Supporting Information

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SI Materials and Methods

In addition to the three traits reported in the main text, experimenters assessed attributions of prosociality, health, and fertility. "Niceness" was included primarily as a validity check on judgments of "nastiness," and, reassuringly, these two variables were well-correlated at both the group and individual levels (group: $r = -0.92$, individual: $r = -0.43$, both $P < 0.0001$), and the effects of ecological variables [e.g., Human Development Index (HDI), urbanization] on personality judgments were qualitatively identical when using nastiness judgments, niceness judgments, or a combination of the two. With regard to judgments of health and fertility, there was similar evidence of redundancy; in addition, we had some concerns regarding the cross-cultural validity of the questions. Feedback from the interviewing stage indicated that "health" and "fertility" were, perhaps unsurprisingly, interpreted quite differently in different populations.

The following definitions were given in our instructions to interviewers:

i) (*a*) Which is the nicest person (agreeable, friendly, easy to live with)?

Nice implies someone who is kind, warm, considerate and pleasant.

i) (*b*) Which is the nastiest person (aggressive, difficult, unpleasant to live with)?

Nasty implies someone who is cruel or unkind, or who competes with and tries to dominate others.

ii) Which is the most healthy person (free from disease, strong)?

This concept also implies that the individual is unlikely to get a disease or is able to survive a disease.

iii) Which is the most fecund/fertile person (likely to have children, or father them)?

This concept can be clarified further: For female faces, who will become pregnant quickly and produce many healthy children? For male faces, who is likely to make a woman pregnant?

iv) Which face is most attractive in a long-term context (for marrying)?

Long-term implies someone you might want to spend time with both within and outside of a sexual context (i.e., someone you might consider marrying or living with).

v) Which face is most attractive in a short term context (not for marrying)?

Short-term means attractive for things like dating or a sexual relationship but without prospects for the long term. We realize this concept may be tricky to translate.

SI Results

Below are descriptions of additional analyses that were permitted by the data collected but are only briefly mentioned in the main text. These descriptions include analyses of cyclical fertility effects, male perceptions of female personality, and tests controlling for nonindependence of groups due to cultural proximity.

Cyclical Fertility Effects on Women's Preferences for Masculinity. Data on menstrual cycle day were available for 495 of the participants, and probability of conception by day of cycle (range: 0–9%) was calculated using data on North American women (1). Although absolute levels of fertility are likely to be population-specific, cyclical variation in fertility is assumed to occur cross-culturally. Women who reported hormonal contraceptive use or long cycle lengths [there are no probability of conception estimates provided for cycle lengths longer than 40 d (1)] were excluded from analyses, leaving probability estimates for 312 women.

To test for cyclical fertility effects on preferences, Kendall rank correlations were conducted for each group (where $n > 5$) between general preferences for masculinity (short-term and long-term preferences averaged together) and day-specific probability of conception. Where sample size permitted ($n > 25$; United Kingdom, Shanghai, and Hangzhou), ordinal generalized linear mixed models (GLMMs) were also fitted, using both day-specific probability of conception and mating context as predictors of preferences for masculinity and testing for an interaction between these predictors. Tests revealed no significant effects of day-specific pregnancy risk on preferences (Fig. S2 and Table S3), and no significant interactions were found between day-specific pregnancy risk and mating context. Spearman's rank correlations produced the same conclusions.

Personality Perceptions for Female Faces. Men's perceptions regarding women's facial morphology and aggressiveness are shown in Fig. S3. All groups except one chose masculine female faces as "least prosocial/most aggressive"; Tchimba participants chose randomly (randomization tests: Tchimba, $P = 0.3$; all others, $P < 0.007$).

Ordinal GLMMs showed that the strength of this trait attribution was marginally associated with the HDI (slope = 2.16, $z = 1.945$, $P = 0.052$). However, ordinal GLMMs fitting homicide rate, disease burden, gross domestic product, and urbanization as potential independent variables demonstrated that urbanization was the best predictor of the strength of the relationship between masculinity and the perceptions of aggressiveness (slope = 0.035, $z = 4.429$, $P < 0.00001$; Fig. S4).

