call "color incongruity," is associated with systolic blood pressure (SBP) through an interaction with socioeconomic status (SES) ($P = 0.009$). For low-SES respondents, darker self-ratings of *color* relative to skin pigmentation are associated with higher mean SBP. For high-SES respondents, however, darker self-ratings of *color* relative to pigmentation are associated with lower mean SBP. We interpret this pattern as evidence that the relationship between skin color and blood pressure is mediated by sociocultural processes, and we highlight the need for testable hypotheses and appropriate measurement operations in research on racial inequalities in health. Am. J. Hum. Biol. 17:195–206, 2005.   © 2005 Wiley-Liss, Inc.

Populations of African ancestry throughout the Americas have higher mean blood pressures and higher rates of hypertension than do others in the same societies. Moreover, within populations of African ancestry, darker-skinned individuals tend to have higher mean blood pressures than do their lighter-skinned counterparts. These patterns have long been observed in the United States (Adams, 1932; Boyle, 1970; Hajjar and Kotchen, 2003), where hypertension contributes more to diminished life expectancy among African Americans than does any other disease (Wong et al., 2002). More recent work extends these patterns to Latin America (Dressler, 1991; Frisancho et al., 1999; James et al., 1991) and the Caribbean (Cooper et al., 1997; Costas et al., 1981; Halberstein, 1999), yet there remains no consensus as to the causes of excess hypertension in the African Diaspora.

The most basic question concerns the relative importance of genetic and environmental factors. In clinical medicine and epidemiology, a common assumption is that people of African ancestry are genetically predisposed to develop high blood pressure (Cooper and Kaufman, 1998; Pickering, 2001). This assumption is unwarranted. The genetics of hypertension are still poorly understood, and there is little evidence to date for a genetic basis to population-level variation in blood pressure (Cooper and Zhu, 2001; Crews and Williams, 1999; Nesbitt and Victor, 2004). Indeed, hypertension susceptibility alleles are likely distributed throughout humankind and contribute to hypertension risk in interaction with adverse environments (Doris, 2002). Moreover, even if population-level differences were genetically determined, it is

untenable to assume that conventional racial categories like *black* or *white* correspond to genetic variation in blood pressure control (Cooper, 1984; Rosenberg et al., 2002). Such categories do correspond, however, to social processes related to hypertension, including poverty, residential segregation, diet, and exposure to social stressors (Cooper, 2001; Dressler, 1996; Williams and Collins, 2001).

Research on the relationship between dark skin color and high blood pressure in the African Diaspora encapsulates this debate. Previous attempts to explain the relationship as an artifact of known risk factors have met with mixed success. Some studies report that the relationship disappears after controlling for socioeconomic status (SES) (Keil et al., 1977, 1981), while others reveal a persistent association within levels of education, occupation, or income (Gleiberman et al., 1995; Harburg et al., 1978). Accounting for known risk factors like diet, obesity, and physical activity level reduces but does not always eliminate the relationship (Costas et al., 1981; Klag et al., 1991).

Three broad hypotheses have been advanced to explain the residual relationship between skin color and blood pressure. Some researchers propose that dark skin color, as a marker of African admixture, is linked to a genetic predisposition for hypertension (Boyle, 1970; Gleiberman et al., 1999). Others speculate that dark skin color and high blood pressure are linked by an endocrine pathway involved in both melanin production and blood pressure control (Harburg et al., 1978; Mosley et al., 2000). Still others suggest that dark skin color, as a marker of subordinate social status in racially stratified societies, increases exposure to psychosocial stress associated with racism and social inequality (Dressler, 1991; Tyroler and James, 1978).

However, existing research does not provide an adequate means of evaluating these alternatives. Part of the problem is that the genetic, physiologic, and sociocultural hypotheses refer to distinct dimensions of skin color. Both the hypothesis that skin color reflects genetic susceptibility and the hypothesis that skin color and blood pressure are linked physiologically refer to the *phenotype of skin pigmentation*. By contrast, the hypothesis that skin color is linked to increased psychosocial stress refers to the *cultural significance of skin color* as a criterion of social classification. These conceptually distinct variables require distinct measure-

ment operations. Yet all previous studies of the skin color–blood pressure relationship operationalize skin color implicitly in terms of skin pigmentation, as measured by reflectance spectrophotometry (Boyle, 1970; Ernst et al., 1997; Keil et al., 1977, 1981; Klag et al., 1991; Mosley et al., 2000), by observer ratings (Dressler, 1991; Dressler et al., 1999; Gleiberman et al., 1995; Harburg et al., 1973, 1978; Mosley et al., 2000; Sichieri et al., 2001), or by comparison to standardized color chips (Costas et al., 1981).

