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The global ecology of differentiation between us and them

Evert Van de Vliert

Humans distinguish between we-groups and they-groups, such as relatives versus strangers and higher-ups versus lower-downs, thereby creating crucial preconditions for favouring their own groups while discriminating against others. Reported here is the finding that the extent of differentiation between us and them varies along latitude rather than longitude. In geographically isolated preindustrial societies, intergroup differentiation already peaked at the equator and tapered off towards the poles, while being negligibly related to longitude (observation study 1). Contemporary societies have evolved even stronger latitudinal gradients of intergroup differentiation (survey study 2 around 1970) and discrimination (mixed-method study 3 around 2010). The geography of contemporary differentiation and discrimination can be partially predicted by tropical climate stress (warm winters, hot summers and irregular rainfall), largely mediated by the interplay of pathogen stress and agricultural subsistence (explanatory study 4). The findings accumulate into an index of intergroup discrimination by inhabitants of 222 countries (integrative study 5).

To survive and thrive, all humans construe and construct ingroups (us) and outgroups (them)[1–4]. The nearer ingroups are unprecedented tools for controlling own security, belongingness, identity and social coordination against potentially dangerous and disturbing outgroups. Nevertheless, inhabitants of distinct world regions differ considerably in intergroup differentiation—defined here as judging and treating people as members of either ingroups or outgroups rather than individuals. Increases in intergroup differentiation come with sharper us/them boundaries, larger psychosocial distances and greater behavioural differences between familiars and strangers (collectivism), as well as higher-ups and lower-downs (hierarchism)[2,3,5–8]. The geographic diversity of these cultural mindsets and practices raises the question of whether the strength of the habit of intergroup differentiation is related to the inhabitants' habitat. A tentative answer to this intriguing question is derived here from two habitat hypotheses—the pathogen stress hypothesis[9,10] and the rice–wheat hypothesis[11,12].

The pathogen stress hypothesis[9,10] predicts that human-to-human transmitted diseases promote xenophobia, ethnocentrism and other forms of ingroup–outgroup differentiation. This is because in warmer regions with higher levels of pathogen prevalence, stronger ingroup assortative sociality helps people avoid infection through fewer contacts and interactions with outsiders and strangers. The rice–wheat hypothesis[11,12] argues that rice villages had more intense and more reciprocal labour exchanges than wheat areas. To manage irrigation networks, inhabitants of rice villages had to coordinate water use and shared infrastructure—often between families and at the village level. This created a culture with tight, interdependent ties in relatively small networks. Thus, the distinction between tight, near ties and loose, distant ties became stronger in rice regions than in wheat regions.

Despite their many differences, the two hypotheses share the idea that stronger differentiation and discrimination between us and them evolved from higher tropical climate stress at lower latitudes. On closer scrutiny, the two hypotheses have a common denominator (latitude) with an implicit side (geography) and an explicit side (ecology). Implicit latitudinal gradients in humans have an inherent relationship with explicit latitudinal gradients in animals (including microorganisms and parasites) and in plants (including rice and wheat). It is easy to underestimate the relevance of this conceptual entwinement given that the south–north axis of the Earth represents a bipolar field of stressful environmental impacts on livability and life, whereas the west–east axis does not. Specifically, unlike different longitudes at the same latitude, different latitudes at the same longitude confront humans with vastly different seasonal cycles of cold, heat, drought, deluge, pathogen prevalence and crop growth[13].

Indeed, the common latitudinality of the pathogen stress and rice–wheat hypotheses opens up integrative theory linking geographic locations with ecological explanations of intergroup differentiation manifested in ingroup–outgroup boundaries, distances and differences. Geographically and ecologically, the two hypotheses predict south–north distributions of collectivism and hierarchism. For example, both hypotheses can correctly predict that the Chinese are more collectivist in hierarchical ways and less individualist in egalitarian ways than Europeans[2,3], because life-threatening pathogens and socially interdependent rice cultivation both decrease from the south (China) to the north (Europe) rather than from the east (China) to the west (Europe). Both hypotheses also predict opposite south–north gradients in identification with ingroups and discrimination of outgroups below and above the equator because pathogen stress and rice cultivation both decrease from the equator towards the mutually opposite north and south poles.

The latitudinal gradient of intergroup differentiation would be supported if collectivism and hierarchism were to increase towards the equator in both hemispheres (convergent validity) but were to be unrelated to longitude west and east of the Greenwich meridian (discriminant validity). In statistical terms, I expected intergroup differentiation to have a bell-shaped distribution around the equator but not around the Greenwich meridian. This geographic side of the proposed latitudinal theory of intergroup differentiation was tested in preindustrial societies (study 1), and in contemporary societies around 1970 (study 2) and around 2010 (study 3), with care taken to include the intertwined archetypal components of collectivism and hierarchism. Although the three studies tested a

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Table 1 | Geography of intergroup differentiation in 90 preindustrial societies

Coordinates	Preindustrial differentiation				Contemporary differentiation and discrimination			
	Collectivism		Hierarchism		Differentiation 1970		Discrimination 2010	
	B	*P*	*B*	*P*	*B*	*P*	*B*	*P*
Linear latitude	−0.06 (−0.27 to 0.14)	0.53	−0.02 (−0.22 to 0.18)	0.84	−0.54 (−0.73 to −0.36)	<0.001	−0.44 (−0.55 to −0.34)	<0.001
Squared latitude	−0.16 (−0.32 to 0)	0.05	−0.25 (−0.41 to −0.09)	0.002	−0.51 (−0.64 to −0.38)	<0.001	−0.41 (−0.50 to −0.32)	<0.001
Linear longitude	0.18 (−0.02 to 0.38)	0.08	0.18 (−0.02 to 0.38)	0.08	−0.06 (−0.24 to 0.12)	0.48	0.03 (−0.10 to 0.16)	0.62
Squared longitude	−0.16 (−0.39 to 0.07)	0.17	−0.08 (−0.30 to 0.15)	0.49	−0.07 (−0.27 to 0.12)	0.46	−0.19[a] (−0.31 to −0.06)	0.005[a]
R^2	0.15	<0.001	0.19	<0.001	0.63	<0.001	0.57	<0.001

Shown are unstandardized regression coefficients, with 95% CIs within brackets (two-tailed tests). There is no multicollinearity (variance inflation factors < 1.43), and there are no outliers (Cook's distances < 0.22). [a]This is a confounded effect: in and of themselves, linear longitude ($B_{(101)} = -0.03$; $P = 0.75$; CI = −0.23 to 0.17) and squared longitude ($B_{(101)} = 0.03$; $P = 0.71$; CI = −0.15 to 0.21) did not reach significance ($R^2 = 0$; $P = 0.90$).

purely descriptive theory of biogeographic links between latitude, longitude and differentiation (studies 1 and 2) including discrimination (study 3), study 1 also strengthens basic ecological explanations for the following reasons.