Potential Nonindependence of Groups Due to Cultural Proximity. An issue for cross-cultural comparative research is the possibility of nonindependence of groups (2). This nonindependence can occur when populations share "packages" of traits due to common (cultural) ancestry (vertical transmission) or to copying and borrowing from each other (horizontal transmission). Processes such as this one can lead to an increase in type 1 errors when testing for associations between two traits at the country level and to an overestimation of the size of the effect of one variable upon another (2, 3). Thus, for example, one country might develop technologies that lead to an increase in environmental development and at the same time, by chance, hold certain stereotypes about facial appearance. During cultural contact with other groups, both the technology and the stereotypes could be transmitted as a package. This bundled transmission could lead to a global association between environmental development (HDI) and particular stereotypes, even though the stereotypes are not causally or functionally related to development.

One way of addressing this issue, as detailed by Eff (3), is to create spatially "lagged" control variables that reflect the average status of proximate groups. The term "proximate" can mean geographic proximity, but cultural/linguistic similarity and other measures of proximity are also possible (3). To factor out the effects of nonindependence due to proximity, the predicted values of the

dependent variable are multiplied by a weighting matrix to produce a lagged variable that reflects the predicted values of the dependent variable in proximate groups. This derived variable is then entered as an independent variable in the regression, along with any other potential explanatory variables. If an explanatory variable remains a significant predictor of the dependent variable when the lagged variable is also included in the model, this result indicates that the relationship between the explanatory variable and the dependent variable is not merely a result of nonindependence due to proximity.

For reasons outlined elsewhere (4), predicted rather than actual values of the dependent variable are used to construct the lagged variable. Predicted values are derived from parameter estimates calculated by performing a regression with preferences/perceptions as dependent variables and explanatory variables, such as the HDI, as independent variables.

To address the issue of nonindependence in our sample, we introduced a control for linguistic similarity that we used as a proxy for cultural proximity, following the method used by Mace et al. (2) (Fig. S5). Research suggests that cultural behaviors are more likely to be clustered by language and/or ecology than by geographical proximity (5, 6). We used a measure of linguistic proximity among contemporary world nations, as detailed and made freely available elsewhere (3). This measure possesses the advantage that it incorporates both the phylogenetic distances between languages and the existence of multiple languages in single countries, and it is likely to reflect both vertical and horizontal cultural contact.

Linguistic proximity values were used to construct a 12×12 weighting matrix. Populations in our sample were assigned to the contemporary countries shown in Table S2, with the exception of the Tuvan population, which, for linguistic reasons, was classified as being from Mongolia rather than Russia. The Canadian student and Cree Canadian groups were treated as two samples from the same country, as were the Shanghai and Hangzhou populations. Following Eff (3) and Tolnay et al. (4), the culturally lagged variable was then calculated in two stages. First, the predicted value of (male) preferences was calculated for each country using parameters derived from a linear regression, weighted by sample size, with actual values of preferences as a dependent variable and the HDI as an independent variable. Second, the weighting matrix was multiplied by a 12×1 matrix of these predicted (male) facial preferences in each country to create a 12×1 matrix representing the culturally lagged variable for (male) preferences in each country. For each population, the value of this lagged variable reflects the (predicted) preferences of men from linguistically similar groups. The process was repeated to create lagged variables for female preferences and for personality perceptions. These lagged variables were then entered as independent variables into further regressions, along with the HDI, to test whether the HDI would survive as a significant explanatory variable after controlling for cultural nonindependence.

Tests for cultural proximity effects: Male preferences for femininity. To test whether preferences were significantly structured by cultural-linguistic proximity, a weighted (weighted least squares, by male sample size) linear regression was performed with male preferences for femininity as a dependent variable and culturally lagged preferences for femininity as an independent variable. This analysis revealed a marginally significant positive relationship ($R^2_{adj} = 0.18$, $F_{1,10} = 3.40$, $P = 0.095$, $\beta = 0.50$), indicating a potential effect of cultural similarity on preferences. To determine whether the HDI was still a significant predictor of preferences after taking account of cultural similarity, a stepwise regression was performed with male preferences for femininity as a dependent variable and both the HDI and culturally lagged preferences for femininity as independent variables. The model retained the HDI, as previously ($R^2_{adj} = 0.40$, $F_{1,10} = 8.21$, $P = 0.017$, $\beta = 0.67$), but not culturally lagged preferences ($\beta = -0.025$, $t = 0.068$, $P = 0.948$). There was no evidence of an issue with collinearity between the HDI and culturally lagged preferences [tolerance = 0.46, variance inflation factor (VIF) = 2.16]. These results indicate that femininity preferences are organized according to environmental factors rather than cultural-linguistic proximity.