A related problem is that most previous studies interpret skin color measurements superficially as indicators of genetic admixture or of social stress, without developing specific hypotheses that relate these measures to blood pressure. The assumption that skin color is a valid indicator of genetic differences in blood pressure control is dubious on empirical grounds. Recent studies suggest that skin pigmentation may be informative about continental ancestry (e.g., Halder and Shriver, 2003), but there remains no compelling evidence that continental ancestry, in turn, is informative about alleles related to blood pressure regulation (Daniel and Rotimi, 2003; Nesbitt and Victor, 2004). Indeed, skin pigmentation may be informative about continental ancestry precisely because "pigmentation genes are unlike the bulk of the genetic variation among populations" (Parra et al., 2004). Whereas most genetic markers show relatively small differences between human populations (Rosenberg et al., 2002), skin pigmentation shows significant regional variation in response to the distribution of selective forces, namely, UV radiation. Skin pigmentation thus corresponds poorly to the global apportionment of human genetic variation (Relethford, 2002) and should not be used uncritically as a marker of genetic predisposition to disease (Parra et al., 2004).

The assumption that skin color is a marker of exposure to social stress is empirically sound, given evidence that darker-skinned African Americans report higher levels of perceived discrimination (Klonoff and Landrine, 2000). However, few studies articulate the sociocultural processes that may link specific measures of skin color with physiological responses to stress. Developing more precise hypotheses, derived from theory, would permit more specific tests with a greater likelihood of rejecting a false hypothesis.

This article addresses these issues by operationalizing the distinction between cultural

and biological dimensions of skin color and by developing a more precise hypothesis regarding the sociocultural significance of skin color and its relationship to blood pressure. Based in southeastern Puerto Rico, the study combines ethnographic and survey methods. The ethnographic phase of the project aimed to describe the cultural significance of skin color as a criterion of social classification in Puerto Rico (Gravlee, 2005). The focus of this phase was the cultural domain of *color* (ko-lór, literally "color"). Despite its literal translation, the emic concept of *color* cannot be reduced to skin color. Other physical traits, notably hair texture and facial features, influence the ascription of *color* (Duany, 2002; Gravlee, 2005; Seda Bonilla, 1991), and most ethnographers report that social status markers, including wealth and family background, also influence *color* classification (Godreau, 2000; Torres, 1998). The salience of factors other than skin color means that, for a given level of pigmentation, there is likely to be variation in social classification, making it possible to estimate the association between blood pressure and both the cultural and biological dimensions of skin color.

This paper provides such estimates. In particular, we attempt to isolate the cultural and biological dimensions of skin color by measuring both self-perceived *color* and skin pigmentation, as determined by reflectance spectophotometry. We do not assume that these variables have independent, additive associations with blood pressure. Rather, we suggest that the discrepancy between self-perception and pigmentation, a measure we call *color incongruity*, may be a useful indicator of exposure to social stressors related to blood pressure. That is, those who regard themselves as lighter or darker than expected on the basis of skin pigmentation may experience more frequent frustrating social interactions, as their self-image may not be confirmed by others. Chronic exposure to such frustrating interactions, in turn, may be related to sustained elevated blood pressure.

This expectation follows from previous research on the concept of status inconsistency (Hughes, 1945; Vernon and Buffler, 1988). Status inconsistency theory stems from the observation that individuals may differ on two or more dimensions of social status. For example, a shoe salesman who holds a Ph.D. may be thought to be inconsistent with respect to occupational status and education. It has been hypothesized that such status inconsistencies are stressful, in that they can threaten one's concept of self and lead to uncertain and unsatisfying social interactions (e.g., people buying shoes don't necessarily want to hear about the latest theory in whatever field). Status inconsistency along multiple dimensions has been found to be associated with poorer health status, including psychological stress and higher blood pressure (Dressler, 1988, 1991). Given the salience of skin color as a social status marker in Puerto Rico (Duany, 2002; Gravlee, 2005; Seda Bonilla, 1991), we hypothesize that thinking of oneself and therefore presenting oneself in mundane social interaction as having a *color* relatively lighter than that measured by reflectance spectrophotometry may lead to the kind of unsatisfying social interactions and subsequent elevated blood pressure predicted by general status inconsistency theory.