Perhaps most notably, preindustrial societies (for example, Aweikoma, Aztec, Cayapa, Copper Eskimo, Fon and Timbira) had not been influenced by global economic, educational and medical developments, so intergroup differentiation cannot have been the result of modernization[14,15]. Likewise, biogeographic links across preindustrial societies cannot have been affected by relatively recent patterns of migration and colonization, world wars, or intensifying international exchange (for example, tourism, trade and internet). Studying preindustrial societies also overcomes the research problem that the rapidly increasing interdependence of contemporary societies produces violations of the statistical assumption of independent units of observation. In short, compared with studies 2 and 3, study 1 draws less distracting attention to recent developments and hints more convincingly at ecological explanations of the latitudinal gradient of intergroup differentiation.

Such ecological explanations derive ultimately from tropical climate stress but more proximately from biological understandings of latitudinal gradients in animals and plants[16,17]. One understanding is that animals and plants often modify each other's impact on the latitudinality of livability and life. This raises the possibility that pathogen stress and agricultural subsistence shape intergroup differentiation in conjunction rather than in parallel. Warmer latitudes have both greater infection prevalence and greater group density[17], with the probable consequence that tropical inhabitants tend to be more wary of disease-carrying outsiders and strangers (that is, they tend to value ingroups over outgroups, irrespective of their own subsistence style). At colder latitudes, where infectious diseases are less common and where group density is lower[17], the mode of subsistence may have more leeway to impact on intergroup differentiation. The mechanism nowadays may be that contacts and interactions with outgroup members are minimal in the agrarian sector, moderate in the industrial sector and maximal in the service sector. A more agrarian lifestyle towards the poles might thus increase the otherwise relatively low local levels of differentiating and discriminating between insiders and outsiders.

The relevance of this speculative interplay of pathogen stress and agricultural subsistence for explaining the latitudinal gradient of intergroup differentiation was tested on contemporary societies in study 4. The point of departure was that higher ecological stress is empirically linked to more intergroup differentiation and discrimination[7–12]. Importantly, however, this general starting point was amended with the note that higher cold stress is a special case as it comes with less pathogen stress, heat stress and stressful irregular rainfall. Tropical climate stress was also more proximately represented by pathogen prevalence and the problems for agricultural subsistence caused by the accumulation of warm winters, hot summers and irregular rainfall. Poverty stress was modelled to control for the confounding fact that the tropics are lagging behind the rest of the world on modernization—economically, educationally and medically.

Results

Study 1. Study 1 looked at the geography of intergroup differentiation in the preindustrial past. The standard cross-cultural sample[18–21] of preindustrial societies allows historical tests of the hypothesis that intergroup differentiation has a bell-shaped distribution around the equator rather than the Greenwich meridian. An advantage of using this representative dataset is that it reduces phylogenetic and spatial autocorrelation because only one society was selected from each cluster of societies inhabiting a particular world area.

Ross[20] coded ethnographic reports on 90 randomly chosen societies and then factor analysed the coded variables. Collectivism consisted of seven ordinal codes regarding ingroup control over members (for example, "The community makes collective decisions, formally or informally, which impinge on many aspects of people's lives"), ingroup loyalty and promoting own ingroup interests in other groups (Cronbach's $\alpha = 0.80$). Hierarchism was based on 12 ordinal codes regarding leadership centrality and authority, power distance, autocratic management (for example, "Leaders make most decisions and involvement of the average person is highly limited or absent") and use of enforcement mechanisms (for example, "There is great sanctioning power available to enforce decisions") (Cronbach's $\alpha = 0.92$). All coded components and coding scales are listed and discussed in the Supplementary Methods for study 1.

Societal locations were estimated as midrange degrees of latitude (negative below the equator and positive above it) and longitude (negative west of the Greenwich meridian and positive east of it). Linear latitude and linear longitude were also squared to test for the presence of bell-shaped curves (societal scores for location, differentiation and their inter-relations are detailed in the Supplementary Data for study 1 and Supplementary Table 1, respectively). Squared latitude was associated with collectivism ($B_{(85)} = -0.16$; $P = 0.05$; $R^2 = 0.15$; confidence interval (CI) = −0.32 to 0) and hierarchism ($B_{(85)} = -0.25$; $P = 0.002$; $R^2 = 0.19$; CI = −0.41 to −0.09), whereas the effects of linear latitude, linear longitude and squared longitude

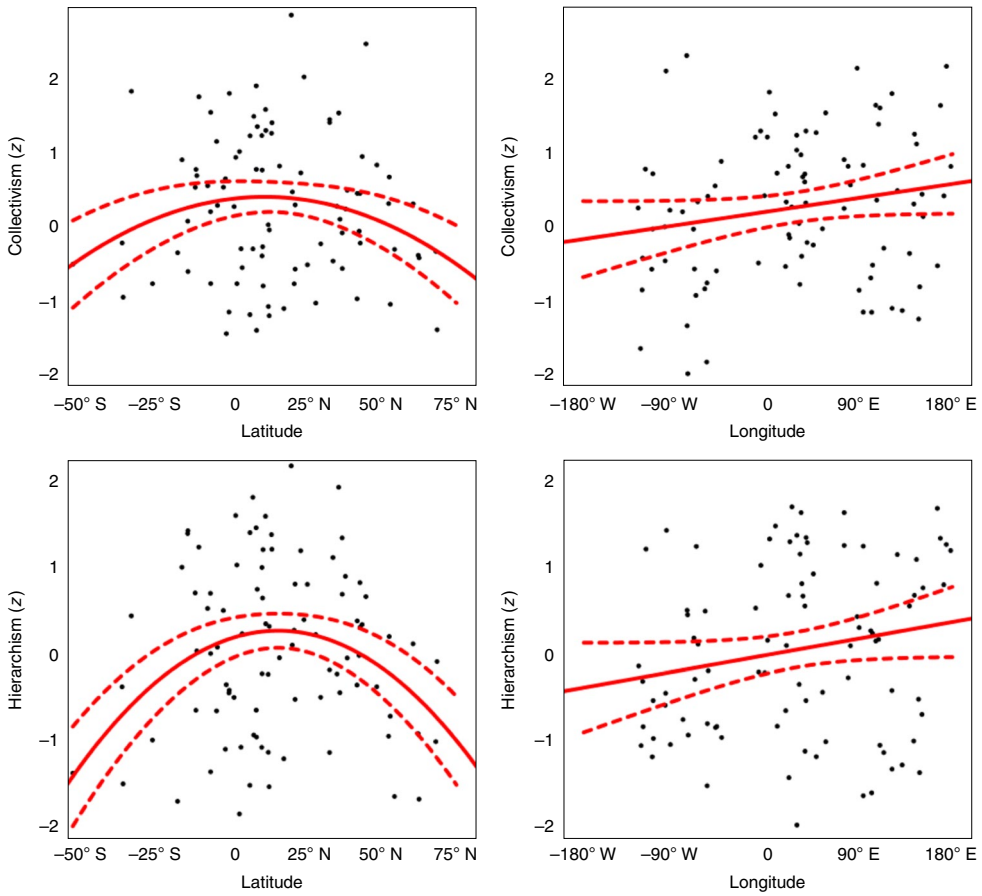

Fig. 1 | Scatter plots and regression fit lines for the geography of intergroup differentiation in 90 preindustrial societies. Left: significant curvilinear distributions of collectivism (top) and hierarchism (bottom) along latitude while controlling for linear latitude, linear longitude and squared longitude (for collectivism: $B_{(85)} = -0.16$; $P = 0.05$; $R^2 = 0.15$; ΔR^2 squared latitude = 0.12; CI = −0.32 to 0; for hierarchism: $B_{(85)} = -0.25$; $P = 0.002$; $R^2 = 0.19$; ΔR^2 squared latitude = 0.16; CI = −0.41 to −0.09). Right: insignificant linear distributions of collectivism (top) and hierarchism (bottom) along longitude after controlling for linear latitude, linear latitude and squared longitude (for both collectivism and hierarchism: $B_{(85)} = 0.18$; $P = 0.08$; ΔR^2 linear longitude = 0.03; CI = −0.02 to 0.38). The broken lines represent 95% CI limits.