Tests for cultural proximity effects: Female preferences for masculinity. To test for an organizing effect of cultural-linguistic proximity on female preferences, a further linear regression (weighted by female sample size) was performed, with preferences for masculinity as a dependent variable and culturally lagged preferences as an independent variable. The model was nonsignificant ($R^2_{adj} = 0.08$, $F_{1,10} = 2.00$, $P = 0.187$, $\beta = 0.41$). A stepwise regression with both the HDI and culturally lagged preferences as independent variables again retained only the HDI ($R^2_{adj} = 0.27$, $F_{1,10} = 5.15$, $P = 0.047$, $\beta = 0.58$; culturally lagged preferences: $\beta = 0.06$, $t = 0.18$, $P = 0.865$). There was no evidence of an issue with collinearity between the HDI and culturally lagged preferences (tolerance = 0.59, VIF = 1.69). These results indicate that, as with men's preferences, women's preferences for dimorphism are organized according to environmental factors rather than cultural-linguistic similarity.

Tests for cultural proximity effects: Personality perceptions for male faces. To test for an organizing effect of cultural-linguistic proximity on personality perception, a regression was conducted with personality attribution (i.e., mean masculinity of the face chosen as most aggressive) as the dependent variable and culturally lagged personality attribution as an independent variable. This analysis revealed a marginally significant positive relationship ($R^2_{adj} = 0.21$, $F_{1,10} = 3.94$, $P = 0.075$, $\beta = 0.532$). As previously, a stepwise regression was conducted with both the HDI and culturally lagged personality attributions as independent variables. As with preferences, the model retained the HDI ($R^2_{adj} = 0.596$, $F_{1,10} = 17.22$, $P = 0.002$, $\beta = 0.795$), but not culturally lagged preferences ($\beta = -0.03$, $t = -0.11$, $P = 0.914$), as a predictor. There was no evidence of an issue with collinearity between the HDI and culturally lagged attributions (tolerance = 0.53, VIF = 1.90). These results indicate that, as with preferences, personality perceptions are predicted by environmental factors rather than cultural-linguistic similarity.

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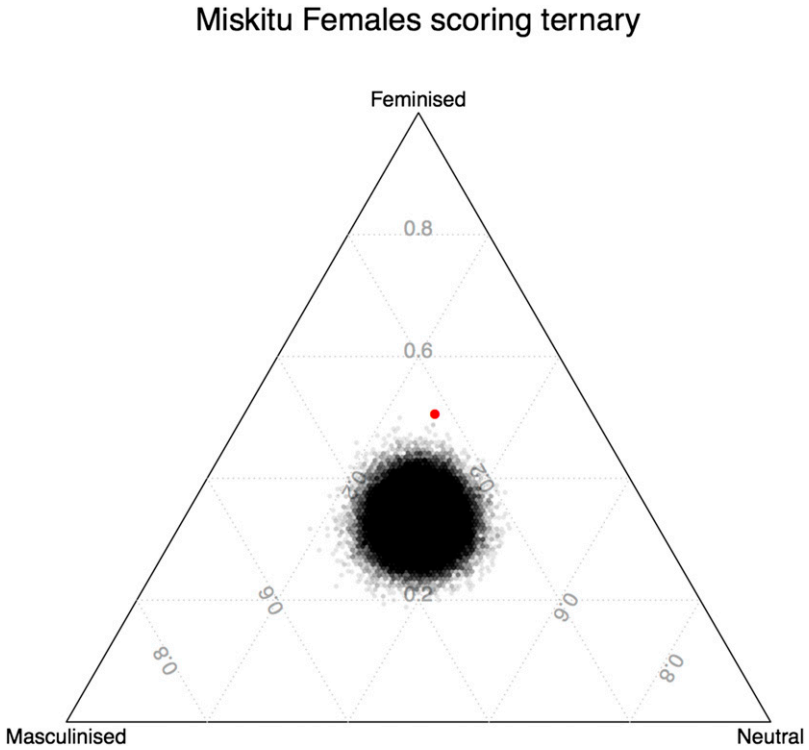