This hypothesis can also be extended to consider other dimensions of social status. Several studies have shown that the association of skin color and health outcomes can vary by socioeconomic status (Dressler et al., 1999; Kessler and Neighbors, 1986; Klag et al., 1991). Building on this work, we pose the following question: If there is a deleterious effect of being inconsistent with regard to self-perceived color and an objective measure of skin pigmentation, is that effect constant across levels of socioeconomic status? The ethnographic record from Puerto Rico suggests that the effect of color incongruity likely depends on socioeconomic status. Classic and contemporary studies observe that Puerto Rico is stratified by both color and class but that the salience of the former as a basis for discrimination rises along with the latter (Mintz, 1956; Muñoz Vázquez and Alegría Ortega, 1999; Seda Bonilla, 1972; Tumin and Feldman, 1971). Our analysis thus incorporates a test for a statistical interaction between color incongruity and socioeconomic status.

METHODS

Research setting and sampling

The research took place in Guayama, Puerto Rico, a southeastern coastal town of approximately 44,000 people. Guayama was selected primarily because its history and economic development ensured sufficient variation in two key independent variables: skin

color and socioeconomic status. As a center of the Puerto Rican sugar economy, Guayama was central in the importation of African slaves in the early nineteenth century. At the peak of sugar production, slaves accounted for nearly 30% of the local population—as much as anywhere on the island (Scarano, 1984). This concentration of African slaves, together with the history of admixture in the region (Mintz, 1974), entails a broad distribution of skin tones in Guayama. Guayama's recent transition from an agricultural to an industrial economic base also entails an adequate range of socioeconomic variation.

The sample was chosen to maximize contrasts in terms of these key independent variables rather than to estimate population parameters. Following Dressler et al. (1999), we used a variant of cluster sampling that combines probability and nonprobability sampling methods. The method involves identifying clusters of sampling units that span the range of variation on important independent variables and then selecting a probability sample within each cluster. This strategy is appropriate, given the goal of maximizing internal rather than external validity.

Previous ethnography suggested a meaningful clustering based on distinct types of neighborhoods associated with divisions of class and *color* (Gravlee, 2005; Torres, 1995). The first cluster consisted of *caseríos*, or public housing facilities, in Guayama. These marginalized communities tend to have high unemployment rates, but those who are employed typically hold semiskilled or low-status service jobs. In addition, *caseríos* are commonly regarded as places of *negros*, or blacks. The second cluster was a lower-class *barrio* on the edge of town, first settled by freed slaves and their descendants. Community residents are typically employed as secretaries, teacher's assistants, factory workers, or mechanics, for example. Most own their homes, though the quality of housing ranges from small, tin-roof wood or concrete block houses to modern, two-story concrete homes. The third cluster was a middle-class *urbanización*, or planned subdivision, near the center of town. *Urbanizaciones* are generally associated with higher social status and whiteness. Homes in this particular *ubranización* are mostly modest, one-story concrete houses with small, well-groomed yards. Typical residents include teachers, bankers, mid-level managers, or technical workers in area pharmaceutical plants. The final cluster was the only gated *urbanización*

in Guayama. This development, built in the early 1990s over former sugar cane fields, is home to Guayama's new elite. It is especially attractive to physicians and to scientists and engineers from local petroleum and pharmaceutical plants.

A two-stage probability sample was selected within each cluster. For the two *urbanizaciones*, the sampling frame was a set of detailed maps provided by the municipal government. In the *barrio*, we enumerated all households to update a map drawn by community leaders in 1990. For the *caseríos*, an official listing of all housing units in the five public housing facilities formed the sampling frame. Within each cluster, 25 households were selected at random. We visited each household and invited its members to participate. During this initial meeting, we briefly explained the project's aims and the informed consent procedure, as approved by the Institutional Review Board at the University of Florida. One adult between the ages of 25 and 55 was selected at random from each household, for a total sample size of 100. This age range was chosen to ensure the greatest variation in blood pressure. If the sampled household had no eligible members, refused to participate, or could not be reached after three attempts, another household was substituted at random. Response rates ranged from 80.6% to 89.3% across neighborhoods, with an overall rate of 85.5%.

Interview protocol and measurement

All interviews were conducted in participants' homes. The interview schedule was designed to be used with handheld computers and software designed for mobile computer-assisted personal interviewing (MCAPI). The advantages of this technology for data quality are described elsewhere (Gravlee, 2002). Briefly, MCAPI helped reduce errors in data input, eliminated the error-prone step of data entry, facilitated complex branching and skip patterns, permitted randomization of certain questions and response lists, and reduced average interview length and fatigue.