did not reach significance (Table 1). As predicted, differentiation between us and them peaks at the equator and tapers off towards the poles. Figure 1 visualizes the distribution of collectivism and hierarchism along both latitude and longitude. That intergroup differentiation increased towards the equator in geographically isolated preindustrial societies strengthens the idea, tested in study 4, that latitude-related ecological conditions predict intergroup differentiation and discrimination[7–12,22].

Study 2. Study 2 was an investigation of the geography of intergroup differentiation around 1970. Back in the 1970s, the Dutch social psychologist and former IBM engineer Geert Hofstede[3,23] made a mysterious discovery that could, in hindsight, be interpreted as a coincidental measurement of boundaries, distances and differences between groups, be they familiars versus strangers (collectivism) or higher-ups versus lower-downs (hierarchism). When Hofstede analysed cross-national data from survey responses to 32 value questions, he found a cryptic bipolar factor that strongly covaried with absolute latitude (see Supplementary Methods for study 2 for details). One pole reflected independence from the social context consisting of groups and leaders, while the opposite pole reflected dependence on the social context consisting of groups and leaders. Confronted with this ambiguous result, Hofstede decided to treat the same value dimension as though it represents two different dimensions—a bipolar dimension ranging from individualism to collectivism, and a unipolar dimension ranging from small to large power distances.

As argued in the Supplementary Methods for study 2, the seemingly cryptic common denominator of collectivism and power distance, as described by Hofstede[3,23], can be interpreted as the extent to which people are viewed as members of ingroups or outgroups rather than individuals. This latent dimension ranges from little social cognitive differentiation (low collectivism and low hierarchism) to much social cognitive differentiation (high collectivism and high hierarchism). The original dimension was reconstructed by reintegrating individualism/collectivism and power distance (Eigenvalue $\lambda = 1.68$; $R^2 = 0.84$), and was then used to test whether intergroup differentiation around 1970 peaked at the equator and tapered off towards the poles, while being unrelated to longitude (country scores are reported in the Supplementary Data for study 2). Dwarfing west–east differences, linear latitude ($B_{(48)} = -0.54$; $P < 0.001$; CI = −0.73 to −0.36) and squared latitude ($B_{(48)} = -0.51$; $P < 0.001$; CI = −0.64 to −0.38) accounted for 63% of the variation in intergroup differentiation (Table 1 and top row of Fig. 2).

Study 3. Study 3 was an investigation of the geography of intergroup discrimination around 2010. A mixed-method investigation of discrimination in 104 countries tested the solidity of the findings. Ethnic, sexual and religious minority groups received special attention with a view to societal and ethical relevance.

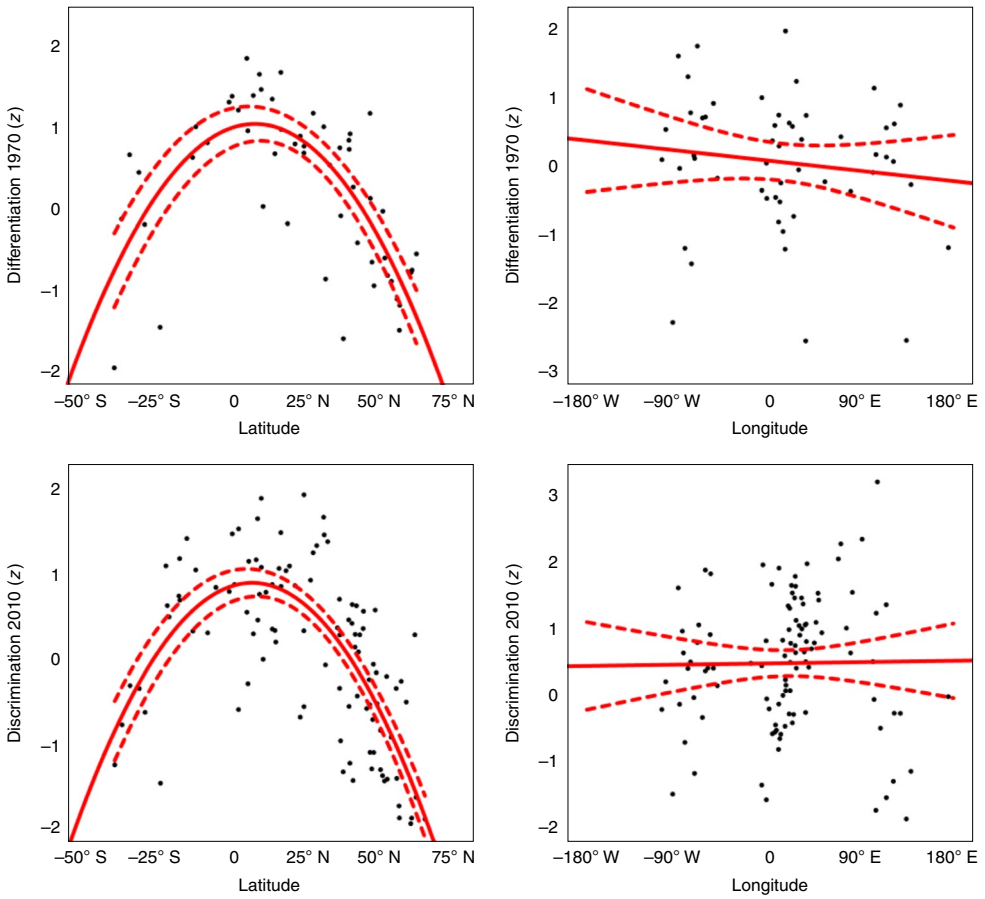

Fig. 2 | Scatter plots and regression fit lines for the contemporary geography of intergroup differentiation and intergroup discrimination. Left: significant curvilinear distributions of differentiation (top) and discrimination (bottom) along latitude while controlling for linear latitude, linear longitude and squared longitude (for 53 societies around 1970: $B_{(48)} = -0.51$; $P < 0.001$; $R^2 = 0.63$; ΔR^2 squared latitude = 0.48; CI = −0.64 to −0.38; for 104 societies around 2010: $B_{(99)} = -0.41$; $P < 0.001$; $R^2 = 0.57$; ΔR^2 squared latitude = 0.37; CI = −0.50 to −0.32). Right: insignificant linear distributions of differentiation (top) and discrimination (bottom) along longitude after controlling for linear latitude, squared latitude and squared longitude (for 53 societies around 1970: $B_{(48)} = -0.06$; $P = 0.48$; ΔR^2 linear longitude = 0; CI = −0.24 to 0.12; for 104 societies around 2010: $B_{(99)} = 0.03$; $P = 0.62$; ΔR^2 linear longitude = 0; CI = −0.10 to 0.16). The broken lines represent 95% CI limits.