Fig. S1. Male faces preferred by Miskitu females, collapsed across mating context. This figure gives a graphical demonstration of how randomization tests were organized. The red locus indicates the mean proportion of observed choices by Miskitu females for masculinized, neutral, and feminized male faces. The distribution of dark loci represents the mean proportion of "choices" for 100,000 simulated samples (of equal size to the Miskitu sample). Simulated participants were "choosing" at random. The proportion of the simulated loci equal to or greater in distance from the center than the distance of the observed locus from the center is the *P* value (the probability of a result at least as extreme as observed, given random choice). Miskitu females showed a significant preference for feminized faces.

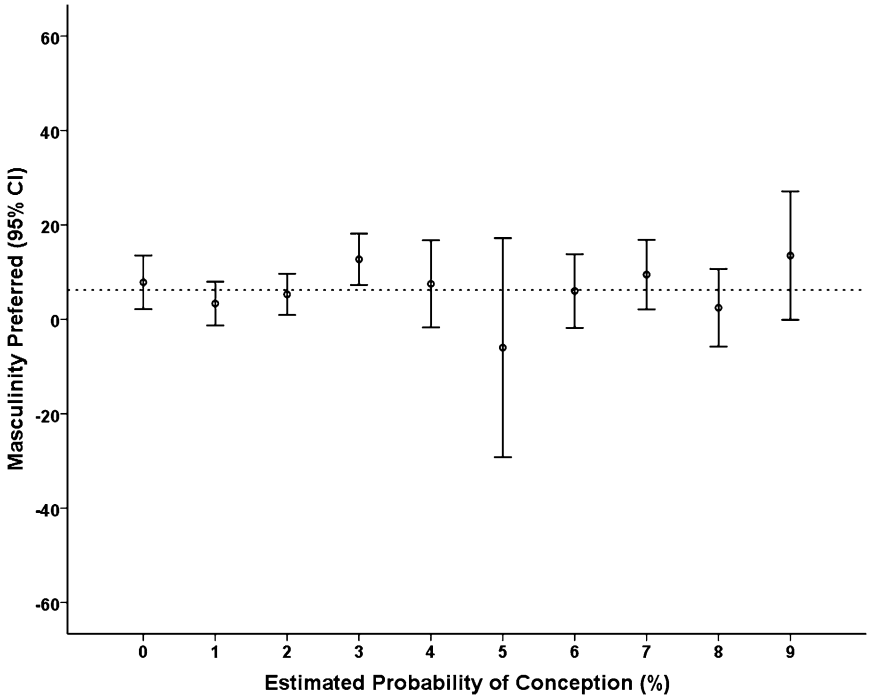

Fig. S2. Female preferences for masculinity in male faces, by pregnancy risk rounded to nearest integer. Pregnancy risk is defined as probability of conception, based on the day of the menstrual cycle. Preferences are averaged across long-term and short-term contexts. Data from all groups are displayed together, with dotted line representing average preference across all participants.