Blood pressure measurements were made with an automatic blood pressure monitor, Omron Model HEM-737AC (Omron Healthcare, Inc., Vernon Hills, IL). Like other oscillometric blood pressure monitors, this device reduces observer error in blood pressure measurement (Pickering, 2003). It has been validated for use in population-based studies

(Anwar et al., 1998) and has been recommended by the European Society of Hypertension (O'Brien et al., 2001). Three blood pressure measurements were taken at standardized intervals in the beginning, middle, and end of the hour-long interview, following the American Heart Association protocol (Perloff et al., 2001). We measured the circumference of the respondent's left arm to ensure that the correct cuff size was used. All analyses were performed separately for systolic and diastolic blood pressure, with the average of three measurements for each outcome taken as the dependent variables.

Skin pigmentation was measured with a handheld narrow-band reflectometer (Derma Spectrometer; Cortex Technology, Hadsund, Denmark) designed and validated for measuring human skin pigments (Shriver and Parra, 2000). The DermaSpectrometer emits light at green (568 nm) and red (655 nm) wavelengths. It separates the reflected light due to melanin from that due to hemoglobin and summarizes this value as the M (melanin) Index. Analyses reported here concern the average M Index from three measurements taken at the upper inner arm, following the method of Shriver and Parra (2000). As a measure of pigmentation due to melanin, the M index estimates the skin color variable implicit in the genetic and physiologic hypotheses for the skin color–blood pressure relationship.

Self-rated *color* was measured with an instrument derived from ethnography. The ethnographic record in Puerto Rico establishes the salience of a light-dark continuum in the local model of *color* classification (Duany, 2002; Gravlee, 2005; Seda Bonilla, 1991). Survey participants were therefore given a laminated card that depicted a nine-point rating scale with the end points of *claro* (light) and *oscuro* (dark). We asked participants to imagine that the scale represented the *color* of people in Puerto Rico, with the lightest on one extreme and the darkest on the other. We then asked participants to place themselves on this scale. The emphasis on self-perception in terms of a locally appropriate cultural model distinguishes this measure from rating scales used in other studies (e.g., Gleiberman et al., 1995; Harburg et al., 1973), which attempt to estimate skin pigmentation by observer rating. The end points of *claro* and *oscuro* also frame the question in familiar terms, while avoiding the strong connotations of terms like *negro*, or black

(Godreau, 2000). Responses were scored from 1 (*claro*) to 9 (*oscuro*).

Standard sociodemographic and psychosocial variables were used to control for competing explanations: sex (0 = female, 1 = male), age (in years), SES, body mass index (BMI, weight (in kg)/height (in m)^2), current antihypertensive medication (0 = no, 1 = yes), perceived stress, and perceived chronic discrimination. The SES score was constructed using loadings on the first principal component of household income (nine categories) and years of education. Perceived stress was measured with the 10-item version of Cohen and colleagues' (1983) Perceived Stress Scale. This scale asks respondents to rate how often they have had certain experiences in the last month (e.g., "you were unable to control the important things in life," "you felt that things were going your way"). Perceived discrimination was measured with Williams and colleagues' (1997) questionnaire. This instrument asks how often respondents are treated unfairly in their everyday life (e.g., "you are treated with less courtesy than other people," "people act as if they're better than you are"). Spanish versions of the latter two instruments were developed in the ethnographic phase of the project.

Statistical analysis

The color incongruity measure was formed by computing *z*-scores for both *color* and pigmentation (to remove scale effects) and taking the difference between them. Positive values indicate darker self-ratings of *color*, relative to skin pigmentation, while negative values indicate lighter self-ratings, relative to pigmentation. This measure poses a modeling problem common to all status inconsistency measures (Whitt, 1983). Briefly, because color incongruity is a perfect linear function of *color* and pigmentation, the model would not identify the effect of incongruity correctly if the original skin color measures were entered as controls. To solve this problem, we adopted Hope's (1975) diamond model, which uses the sum of pigmentation and self-rated *color* ("color sum") to control for the simple main effects of the skin color variables.

Multiple regression and diagnostics were performed in the R statistical computing environment (http://www.r-project.org/). Age, sex, BMI, and current antihypertensive medication were forced into separate models for systolic and diastolic blood pressure.

Both models included main effects and cross-product terms to test for interactions between SES and both the color sum and color incongruity scores, as described above. Perceived stress and perceived chronic discrimination were allowed to enter on a stepwise basis. Predictors were mean-centered to reduce multicollinearity and to facilitate interpretation of the interaction terms (Cohen et al., 2003).