In each society, the discriminatory boundaries, distances and differences were represented by: (1) participative observations of nepotism in work organizations[5] (that is, favouritism shown to relatives by appointing them to senior management positions); (2) a compilation of publicly available indicators of social exclusion of vulnerable groups in society[24,25]; and (3) unobtrusive ratings of legal discrimination taking place by imposing restrictions of freedom on a minority of inhabitants[22] (for details, see Supplementary Data and Supplementary Information for study 3). To reduce the effects of measurement error, nepotism, social exclusion and legal discrimination were standardized and then averaged into a reliable composite score of current discrimination (Eigenvalue $\lambda = 2.00$; $R^2 = 0.67$; Cronbach's $\alpha = 0.75$).

As hypothesized, compared with longitude, latitude had a more pronounced association with differentiating discrimination. Indeed, linear longitude ($B_{(101)} = -0.03$; $P = 0.75$; CI = −0.23 to 0.17) and squared longitude ($B_{(101)} = 0.03$; $P = 0.71$; CI = −0.15 to 0.21) had negligible links ($R^2 = 0$; $P = 0.90$), whereas linear latitude ($B_{(101)} = -0.39$; $P < 0.001$; CI = −0.49 to −0.29) and squared latitude ($B_{(101)} = -0.40$; $P < 0.001$; CI = −0.49 to −0.31) accounted for 54% of the variation in discrimination. The results of the combined equation in Table 1 ($R^2 = 0.57$) are insensitive to removing the ten northernmost countries (controlling for sampling bias) or the ten largest countries (controlling for measurement inaccuracy) (Supplementary Results for study 3). The lower part of Fig. 2 provides a visual summary of the inference that current discriminatory practices have a bell-shaped distribution around the equator rather than the Greenwich meridian.

Taken together, studies 1–3 support the robustness of the geography of intergroup differentiation across time periods, convenience samples and research methods. These results are waiting to be replicated across regions within Brazil—the only large country straddling the equator. The United States does have a south–north cline of differentiation and discrimination between us and them. For the 48 states between Mexico and Canada, my data repository at https://hdl.handle.net/10411/YXI7WH reports midrange latitude, midrange longitude, collectivist family ties[9] and the Conway et al.[22] measure of legal discrimination introduced above. Collectivism decreases northward towards the Canadian border ($B_{(45)} = -0.84$; $P < 0.001$; CI = −1.15 to −0.54 for latitude) but does not seem to systematically vary from the west coast to the east coast ($B_{(45)} = 0.01$; $P = 0.93$; CI = −0.29 to 0.31 for longitude) ($R^2 = 0.41$). Legal discrimination likewise decreases northward ($B_{(45)} = -0.62$; $P < 0.001$; CI = −0.96 to −0.28) rather than westward or eastward ($B_{(45)} = -0.29$; $P = 0.09$; CI = −0.62 to 0.05) ($R^2 = 0.26$).

Study 4. The reported south–north gradients of distinguishing between we-groups and they-groups are difficult to understand

without taking account of south–north gradients in explanatory factors that also reverse their direction at the equator. The Supplementary Results for study 4 therefore provide preliminary tests of the equatorial reversal of 17 ecological and historical conditions that are potentially relevant for explaining the geography of intergroup differentiation and discrimination. The 11 factors that passed this latitudinal validity test were used as predictors.

In preindustrial societies, agricultural subsistence and community size stand out as potential precursors to collectivism and hierarchism. The greater biodiversity in plants and animals at lower latitudes[16,17] provides a plausible reason why structurally complex and intertwined processes of domestication, fixed settlement and population growth would have flourished in the tropics. It may well explain why agricultural subsistence and community size—just like intergroup differentiation—peaked at the equator and tapered off towards the poles. To explore this puzzle further, agricultural subsistence and community size in the preindustrial era are discussed at length in the Supplementary Methods for study 4, and their societal scores are listed in the Supplementary Data for study 1. As hypothesized, increases in collectivism and hierarchism towards the equator can be convincingly predicted by increases in agricultural subsistence and community size towards warmer latitudes. More refined sequential process analyses revealed that the observed latitudinal gradients of collectivism and hierarchism were due to effects of agricultural subsistence mediated by community size rather than effects of community size mediated by agricultural subsistence (Supplementary Results for study 4).

In contemporary societies, climate stress, pathogen stress and subsistence style were measured as: (1) the mean downward deviation from 22 °C (cold stress) and the mean upward deviation from 22 °C (heat stress)[8,26]; (2) the extent to which there is periodically too little then too much precipitation (rainfall stress)[27]; (3) the prevalence of human-to-human transmitted diseases (for example, measles, cholera, leishmaniasis and leprosy) (pathogen stress)[9]; and (4) the percentage of employment in the agrarian sector rather than the industrial or service sectors (agricultural subsistence)[28,29] (data for 107 societies are available in the Supplementary Data for study 4). Wealth in the form of income per head[29–31] was controlled for (reversed to represent poverty stress).

The Supplementary Results for study 4 show that pathogen stress and agricultural subsistence modify each other's positive impact on intergroup differentiation around 1970 ($B_{(48)}=-0.50$; $P=0.004$; $R^2=0.64$; CI = −0.83 to −0.17; Fig. 3) and intergroup discrimination around 2010 ($B_{(100)}=-0.21$; $P<0.001$; $R^2=0.56$; CI = −0.32 to −0.10; Fig. 4) in a similar manner. Agricultural subsistence increases intergroup differentiation and discrimination where pathogen stress is low (at higher latitudes with lower group density), but not (or less so) where pathogen stress is high (at lower latitudes with greater group density). Further modelling finds that the pathogen–subsistence interactions largely mediate tropical effects of warm winters and irregular rainfall on intergroup differentiation and integration, and demonstrates that poverty stress can only to an unconvincing extent account for the interaction effect of pathogen stress and agricultural subsistence (Supplementary Results for study 4). Removing the ten northernmost countries or the ten largest countries has a negligible effect, a straightforward group-density explanation[17,32,33] receives little support and there is no evidence of reverse causality (see Supplementary Results for study 4).