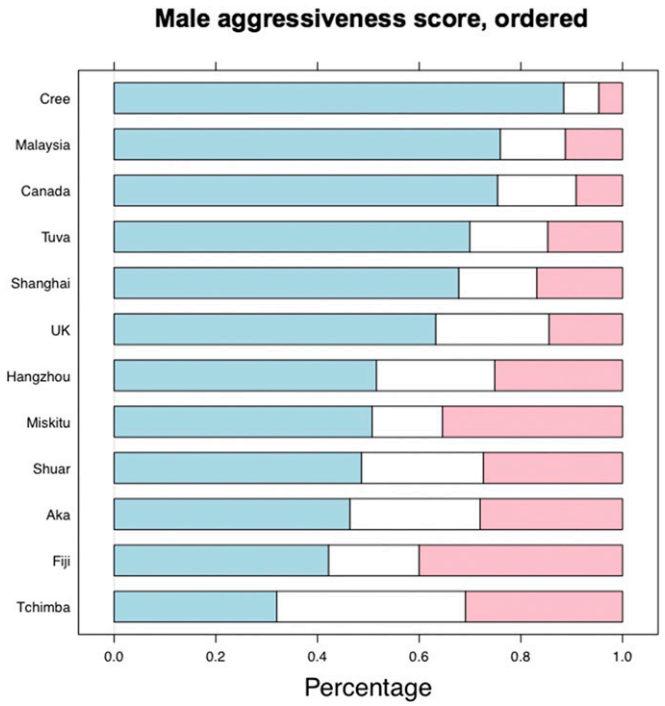

Fig. S3. Female faces perceived as most aggressive-looking, by group. Blue sections indicate the proportion of the group that chose masculinized faces as most aggressive, white sections indicate the proportion that chose neutral faces, and pink sections indicate the proportion that chose feminized faces.

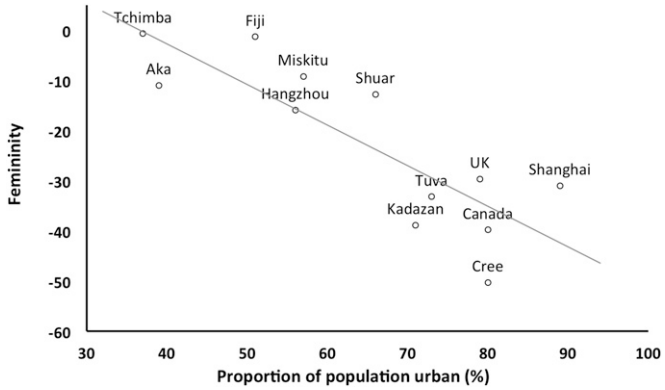

Fig. S4. Female faces perceived as most aggressive-looking, by level of urbanization. Average levels of femininity in the faces chosen as most aggressive-looking, against level of urbanization. Participants in urban environments were more likely to choose masculine faces when asked to choose the most aggressive-looking face.

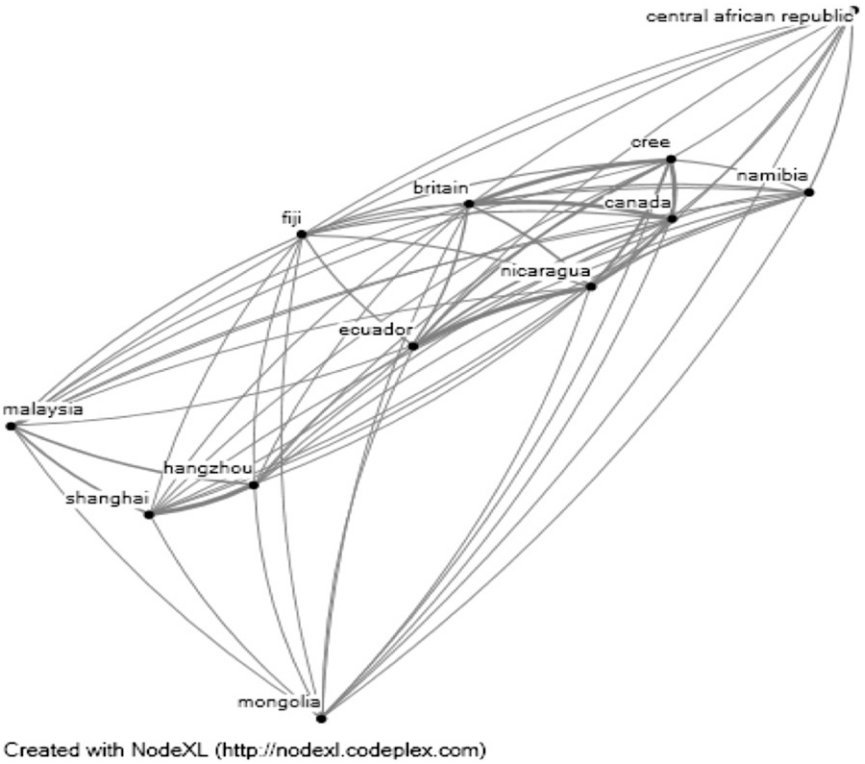

Fig. S5. Visualization of the linguistic proximity of the groups in our sample. Proximity measures are taken from a weighting matrix provided by Eff (3), and are indicated on the graph both by line thickness and by the physical proximity of vertices (as determined by the Fruchterman–Reingold algorithm).