RESULTS

Table 1 gives descriptive statistics for the total sample and separately for the four sampling clusters. Consistent differences across clusters in socioeconomic status, pigmentation, and *color* suggest that the sampling strategy successfully captured variation on these key independent variables. However, simple random sampling within each cluster resulted in an overrepresentation of women, due to the

uneven sex distribution in the public housing facilities (*caseríos*).

Table 2 shows bivariate correlations for systolic and diastolic blood pressure, control variables, skin pigmentation (M Index), and self-rated *color*. There is no evidence that skin pigmentation is associated with either systolic or diastolic blood pressure, but there is borderline evidence of a bivariate association between higher systolic blood pressure and darker self-rated *color*. This relationship does not hold for diastolic blood pressure. Table 2 also indicates that there is a moderately strong association between skin pigmentation and self-ratings of *color*. However, the magnitude of this association ($r = 0.62$) is not so great that self-rated *color* and skin reflectance could be regarded as equivalent measures.

Table 3 reports multiple regression analyses for systolic and diastolic blood pressure. Because centered predictors are used, the intercepts represent arterial blood pressure at the sample centroid. Perceived discrimination

TABLE 1. *Means ($\pm$SD) or percentages for major variables, for total sample (N = 100) and by sampling cluster (n = 25)[a]*

	Total sample	Caseríos	Barrio	Open urbanización	Gated urbanización
Systolic blood pressure	125.4 (17.4)	124.4 (17.9)	126.5 (20.4)	129.7 (18.2)	121.0 (11.7)
Diastolic blood pressure	80.1 (10.6)	80.6 (9.1)	79.0 (11.3)	83.2 (11.9)	77.6 (9.5)
Age	39.2 (8.0)	38.2 (8.2)	38.7 (10.0)	39.9 (8.0)	40.1 (5.3)
Sex (% female)*	62.0	84.0	56.0	56.0	52.0
Body mass index	28.6 (6.1)	27.4 (6.3)	27.4 (6.5)	29.6 (5.6)	29.9 (5.8)
Education (years)***	14.1 (3.6)	10.9 (2.8)	12.4 (3.4)	15.7 (1.5)	17.5 (1.9)
Household income (imputed)***	37,995 (35,536)	6,120 (1,666)	19,200 (19,421)	35,160 (16,117)	91,500 (12,353)
Antihypertensive medication (%)	10.0	8.0	4.0	8.0	20.0
M index***	38.2 (6.7)	40.7 (6.1)	41.8 (7.0)	35.9 (6.4)	34.6 (4.5)
Self-rated *color***	4.5 (1.9)	5.0 (2.0)	5.0 (2.1)	4.1 (1.8)	3.7 (1.5)

[a]Tests of significance by ANOVA for continuous variables and by chi-square for categorical variables *$P < 0.10$; **$P < 0.05$; ***$P < 0.001$.

TABLE 2. *Correlation matrix of systolic and diastolic blood pressure, skin color variables, and major controls*

Variables[a]	1	2	3	4	5	6	7	8
1. SBP	—							
2. DBP	0.78***	—						
3. Age	0.46***	0.37***	—					
4. Sex	0.20**	0.04	−0.07	—				
5. BMI	0.05	0.11	−0.04	0.14	—			
6. SES	−0.09	−0.13	0.10	0.24**	0.19*	—		
7. BP medicine	0.30**	0.25**	0.19*	0.08	0.09	0.18*	—	
8. M Index	−0.04	−0.07	−0.02	−0.04	−0.16	−0.41***	−0.15	—
9. Self-rated *color*	0.17*	0.00	0.10	0.00	−0.13	−0.30***	−0.04	0.62***

[a]Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; SES, socioeconomic status; BP medicine, currently taking antihypertensive medication.
*$P < 0.10$, **$P < 0.05$, **$P < 0.001$.

TABLE 3. Regression of systolic and diastolic blood pressure on color incongruity and covariates; mean-centered predictors (N = 100)

	Systolic blood pressure[a]			Diastolic blood pressure[b]		
	B	SE	P	B	SE	P
Constant	122.60	2.02	0.000	79.52	1.38	0.000
Age	0.86	0.18	0.000	0.48	0.13	0.000
Sex	7.56	3.03	0.015	1.83	2.08	0.382
BMI	0.13	0.23	0.583	0.22	0.16	0.183
Antihypertensive	10.61	4.85	0.031	6.70	3.33	0.047
SES	−3.69	1.64	0.027	−3.01	1.13	0.009
Color sum	−0.02	0.85	0.979	−0.71	0.58	0.224
Color incongruity	0.89	1.91	0.644	−0.33	1.31	0.801
SES * color sum	0.77	0.90	0.395	0.87	0.62	0.159
SES * color incongruity	−5.53	2.08	0.009	−1.65	1.43	0.250