A final analysis explored whether the explanatory power of the latitudinal theory of intergroup differentiation generalizes from groups in general to men and women in particular. Using the 157-nation Gender Inequality Index of the United Nations[34] as a proxy for gender discrimination indeed replicated the patterns of results. Specifically, pathogen stress ($B_{(149)}=0.24$; $P<0.001$; CI = 0.13 to 0.34), agricultural subsistence ($B_{(149)}=0.09$; $P=0.23$; CI = −0.05 to 0.23), their interaction ($B_{(149)}=-0.11$; $P=0.009$; CI = −0.19 to −0.03),

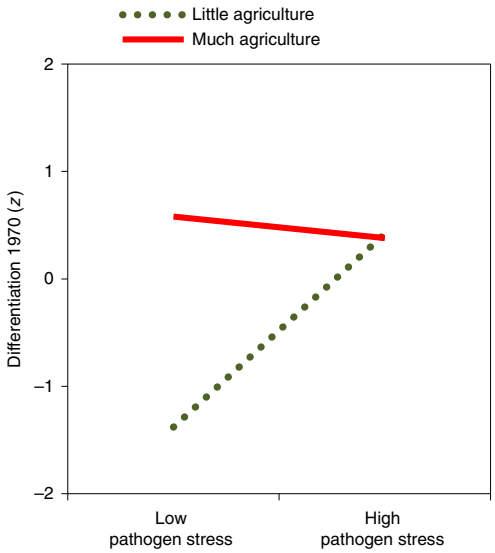

Fig. 3 | Joint effects of pathogen stress and agricultural subsistence on intergroup differentiation in 52 societies around 1970 ($R^2=0.64$). Horizontally viewed, the upper slope indicates that, irrespective of pathogen stress ($B_{(48)}=-0.09$; $P=0.72$; CI = −0.63 to 0.43), much agriculture is associated with high differentiation, whereas the lower slope indicates that higher pathogen stress ($B_{(48)}=0.90$; $P<0.001$; CI = 0.61 to 1.18) increases differentiation if there is little agriculture. Vertically viewed, the left gap between slopes indicates that more agriculture ($B_{(48)}=0.98$; $P<0.001$; CI = 0.40 to 1.55) increases differentiation if pathogen stress is low, whereas the negligible right gap between slopes indicates that, irrespective of agriculture ($B_{(48)}=-0.02$; $P=0.92$; CI = −0.35 to 0.32), high pathogen stress is associated with high differentiation.

cold stress ($B_{(149)}=-0.18$; $P<0.001$; CI = −0.28 to −0.09), heat stress ($B_{(149)}=0.07$; $P=0.09$; CI = −0.01 to 0.15), rainfall stress ($B_{(149)}=0.21$; $P=0.37$; CI = −0.25 to 0.68) and poverty stress ($B_{(149)}=0.52$; $P<0.001$; CI = 0.38 to 0.66) accounted for 83% of the cross-national variation in gender discrimination (Extended Data Fig. 1).

Study 5. To integrate and extend the above pieces of knowledge, six of the generated regression equations were used to estimate typical levels of intergroup discrimination by inhabitants of 222 countries. The estimates were based on the two geographical equations for preindustrial differentiation, the two geographical equations for contemporary differentiation and discrimination, and the two ecological equations for contemporary differentiation and discrimination (for details, see Supplementary Data and Supplementary Results for study 5). Next, the overlapping estimates allowed the computation of a single index for estimated intergroup discrimination (Eigenvalue $\lambda=4.53$; $R^2=0.75$; Cronbach's $\alpha=0.91$). Finally, that index was validated against the above-discussed measure of gender discrimination[34] ($B_{(155)}=0.38$; $P<0.001$; $R^2=0.56$; CI = 0.33 to 0.43) and against neuroticism[35] ($B_{(98)}=0.15$; $P<0.001$; CI = 0.08 to 0.22) closed-mindedness[36] ($B_{(98)}=0.09$; $P=0.014$; CI = 0.02 to 0.16) and self-esteem[37–39] ($B_{(98)}=0.31$; $P<0.001$; CI = 0.24 to 0.38) as known positive covariates of discrimination ($R^2=0.48$; Supplementary Results for study 5).

Discussion

Freedom from discrimination—by race, ethnicity, gender, sexual orientation, religion or nationality—is a universal human right and a central goal of human development[8]. This principle adds considerable value to the current discovery that differentiation between us and them varies along latitude. The finding that freedom from

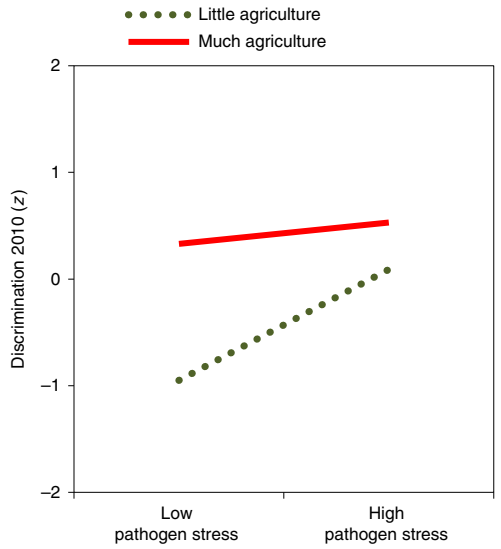

Fig. 4 | Joint effects of pathogen stress and agricultural subsistence on intergroup discrimination in 104 societies around 2010 ($R^2 = 0.56$). Horizontally viewed, the upper slope indicates that, irrespective of pathogen stress ($B_{(100)} = 0.12$; $P = 0.28$; CI = −0.10 to 0.34), much agriculture is associated with high discrimination, whereas the lower slope indicates that higher pathogen stress ($B_{(100)} = 0.64$; $P < 0.001$; CI = 0.42 to 0.86) increases discrimination if there is little agriculture. Vertically viewed, the left gap between slopes indicates that more agriculture ($B_{(100)} = 0.79$; $P < 0.001$; CI = 0.52 to 1.05) increases discrimination if pathogen stress is low, whereas the right gap between slopes indicates that more agriculture ($B_{(100)} = 0.27$; $P = 0.006$; CI = 0.08 to 0.46) also increases discrimination if pathogen stress is high.

differentiation and discrimination is higher at higher latitudes has been supported time and again—crossing time periods (preindustrial, around 1970 and around 2010) with hemispheric location (north and south). The observed latitudinality of differentiation and discrimination seems to fit in with a general tendency of south–north variation in culture[40,41]. Indeed, earlier work may be interpreted as suggesting that linguistic diversity[32] and aggression[13,42] increase towards the equator; conversely, creativity and happiness appear to increase towards the north and south poles[13].

The inferential conclusion that preindustrial northerners and southerners in a given latitudinal hemisphere already differed in habitual mindsets and practices of intergroup differentiation has both strong and weak sides. It is a strength that the results of study 1 rest on geographically representative sampling schemes aiming to produce mutually independent societal datasets[18–21]. A weakness, however, is that the preindustrial world was described by different ethnographic authorities, and that their descriptions were then interpreted by different coders for collectivism and hierarchism. To reduce this weakness, the geographical validity of the south–north distribution of intergroup differentiation was established through the significance of mirrored south–north gradients in the opposite latitudinal hemispheres (convergent validity) and the non-significance of west–east gradients in the western and eastern hemispheres (discriminant validity).