Table S1. Composition of groups and methods of presentation

Group	Age of sample, y		Sample university students, %	Method of presentation
	Median	SD		
Canadian students	22.0	7.3	100	Online
UK students	20.0	6.0	100	Online
Shanghai students	22.0	4.0	100	Cards
Hangzhou citizens	23.0	3.6	75	Online
Cree Canadians	22.5	5.6	13	Cards
Tuvans	25.0	12.4	0	Cards
Kadazan-Dusun and Bajau	27.0	12.1	0	Cards
Fiji	29.0	16.9	0	Cards
Shuar	30.0	13.7	0	Cards
Miskitu	25.0	12.7	0	Cards
Tchimba	28.0	15.5	0	Cards
Aka	37.5	7.0	0	Cards

Table S2. Social, demographic, and economic indicators for wider population

Group	Country	Fertility rate*	Years lost to disease,† %	Historical disease prevalence‡	Homicide rate§	Proportion of population urban¶	GDP‖	HDI**
Canadian students	Canada	1.6	6	−1.31	1.8	80	39,078	0.97
UK students	United Kingdom	1.9	8	−1.01	1.2	79	35,468	0.95
Shanghai students	China	1.8	15	1.03	1.1	89	5,971	0.91
Hangzhou citizens	China	1.8	15	1.03	1.1	56	5,971	0.84
Cree Canadians	Canada	1.6	6	−1.31	1.8	80	39,078	0.82
Tuvans	Russia	1.4	11	−0.39	11.2	73	15,923	0.67
Kadazan-Dusun and Bajau	Malaysia	2.5	26	0.5	2.3	71	14,215	0.73
Fijian villagers	Fiji	2.7	23	−0.07	2.8	51	4,358	0.74
Shuar	Ecuador	2.5	30	0.34	18.2	66	8,014	0.81
Miskitu	Nicaragua	2.7	33	0.16	13.2	57	2,689	0.70
Tchimba	Namibia	3.3	63	−0.09	17.2	37	6,398	0.59
Aka	Central African Republic	4.7	78	1.16	29.3	39	741	0.32

*Average births per woman; data from the World Health Organization (1).
†Life years lost to communicable disease, as a proportion of total years lost to all causes; data from the World Health Organization (1).
‡Data from Murray and Schaller (2).
§Homicides per year per 100,000 people; data from the United Nations Office on Drugs and Crime (3).
¶Proportion of population living in an urban environment; 2008 data from World Bank (4); data on Shanghai and Hangzhou from Government of China statistics (5).
‖Gross domestic product per capita; 2008 data from World Bank (4).
**The human development index is a composite measure of overall development that combines indicators of life expectancy, educational attainment, and income. A high score indicates a high level of development. Local/regional data used for Shanghai (6), Hangzhou (6), Cree Canadian (7), Tuvan (8), Kadazan (9) and Tchimba (10) populations. National data used in all other cases (11). Wherever possible, data year chosen to closely match period of data collection (2008–2009).

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Table S3. Predictions of general female preferences for masculinity in male faces using day-specific conception risk, by group

Group	*n*	Kendall's Tau-b	*P*	CLMM coefficient	*z*	*P*
Canadian students	20	−0.029	0.89	—	—	—
UK students	131	−0.023	0.73	−0.113	−0.049	0.96
Shanghai students	37	0.075	0.56	4.235	1.023	0.31
Hangzhou citizens	47	0.063	0.59	1.306	0.38	0.70
Cree Canadians	13	−0.247	0.29	—	—	—
Tuvans	22	−0.217	0.21	—	—	—
Kadazan-Dusun and Bajau	5	—	—	—	—	—
Fiji	4	—	—	—	—	—
Shuar	19	−0.081	0.69	—	—	—
Miskitu	1	—	—	—	—	—
Tchimba	0	—	—	—	—	—
Aka	13	−0.405	0.10	—	—	—

CLMM, cumulative link mixed model.