[a]Adjusted R^2: 0.377.
[b]Adjusted R^2: 0.206.

and perceived stress did not enter either model. Overall, the predictors explain approximately 38% of variation in systolic blood pressure (SBP) and 21% of variation in diastolic blood pressure (DBP). As expected, there is evidence that the association between color incongruity and SBP varies with levels of SES. The negative coefficient for the interaction term ($b = -5.53, P = 0.009$) indicates that, as SES increases, the slope of SBP on color incongruity decreases.

Figure 1 illustrates the interaction between color incongruity and SES for SBP. The effect is plotted across the mean $\pm$ 1 SD of color incongruity. Continuous covariates are held constant at their sample means, and categori-
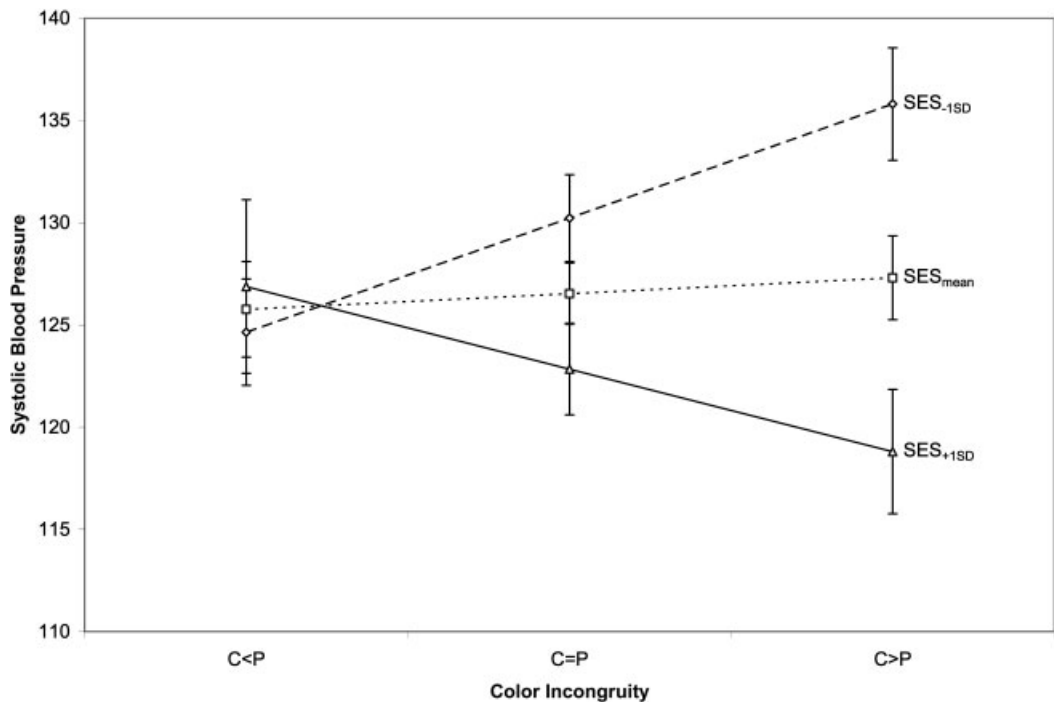

Fig. 1.   Adjusted systolic blood pressure by color incongruity and socioeconomic status (SES).

cal predictors are set to their proportional distributions (Fox, 2003). The plot shows that the directional effect of color incongruity differs at high and low levels of SES. For low-SES respondents, darker self-ratings of *color* relative to skin pigmentation (color incongruity > 0) are associated with higher mean SBP. For high-SES respondents, however, darker self-ratings of *color* relative to pigmentation are associated with lower mean SBP. Consequently, differences in SBP across SES are greatest when respondents rate their color as dark, relative to skin pigmentation. Where self-rated color is relatively light in comparison to skin reflectance, mean SBP is statistically indistinguishable across levels of SES.