As another strength, the observed latitudinality of collectivism and hierarchism in preindustrial societies cannot have been influenced by industrialization, urbanization and modernization, nor by recent patterns of migration, tourism, trade and communication. However, this explanatory strength comes with the weakness that the precise climatic and pathogenic stresses in the past are unknown so that their impacts on discriminatory mindsets and practices remain unstudied. To reduce this weakness, latitude-related ecological conditions—cold stress, heat stress, rainfall stress, pathogen stress and agricultural subsistence—were used as unobtrusive predictors of latitudinal gradients of present-day differentiation and discrimination. Alternative ecological predictors are not readily conceivable. It is easier to imagine how the stronger transitions from agrarian lifestyles to service lifestyles at higher latitudes clarify why contemporary societies have more pronounced latitudinal clines of us versus them (Fig. 2) than preindustrial societies once had (Fig. 1).

Throughout centuries, archetypal forms of differentiation between ingroups and outgroups increased from the north pole towards the equator and decreased from the equator towards the south pole. Hinting at scientific meaning and knowledge is the observable fact that, just like the dependent variables (habits of intergroup differentiation and discrimination), the predictors (habitats with warm winters, hot summers, irregular rainfall and agricultural subsistence) also peak at the equator and taper off towards the poles. Indeed, explanatory value is suggested by south–north rather than west–east distributions of cold stress, heat stress and rainfall stress[27], with pathogen stress and agricultural subsistence in their wake[9–12]. In multiple regards, south–north rather than west–east distributions of demands and burdens shape the survival and flourishing of all living species, especially humans, who are dependent on animals and plants.

Importantly, the explanatory study 4 indicates that one of the ecological stressors—cold winters—has a negative instead of positive relationship with the latitudinal gradients of contemporary differentiation and discrimination. This result reflects the complication that current levels of cold stress seem to reduce intergroup differentiation indirectly, through the reduction of heat stress ($r_{(105)} = -0.60$; $P < 0.001$), rainfall stress ($r_{(105)} = -0.58$; $P < 0.001$) and pathogen stress ($r_{(105)} = -0.65$; $P < 0.001$). Therefore, the negative impact of cold winters may in fact have to be primarily interpreted in terms of the absence of tropical climate stress. Figures 3 and 4 further clarify that even this is an incomplete story. Cold climates also reduce the feasibility of agriculture ($r_{(105)} = -0.42$; $P < 0.001$), and thus the differentiation-enhancing effect of agriculture in cold-weather areas with low pathogen stress.

The results of the five studies go beyond support for the pathogen stress[9,10] and rice–wheat[11,12] hypotheses by synthesizing both hypotheses into a latitudinal theory of intergroup differentiation. This synthesis exposes cross-fertilizing relations between the evolutionary developments of latitudinal gradients in animals such as microorganisms and parasites, in plants such as rice and wheat, and in humans discriminating between familiars and strangers (collectivism), higher-ups and lower-downs (hierarchism), and even men and women. As a case in point, the replicated result that pathogen stress and agricultural subsistence tend to modify each other's positive impact on intergroup differentiation and discrimination may illustrate the coevolution of latitudinal gradients in animals, plants and humans. Given their dependence on animals and plants, humans may be extra sensitive to the myriad latitudinal gradients in other living species.

The coevolutionary nature of the theoretical synthesis may also point to explanations for some heretofore mysterious findings and classic speculations. Most notably, the 62 largest empires in history tended to expand less south–north than west–east[43], in hindsight perhaps because different longitudes at the same latitude offered those civilizations familiar patterns of human livability. Such findings[41] echo the famous conjecture of Diamond[40] that human diversity is structured along the south–north rather than the west–east axis of the Earth. Extending these early insights, the present studies have mapped and examined the systemic entwinement of specific cultural habits and clear-cut geographical locations and ecological conditions. The geographical and ecological inclinations of the 222 area-level baselines of intergroup discrimination in the Supplementary Data for study 5 imply that numerous

intergroup dynamics are shaped by south–north rather than west–east ecologies.

The results emphasize the similarity rather than dissimilarity of two archetypes of culture. The distinctness of individualism/collectivism and power distance or hierarchism is widely taken for granted[3,6] without realizing that both dimensions are allied manifestations of differentiation between ingroups and outgroups. By way of a striking exception, Triandis[2,44] proposed that the superimposition of power equality onto individualism produces horizontal individualism, whereas the superimposition of power inequality onto collectivism produces vertical collectivism—less tellingly also known as tight culture[45]. The preindustrial relationship between collectivism and hierarchism ($r_{(88)}=0.44$; $P<0.001$) reconfirms that preindustrial societies already varied weakly from loose horizontal individualism (for example, Yahgan, Aweikoma, Slave and Copper Eskimo) to tight vertical collectivism (for example, Ganda, Azande, Fon, Hausa, Amhara and Aztec)[45].

Further empirical support for the latitudinal theory of intergroup differentiation would carry scholarly and policy implications. Theoretically, societal- and individual-level functioning may be thought of as evolving in part from the extent of tropical climate stress (warm winters, hot summers and irregular rainfall). Strategically, given that latitude-related variations dwarf longitude-related variations in differentiation between us and them, promoting freedom from differentiation and discrimination requires a south–north rather than west–east agenda for international human development.

Methods

Preindustrial and contemporary societies served as units of observation, publicly available data served as targets of reproducible analysis and SPSS served as the inferential statistics to test the hypotheses. All data are available for inspection (Supplementary Data and Supplementary Information) and analysis (https://hdl.handle.net/10411/YXI7WH), and the SPSS analysis scripts used are provided in the Supplementary Methods. For reasons of comparability and comprehensibility, standardized estimates of intergroup differentiation and discrimination were regressed on standardized predictors. 95% CIs are reported.

Study 1. Representative sampling of 90 preindustrial societies was performed by Ross[20,21], using world region, fixity of settlement, population size and political role differentiation as criteria. The pinpointed dates ranged from 1520–1958 ($M=1904$; s.d. = 63 years). The geographic locations of these societies, reproduced in the Supplementary Data for study 1, were taken from the standard cross-cultural sample[18,19].

As detailed in the Supplementary Methods for study 1, Ross[20] created the composite measures of collectivism and hierarchism based on factor analysis of coded observations. He coded collectivism on four three-point scales and three four-point scales of differentiation between more and less familiar people (Cronbach's $\alpha=0.80$). Likewise, Ross[20] coded hierarchism on six three-point scales, four four-point scales, one five-point scale and one seven-point scale of differentiation between higher-ups and lower-downs (Cronbach's $\alpha=0.92$). As can be seen in the Supplementary Data for study 1, the standard scores of collectivism ranged from −2.00 for Jivaro and Yurok to 1.98 for Aztec and Santal ($M=271.30$; s.d. = 135.05) and proxied a normal distribution (skewness = 0.10; s.e. = 0.25; kurtosis = −0.89; s.e. = 0.50). Hierarchism, ranging from −1.65 for Aweikoma, Copper Eskimo, Mbuti, Slave and Yahgan to 1.70 for Ganda and 1.80 for Marshallese ($M=858.80$; s.d. = 517.65), also had an approximately normal distribution (skewness = 0.01; s.e. = 0.25; kurtosis = −1.17; s.e. = 0.50).