Table 3 provides no evidence of a similar interaction effect for DBP ($P = 0.25$). However, fitting the model to a reduced sample, excluding one highly influential case (Cook's $D = 0.26$), suggests that the interaction between color incongruity and SES may also be associated with DBP ($b = -2.58, P = 0.06$). The influential respondent scores low on SES and is an outlier on both DBP and color incongruity. His average DBP is approximately 3SD above the mean, and although he is relatively dark-skinned, he rates his *color* at the extreme light end of the scale ("1"). The effect is to offset the interaction by flattening the slope of DBP on color incongruity among low-SES respondents. It is also noteworthy that this respondent's BMI is 1 SD below the mean and that he reports the highest level of perceived discrimination by a wide margin. Case diagnostics suggest that he is also influential in the model for SBP, but excluding him from that analysis does not alter the substantive results.

DISCUSSION

This paper is a preliminary attempt to isolate the cultural and biological dimensions of skin color in association with arterial blood pressure. Drawing on the general theory of status inconsistency, we hypothesized that an incongruity between self-perceived *color* and skin pigmentation as measured by reflectance spectrophotometry would be associated with elevated blood pressure in Puerto Rico. We further suggested that this association may depend on socioeconomic status. Our results point to a more complex interaction than anticipated. The directional association between color incongruity and SBP varies with SES, so that darker self-rated *color*, rela-

tive to pigmentation, is associated with higher SBP in low-SES contexts but with lower SBP in high-SES contexts. A similar trend may be at work for DBP, but the evidence for this effect is less robust.

These findings cast doubt on previous suggestions that skin color reflects genetic susceptibility to high blood pressure (Boyle, 1970; Gleiberman et al., 1999) or that skin color and blood pressure are linked physiologically (Harburg et al., 1978; Mosley et al., 2000). Both the genetic and the physiologic hypotheses predict a positive association between skin pigmentation and blood pressure. We observed no association between pigmentation and blood pressure. Instead, the interaction between color incongruity and SES in association with blood pressure supports the hypothesis that skin color is a marker of sociocultural processes related to sustained high blood pressure.

Our data cannot identify the precise sociocultural processes responsible for these relationships, but status inconsistency theory and previous empirical research suggest several possible mechanisms. Status inconsistency theory draws attention to the potentially stressful nature of mundane social interaction when one holds contradictory ranks on multiple dimensions of social status. Problematic social interactions may result from a combination of factors, including individuals' uncertainty about their own behavior or others' conflicting expectations based on an implicit evaluation of social status. In such situations, one's self-image may be threatened if one is not treated as expected (e.g., not having an opinion seriously entertained, making an unrequited smile or gesture). Chronic exposure to such frustrating encounters may result in repeated sympathetic arousal and sustained elevated blood pressure.

Empirical studies have confirmed the predictions of general status inconsistency in diverse cultural contexts (Chin-Hong and McGarvey, 1996; Dressler, 1990; Janes, 1990; McGarvey and Schendel, 1986). A particularly relevant example is Dressler's (1991) study of skin color and blood pressure in Brazil and the United States. Unlike other studies of this problem, Dressler operationalizes skin color as a component of social status by analyzing its relationship to blood pressure with a status incongruity model. In both societies, Dressler observes that dark skin color is associated with blood pressure only in combination with a high-status lifestyle.

He interprets this pattern as a status incongruity effect, arguing that claims to high status through lifestyle are likely to be rejected in everyday social interaction, because dark skin color is a marker of subordinate social status in Brazil and the United States.

Our study in Puerto Rico extends this interpretation by recognizing the potential discrepancy between how individuals perceive their own *color* and the basis on which others perceive them. Ethnographers in Puerto Rico have long noted that the ascription of *color* is responsive to differences in other markers of social status. The interaction between class and color is especially salient in this regard. Mintz (1956), for example, remarks that "an individual's 'color' may 'vary' in accord with changes in his socioeconomic status," and Godreau (2000) argues that Puerto Ricans manipulate identities of *color* to meet different ends, including to avoid being identified as victims of racism or to build social distance and intimacy in everyday social interaction. However, little research addresses whether the dynamic experience of *color* in everyday life involves stressful interactions with adverse consequences for health.

Our results suggest that this question deserves closer scrutiny. Among high-SES respondents, we observed the highest average blood pressures among those who perceive their *color* as relatively light, as compared to their skin reflectance. This self-perception may be problematic in high-SES contexts, where (a) the salience of skin color as a criterion of social status is greatest and (b) dark-skinned people are most likely to encounter racial discrimination (Godreau, 2000; Mintz, 1956; Muñoz Vázquez and Alegría Ortega, 1999). Thus, high-SES respondents who think of their *color* as lighter than we would expect on the basis of skin pigmentation may face chronic exposure to stressful social interactions, as they are not treated in accord with their own self-image. The resulting state of uncertainty and hypervigilance may lead to increased sympathetic nervous system activity and chronic high blood pressure.

Among low-SES respondents, a different process seems to be at work. Low-SES respondents who perceive their *color* as dark, relative to skin pigmentation, have the highest mean blood pressures in our sample. It is unlikely that this pattern reflects increased exposure to frustrating social interactions in low-SES contexts, where (a) dark skin color is the norm and (b) ethnographers suggest that

skin color differences are relatively insignificant (Godreau, 2000; Mintz, 1956; Muñoz Vázquez and Alegría Ortega, 1999). However, most respondents' spheres of social interaction extend beyond low-SES contexts. Many hold semiskilled or low-status service jobs in white-collar settings, and others are likely to be reminded of their subordinate social status in other everyday encounters. Under these circumstances, one plausible interpretation is that darker self-perceptions of *color* are an effect rather than a cause of frustrating social interactions. In some cases, adopting a low-status *color* identity may be an internalized expression of marginal social status and the experience of class-based social exclusion. To test this possibility, future studies would benefit from assessing longitudinal relationships among patterns of social interaction, self- and observer-ascription of *color*, and physiological markers of stress.

We find no evidence that the link between color incongruity and blood pressure is mediated by conventional measures of *perceived* stress or discrimination. This finding is consistent with previous research. Experimental studies show that the cardiovascular system is sensitive both to status differences in social interaction (Lynch, 1985) and to racist stimuli in laboratory settings (Armstead et al., 1989; Clark, 2000). Yet observational studies provide no evidence of a straightforward association between perceived stress or discrimination and blood pressure (Brondolo et al., 2003). This pattern reflects the fact that people may report different levels of stress or discrimination in response to the same exposure, and that the subjective appraisal of whether events are stressful may itself be an active coping response with unknown physiological consequences (Brown, 1974; Williams and Neighbors, 2001). The lack of an association between blood pressure and either perceived stress or perceived discrimination in our sample thus reflects the limitations of such measures as predictors of physiological outcomes.

This study is the first to operationalize the distinction between two dimensions of skin color: the phenotype of skin pigmentation and the cultural significance of skin color as a criterion of social status. Once we recognize that distinction, however, previous studies of the skin color-blood pressure relationship provide additional support for the stress hypothesis as the most plausible alternative. Of the 13 previous studies of this relationship,

only six measured skin pigmentation with reflectance spectrophotometry (Boyle, 1970; Ernst et al., 1997; Keil et al., 1977, 1981; Klag et al., 1991; Mosley et al., 2000). None of these studies reported an association between pigmentation and blood pressure across the entire sample, after controlling for age, sex, and socioeconomic status. Klag et al. (1991) found an association only in the lowest socioeconomic group, while Mosley et al. (2000) reported an association only in Egyptian women. By contrast, the only studies that observed a consistent association between skin color and blood pressure across the sample measured skin color with some form of observer rating (Costas et al., 1981; Gleiberman et al., 1995; Harburg et al., 1973, 1978; Sichieri et al., 2001). Thus, the studies that measure skin pigmentation precisely using reflectance spectrophotometry provide the weakest evidence of an association between skin color and blood pressure. Those that approximate social classification with observer ratings provide the strongest evidence of such an association.

This set of findings illustrates the general need to specify testable hypotheses and appropriate measurement operations in research on health inequalities among racially defined groups (Kaufman and Cooper, 1995). This study is a preliminary step in that direction, though the strength of our findings is tempered by methodological limitations. First, by comparison to other studies of the skin color–blood pressure relationship, our sample is small. One consequence may be unstable parameter estimates, as illustrated by the impact of one influential respondent on the analysis for DBP. Second, we did not collect data on dietary intake or energy expenditure. Previous studies suggest that skin color and social stress are associated with blood pressure independent of such measures (Costas et al., 1981; Dressler et al., 1999), but greater attention to nutritional variables would enhance future research. Third, the biological significance of skin pigmentation may differ in Puerto Rico and in the United States, given different historical processes of admixture in the two settings. It is important to determine whether the patterns observed in Puerto Rico could be observed in the United States or elsewhere in the Americas.

Despite these limitations, this study is significant for operationalizing the distinction between cultural and biological dimensions of skin color and for introducing a specific hypothesis for the relationship between arterial blood pressure and skin color as a criterion of social status. The evidence that blood pressure is associated with color incongruity, but not with skin pigmentation as measured by reflectance spectrophotometry, should stimulate further research to identify both the sociocultural processes and the biological pathways that contribute to excess hypertension in the African Diaspora.

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