To test whether south–north differences dwarf west–east differences in intergroup differentiation, these societal-level scores for collectivism and hierarchism were separately regressed on linear latitude, squared latitude, linear longitude and squared longitude (Table 1). Scatter plots of the standardized residuals show that the linearity and equal variance assumptions are met for both analyses. Theoretically viewed, the results support the biogeographic hypothesis under the assumption that the measures are valid. Methodologically viewed, the results support the convergent and discriminant validity of the measures of collectivism and hierarchism under the assumption that the biogeographic rationale holds true. As further signs of validity, the regression equation for preindustrial collectivism predicts intergroup differentiation around 1970 (study 2: $r_{(51)}=0.42$; $P=0.002$) and intergroup discrimination around 2010 (study 3: $r_{(102)}=0.51$; $P<0.001$); likewise, the regression equation for preindustrial hierarchism predicts intergroup differentiation around 1970 (study 2: $r_{(51)}=0.48$; $P<0.001$) and intergroup discrimination around 2010 (study 3: $r_{(102)}=0.50$; $P<0.001$).

Study 2. Study 2 is a re-analysis of data gathered by Hofstede[3,23] between 1967 and 1973 from more than 160,000 IBM employees working in a convenience sample of 53 countries. The geographic locations of these societies, retrieved from https://developers.google.com/public-data/docs/canonical/countries_csv, are approximately representative of the locations of all independent countries along both bipolar latitude ($\Delta M=2.85$; $t_{(52)}=0.73$; $P=0.47$; CI = −4.99 to 10.69) and nonpolar longitude ($\Delta M=-9.56$; $t_{(52)}=-0.93$; $P=0.36$; CI = −30.10 to 10.99).

As argued in the Supplementary Methods for study 2, Hofstede[3,23] used factor analysis to unknowingly measure societal-level intergroup differentiation with six five-point scales for individualism/collectivism, a five-point scale for power distance and two national percentages for leadership preferences. I reconstructed the underlying differentiation dimension by reintegrating the separated dimensions of individualism/collectivism and power distance (Eigenvalue $\lambda=1.68$; $R^2=0.84$). The Supplementary Data for study 2 show midrange latitude, midrange longitude and the standard scores of collectivism, hierarchism (power distance) and intergroup differentiation for each of Hofstede's 53 societies around 1970. Intergroup differentiation varied from −1.64 for New Zealanders and Danes (low collectivism and hierarchism) to 1.65 for Panamanians and 1.75 for Guatemalans (high collectivism and hierarchism), and proxied a normal distribution (skewness = −0.22; s.e. = 0.33; kurtosis = −1.22; s.e. = 0.64). The regression analysis from study 1 was replicated.

Study 3. Composition and size of the sample of countries for study 3 were determined by the existence of large cross-national datasets that address components of the broad array of intergroup discrimination. Data on nepotism[5], social exclusion[24,25] and legal discrimination[22] without missing values were available for 104 countries representative of the west–east locations of all independent countries ($\Delta M=-4.49$; $t_{(103)}=-0.75$; $P=0.45$; CI = −16.36 to 7.37). There was, however, an over-representation of more northern countries ($\Delta M=5.10$; $t_{(103)}=1.92$; $P=0.06$; CI = −0.17 to 10.36)—a problem addressed below.

The Supplementary Methods for study 3 provide descriptions of the data sources, content domains and methods used to compose the country scores for discrimination in the Supplementary Data for study 3. Nepotism[5] by giving senior management positions to relatives rather than professionals was reliably and validly assessed (on seven-point scales), among samples of a country's top executives, by the World Economic Forum. Social exclusion of minorities is a recently compiled database of the Institute of Social Studies (www.IndSocDev.org)[24,25] integrating objective and subjective indicators of ethnic, religious and economic discrimination across countries. Legal discrimination[22] measures whether the legislature restricts rights to sexual freedom and abortion, as well as criminals' right to stay alive. These measures are not perfect—no measure is—but the combination of nepotism, social exclusion and legal discrimination did produce a reliable index of normally distributed intergroup discrimination (Eigenvalue $\lambda=2.00$; $R^2=0.67$; Cronbach's $\alpha=0.75$; skewness = −0.27; s.e. = 0.24; kurtosis = −0.87; s.e. = 0.47).

The standard scores of intergroup discrimination around 2010 ranged from −2.04 for Swedes and −1.98 for Norwegians to 1.80 for Nigerians and 1.85 for Bangladeshis. Linear latitude, squared latitude, linear longitude and squared longitude served as predictors of discrimination (Table 1). The prediction was repeated twice for 94 countries. First, removing Iceland, Finland, Russia, Norway, Sweden, Estonia, Latvia, Denmark, Canada and the United Kingdom in order to remove the over-representation of more northern countries altered the results in only trivial ways (Supplementary Results for study 3). Second, removing the ten largest countries with the most inaccurate estimates of latitude, longitude and discrimination (Russia, Canada, China, the United States, Brazil, Australia, India, Argentina, Kazakhstan and Algeria) also had a negligible impact (Supplementary Results for study 3).

Study 4. Latitudinal gradients in variables possess convergent validity if their north–south slopes have opposite positive versus negative directions on the opposite sides of the equator[13]. Just as this holds for intergroup differentiation and discrimination, so it should also hold for the explanatory predictors of latitudinal clines of us versus them. The Supplementary Results for study 4 therefore report preliminary tests of whether 17 potential ecological and historical predictors of intergroup differentiation in preindustrial and contemporary societies have oppositely sloping south–north gradients below and above the equator. Six of these independent variables had to be dropped as they do not demonstrate convergent validity across hemispheres. The remaining 11 factors were used as valid predictors of intergroup differentiation and discrimination.

Measurements of the degree of agricultural subsistence in preindustrial societies and of the preindustrial community size are described in the Supplementary Methods for study 4. All other predictors pertain to contemporary societies. Climate stress was operationalized across each country's major cities, weighted for population size. Average annual temperatures and rainfall are inaccurate indicators of local ecological stress, not only because larger seasonal variations have larger impacts on human functioning, but also because higher latitudes have: (1) lower average temperatures; (2) larger seasonal variations in temperature; and (3) more steady rain. These shortcomings of climatic averages as predictors of culture were overcome by concentrating on temperature deviations from a thermal optimum[8,26] and periodic alternations of drought and deluge[27].

Cold stress and heat stress were measured with the thermometer for livability[26] that uses 22 °C (~72 °F) as a central point of reference for optimal livability. The indices of cold stress and heat stress used here[8] are based on a country's mean deviation from 22 °C for the average lowest and highest temperature in the coldest month and the average lowest and highest temperatures in the hottest month. Rainfall stress was proxied by a typical characteristic of tropical climate: too little precipitation in some seasons and too much precipitation in other seasons. This estimate, borrowed and retrieved from a previous study[27], was computed as the reverse of the minimum monthly precipitation divided by the maximum monthly precipitation. Pathogen stress represented the country-level prevalence of human-to-human transmitted diseases, based on data from Fincher and Thornhill[9]. For contemporary agricultural subsistence, I used the average percentage of employment in the agrarian sector from 1990–1995[28] and from 1995–2002[29] (Eigenvalue $\lambda = 1.67$; $R^2 = 0.91$)

Study 4 used four control variables. Poverty stress was the log-transformed reversed income per capita computed by the World Bank in 1970[46] (to predict intergroup differentiation around 1970) and in 2000[30], 2002[29] and 2004[31] (to predict intergroup discrimination around 2010). Ethnic and linguistic group density within a country were approximated by the indices of ethnic and linguistic fractionalization described by Alesina et al.[33]. The order in which the ecological predictors of contemporary differentiation or discrimination and the control variables were added to the model was dictated by the central hypothesis: first, pathogen stress, agricultural subsistence and their interaction; then, their climatic antecedents (cold stress, heat stress and rainfall stress); and ending with the control variables (poverty stress, ethnic group density and linguistic group density).

A likely alternative explanation—not to be confused with the indirect effect of group density through pathogen stress—is that the greater group density towards the equator[17,32] has directly sparked greater intergroup differentiation and discrimination. To explore this potential weakness, the explanatory analysis was repeated replacing poverty stress with ethnic group density[33] and linguistic group density[33]. The Supplementary Results for study 4 indicate that the greater density of ethnic groups ($B_{(94)} = 0.27$; $P < 0.001$; CI = 0.12 to 0.41) and linguistic groups ($B_{(94)} = -0.05$; $P = 0.50$; CI = −0.18 to 0.09) increased the predicted variation in discrimination from 67 to 72% but did not affect the impact of pathogen stress ($B_{(94)} = 0.01$; $P = 0.86$; CI = −0.14 to 0.17), agricultural subsistence ($B_{(94)} = 0.30$; $P < 0.001$; CI = 0.16 to 0.44) and their interaction ($B_{(94)} = -0.17$; $P = 0.002$; CI = −0.28 to −0.06). Thus, the straightforward group-density explanation received little support.

Study 5. The index of baselines of intergroup discrimination by inhabitants of 222 countries was computed by averaging the six regression estimates ($0.38 < r < 0.95$) reported in the Supplementary Data for study 5 (Eigenvalue $\lambda = 4.53$; $R^2 = 0.75$; Cronbach's $\alpha = 0.91$; $M = -0.39$; s.d. = 0.50). The index was validated first against gender discrimination according to the United Nations[34] and then against neuroticism, closed-mindedness and self-esteem retrieved from Gebauer et al.[38] (Supplementary Results for study 5). As an extra indication of construct validity, and reflecting the classic knowledge that personality characteristics have more of an impact in weaker contexts[39], neuroticism has a stronger link with estimated intergroup discrimination at lower levels of stressful ethnic group density ($B_{(94)} = -0.08$; $P = 0.026$; $\Delta R^2 = 0.06$; CI = −0.15 to −0.01; Supplementary Results for study 5).

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

As indicated in the Methods, all data are available for visual inspection (Supplementary Information) and empirical analysis. SPSS data files for preindustrial and contemporary societies can be downloaded from https://hdl.handle.net/10411/YXI7WH. The author is prepared to provide clarifications if needed.

Code availability

The SPSS analysis scripts used in studies 1–5 are provided in the Supplementary Methods. The author is prepared to provide clarifications if needed.

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Author contributions

E.V.d.V. designed and performed the studies, analysed the data, and wrote and edited the manuscript.

Competing interests

The author declares no competing interests.

Additional information

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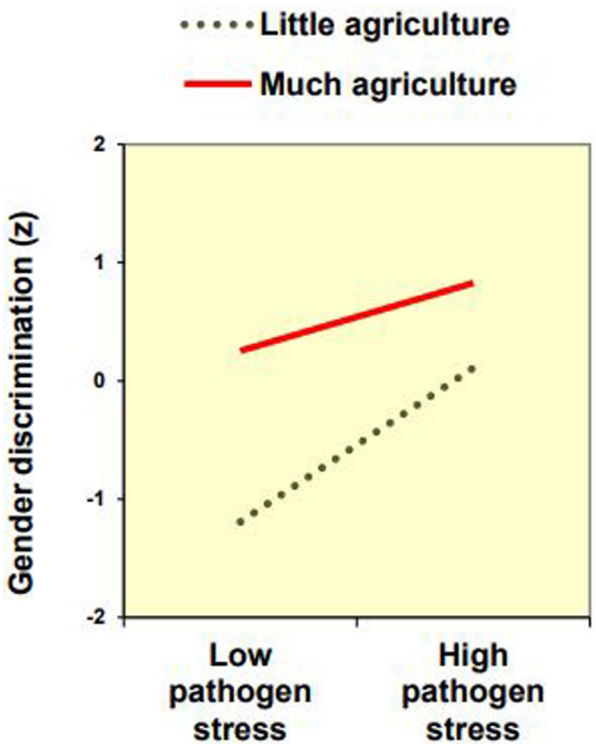

Extended Data Fig. 1 | Joint effects of pathogen stress and agricultural subsistence on gender discrimination in 157 contemporary societies (R^2 = .72). Horizontally viewed, both slopes tell that higher pathogen stress increases gender discrimination, albeit less so in areas with much agriculture ($B_{(153)}$ = .29, $p < .001$, CI = .16 to .42 for the upper slope) than in areas with little agriculture ($B_{(153)}$ = .65, $p < .001$, CI = .49 to .82 for the lower slope). Vertically viewed, both gaps between slopes tell that more agriculture increases gender discrimination, albeit less so in areas with high pathogen stress ($B_{(153)}$ = .36, $p < .001$, CI = .22 to .49 for the right gap) than in areas with low pathogen stress ($B_{(153)}$ = .72, $p < .001$, CI = .56 to .89 for the left gap).

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Data collection	No software used
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Behavioural & social sciences study design

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Study description	Quantitative longitudinal panel
Research sample	Study 1: Representative sample of 90 preindustrial societies (sources: Ross, 1983, 1993) Study 2: Convenience sample of more than 100,000 IBM employees, nested in 53 countries (sources: Hofstede, 1980, 2001) Study 3: Integration of three conveniently available datasets covering 104 contemporary countries (sources: Van de Vliert, 2011; www.IndSocDev.org; Conway et al., 2017)
Sampling strategy	Study 1: 90 even-numbered societies from a standard pool of 186 preindustrial societies Study 2: 53 countries with adequate sample sizes of respondents Study 3: 104 countries with no missing data for nepotism, social exclusion, and legal discrimination
Data collection	Observation Study 1: standardized coding of preindustrial societies by ethnographic authorities Survey Study 2: country-level aggregation of individual-level responses Mixed-method Study 3: (i) country-level aggregation of participative observations of nepotism by top executives, (ii) compilation of publicly available indicators of social exclusion, and (iii) expert ratings of legal discrimination in each country
Timing	Study 1: 1520 to 1958 Study 2: 1967 to 1973 Study 3: 2005-2015
Data exclusions	Study 1: no exclusion of data Study 2: exclusion of Slovenia in some analyses because poverty stress score was missing Study 3: no exclusion of data
Non-participation	Non-participation was impossible in observation Study 1, averaged out in survey Study 2, and impossible in mixed-method Study 3
Randomization	Preindustrial societies and contemporary countries were allocated to the Northern and Southern Hemispheres in order to establish convergent validity, and to the Eastern and Western Hemispheres in order to establish discriminant validity

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology
☒	☐ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging