Heterogeneity of long-history migration explains cultural differences in reports of emotional expressivity and the functions of smiles

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A small number of facial expressions may be universal in that they are produced by the same basic affective states and recognized as such throughout the world. However, other aspects of emotionally expressive behavior also vary widely across culture. Just why do they vary? We propose that some cultural differences in expressive behavior are determined by historical heterogeneity, or the extent to which a country's present-day population descended from migration from numerous vs. few source countries over a period of 500 y. Our reanalysis of data on cultural rules for displaying emotion from 32 countries [*n* = 5,340; Matsumoto D, Yoo S, Fontaine J (2008) *J Cross Cult Psychol* 39:55–74] reveals that historical heterogeneity explains substantial, unique variance in the degree to which individuals believe that emotions should be openly expressed. We also report an original study of the underlying states that people believe are signified by a smile. Cluster analysis applied to data from nine countries (*n* = 726), including Canada, France, Germany, India, Indonesia, Israel, Japan, New Zealand, and the United States, reveals that countries group into "cultures of smiling" determined by historical heterogeneity. Factor analysis shows that smiles sort into three social-functional subtypes: pleasure, affiliative, and dominance. The relative importance of these smile subtypes varies as a function of historical heterogeneity. These findings thus highlight the power of social-historical factors to explain cross-cultural variation in emotional expression and smile behavior.

smile | emotion | culture | historical demographics | collectivism-individualism

Human facial expressions of emotion determine the meaning of most social encounters and communicative acts (1). Some expressions, such as those expressions that are associated with subjective feelings of fear and disgust, may have adaptive functions that make them universally displayed and recognized (2, 3). However, even these expressions are subject to considerable variation in subtle aspects of their appearance (4) and in the frequency and context (5) of their occurrence across cultures. Accounting for cultural differences in facial expression of emotion remains an unresolved problem. Here, we demonstrate that differences in norms guiding emotional expressivity, and the use of the smile to solve problems of social living, are explained by heterogeneity of long-history migration or the extent to which a country's present population descends from numerous (vs. few) source countries (6).

On the basis of textual and genetic data, Putterman and Weil (6) constructed the World Migration Matrix. The matrix is composed of 165 rows for present-day countries and 172 columns corresponding to the 165 present-day countries, plus seven original source countries with current populations of less than 500,000. The entries in the matrix represent the proportion of each present-day country's descendants attributable to each source country in A.D. 1500. The matrix can be found at www.econ.brown.edu/fac/louis_putterman/world%20migration%20matrix.htm. (Information about the sources used to compile the matrix can be found in the Main Appendix to the World Migration Index at www.econ.brown.edu/fac/louis_putterman/Appendix%20to%201500%20Origins%20Matrix%201.1.doc.)

Here, we use the number of source countries that have contributed to a given country's present-day population since A.D. 1500 as an index of heterogeneity of long-history migration. As examples, Canada and Uruguay evolved from substantial migration flows, with 63 and 35 source countries, respectively, contributing to their populations. Pakistan and Austria are historically far less diverse, with three and seven source countries, respectively. We suggest that this measure of historical heterogeneity captures the extent to which contact between diverse cultures and languages occurred in a given country. The diagonal entry in the matrix is a measure of overall indigeneity. A score of 0 indicates that today's population descended entirely from other source countries. A score of 1 indicates perfect stability, such that the entire population descends from the inhabitants of that

Significance

In an age of globalization, emotional understanding is the central problem of human interaction. Here, we show that historical heterogeneity, or the extent to which a country's present-day population descends from numerous (vs. few) source countries, predicts cultural variation in norms for emotional expressivity. Reanalysis of cultural display rules from 32 countries reveals that historical heterogeneity is associated with norms favoring greater emotional expressivity. In addition, the results of a study of nine countries show that the belief that smiles signal social bonding motives vs. the negotiation of status in a social hierarchy is predicted by historical heterogeneity as well.

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Data deposition: Materials and detailed results are included in *Supporting Information*. Data from both studies can be accessed at https://drive.google.com/file/d/0B5A764nHr4LoS0o0ajhEQjBaUkE/view?usp=sharing.

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territory in A.D. 1500. Unsurprisingly, indigeneity is negatively correlated with the number of source countries [$r(163) = -0.64$, $P < 0.001$], such that populations with lower proportions of indigenous ancestors descended from a larger numbers of source countries. However, indigeneity is a less perfect measure of heterogeneity, because a score of 0 could be established by any number of source countries, including very few as in the case of Hong Kong (three source countries).

In the research reported here, we demonstrate that our index of historical heterogeneity accounts for variation in norms for emotional expressivity beyond the variation in norms for emotional expressivity explained by other dimensions of culture, such as individualism-collectivism (I-C) (7, 8), residential mobility (9, 10), and present-day ethnic diversity (11, 12). We also link historical heterogeneity to shared beliefs about the causes and meanings of the human smile.

A first hypothesis holds that historical heterogeneity is associated with norms favoring emotional expressivity, where expressivity means that people display felt emotions on the face and body. The prediction is derived from several considerations. Members of historically homogeneous societies, originating from one or few source countries, have common practices, rules, and language that together guide their emotions and their expectations of others' emotions in daily interaction; that is, they live within a coherent "emotion culture," which provides predictability about the emotions of any single person in any given context (13). In contrast, historical heterogeneity implies the collision of many diverse source countries or emotion cultures, and the need to convey one's feelings and intentions accurately through nonverbal cues in the place of other channels of communication (14). Amplified emotional expressivity in the face and body would be a likely adaptation to diversity in original emotion practices, rules, and language. Because self-reports about expressivity are significantly correlated with expressive behavior, we should detect these relationships in norms, or display rules, for expressive behavior (15).

Another basis for this hypothesis takes into account the social advantages incurred by emotional expressivity. Accurate communication of one's emotions through nonverbal channels has been linked to increased interpersonal attractiveness (16) and trustworthiness (17), both of which facilitate social coordination (18). Such benefits should be especially important in heterogeneous societies, in which individuals need to build a basis for cooperation in the absence of historically determined relationship bonds. Bodily and facial cues for establishing coordination and trust are less crucial when individuals are well acquainted with their interaction partners, and when social structure already exists.

A second hypothesis links historical heterogeneity to the most nuanced and important of human facial expressions—the smile. We propose that in addition to general expressivity, historical heterogeneity explains cultural variation in beliefs about the functions of the smile. According to the recent Simulation of Smiles model (19), smiles serve to solve these three fundamental tasks of group living: (*i*) providing rewards (to self and others), (*ii*) creating and maintaining social bonds, and (*iii*) negotiating status in social hierarchies. Smiles that serve these tasks are termed, respectively, pleasure (or enjoyment), affiliative, and dominance smiles. Here, we argue that the tasks of providing rewards, bonding, and negotiating status are not of equivalent importance when living in homogeneous compared with heterogeneous societies.

Sociologists and anthropologists confirm that information about what is appropriate and inappropriate, and who is related to whom through which type of relationship, tends to be predictable in homogeneous cultures (20, 21). In contrast, a society that emerged from a large number of source countries is inherently a context of social uncertainty, in which trust and commitment formation are of critical importance (22–24). Unrestrained expressivity may help reduce such uncertainty in the absence of other information about another person's intentions. This ■■■ is especially true of the expression of positive emotions and motives: During interactions with strangers, the presence of a smile reliably predicts trust and sharing resources (25, 26). Moreover, observing smiles that accompany cooperative behaviors increases one's cooperation in the future (27). Thus, smiles that signal friendly (rather than aggressive or competitive) intent should be more common, and recognized as more common, in historically heterogeneous societies. Negotiating status is another matter. This type of social interaction is complex and potentially disruptive in historically homogeneous cultures, such as Japan (28) and China (29), where long-term population stability created conditions favorable to the development of fixed hierarchies. In similar circumstances, a smile can signal that the interaction will not disturb the social order, whereas specific features of the smile convey derision, criticism, and other signs of superior status (30); that is, a smile can successfully point out that the violation of established group norms has occurred or communicate superiority, without provoking open conflict (31). This use of the smile would be less frequent, if not less important, in historically heterogeneous societies, where hierarchy is based less on social ties and instability of hierarchy is less costly to the social order. From these considerations, we derive the hypothesis that feelings and states related to social bonding are believed to be more conducive of smiling in historically heterogeneous compared with homogeneous societies, whereas feelings and states related to hierarchy negotiation are believed to be more conducive of smiling in historically homogeneous compared with heterogeneous societies.

Relations between long-history migration patterns and other dimensions of culture were first examined. Historical heterogeneity might be correlated with the cultural value dimension of I-C, and these values could explain norms for emotional expressivity. In particular, collectivist cultures encourage salient between-group boundaries and a small number of stable, homogeneous social groups. In contrast, individualist cultures promote numerous, flexible social groups that encourage interactions with strangers and relationships based on mutual trust rather than on shared group membership (32–35). Emotional expressivity would facilitate the goals of individualistic far more than collectivistic cultures (36). Residential mobility (9) refers to the probability of changing place of residence, and is associated with pressures to make new social bonds and to enter or leave social groups. Although residentially mobile societies and heterogeneous societies share some social features (e.g., the need to interact with strangers), residential mobility does not imply contact or interdependence of individuals from different cultures and linguistic groups. However, trends in mobility might also explain norms for emotional expressivity. Both I-C and residential mobility could thus be associated with higher expressivity norms in theory, although for different reasons than those reasons established by large-scale migration.

We also compare the influences of historical heterogeneity with the influences of current ethnic diversity (11, 12), or the heterogeneity of the present-day population. Although an ethnically diverse environment is one in which emotional expressivity and specific functions of the human smile should, in theory, become normative, time is often required for a set of beliefs to be established and shared within cultural communities. Cultural variation in psychological processes observed at a given moment often results from adaptive responses to ecological environments in the distant past (37). If emotional expressivity and changes in beliefs about the significance of smiles are historically accumulated responses to successful heterogeneous living, historical heterogeneity will predict emotional expressivity even after controlling for present ethnic diversity.

Study 1: Historical Heterogeneity and Emotional Expressivity

We first established the relationships between historical heterogeneity, three different indicators of I-C (38–40), a measure of present-day ethnic diversity based on the Herfindahl index ["ethnic fractionalization" (11)], the number of source countries contributing to a given population in 2013 (12), and an index of residential mobility (10). Correlations between these five measures for the 32 countries used in subsequent analyses are presented as a color-coded matrix in Fig. 1. The dimensions are sensibly related but not identical to historical heterogeneity. This ■■■ leaves open the possibility that historical heterogeneity explains important and unique cross-cultural variance in the endorsement of norms for emotional expressivity, above and beyond the variance explained by other dimensions.

To test the hypothesis that historical heterogeneity is positively associated with emotional expressivity, we reanalyzed existing data on emotional "display rules" across cultures (33) (details are provided in Table 1).

In the study, 5,340 respondents completed a questionnaire measuring the social norms that govern the expression of anger, contempt, disgust, fear, happiness, sadness, and surprise in private and public contexts. Matsumoto et al. (36) used these responses to calculate a single score of Overall Expressivity, ranging generally from 0 to 1 and reflecting the extent to which participants believe they should dissimulate vs. freely express or even amplify expression of the emotions they feel. (We also examined another index of expressivity norms, ranging from 0 to 294 and representing the total number of instances in which a given participant selected "express it as you feel it" as the most appropriate behavior in a given situation. This second measure was significantly correlated with the dimension of Overall Expressivity [$r(30) = 0.797$, $P < 0.000$] and with the number of source countries [$r(30) = 0.555$, $P = 0.001$].) Analyses revealed that mean Overall Expressivity scores for the 32 countries were significantly correlated with historical heterogeneity [$r(30) = 0.50$, $P = 0.003$), such that display rules favoring the expression of emotion were endorsed more with increasing number of source countries. [The same was true for participants' individual scores of Overall Expressivity: A linear mixed model analysis with individuals nested within countries showed that country-level heterogeneity was positively related with participants' norms of Expressivity ($b = 0.001$, SE < 0.001, $t = 3.78$, $P < 0.001$).]

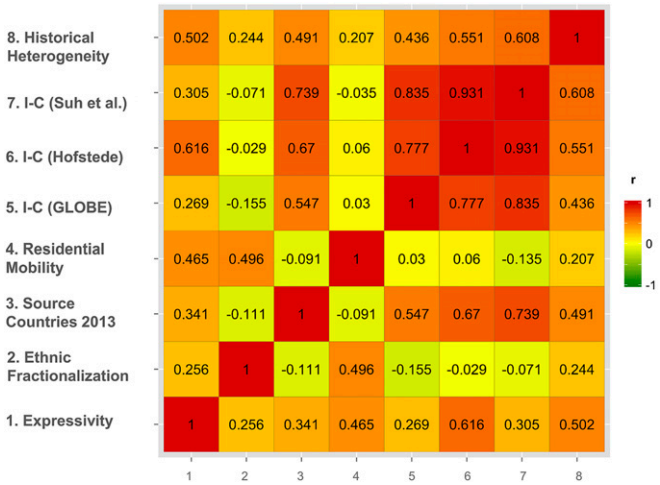

Fig. 1. Correlation matrix for emotional expressivity, historical heterogeneity, and other cultural dimensions.

We next related historical heterogeneity to other cultural variables and tested the extent to which it explains statistical variance in reported norms for emotional expressivity beyond the variance accounted for by other cultural dimensions (all correlations are shown in Fig. 1).

Results of country-level simultaneous (Fig. 2, model 1) and backward regression (Fig. 2, model 2) models indicate that historical heterogeneity explains unique variance in expressivity norms, such that individuals in more historically heterogeneous cultures believe that emotions should be expressed. Two measures of I-C (39, 40) and residential mobility (10) were also significant predictors of emotional expressivity, such that individuals in countries with more individualistic values and higher mobility believe that emotion should be expressed rather than dissimulated.

Study 2: Historical Heterogeneity and the Functions of Smiles

A second cross-cultural study was conducted to test the hypothesis that the feelings and states related to social bonding are thought to be more conducive of smiling in heterogeneous compared with homogeneous societies, whereas feelings and states related to hierarchy negotiation are more conducive of smiling in homogeneous compared with heterogeneous societies. We invited individuals in nine countries ($n = 726$; details are provided in Table 2 and Table S1), responding in their native language, to rate the extent to which 15 possible emotional and motivational states cause people to smile in their culture.

Supporting the social-functional typology of smiles, factor analysis of the emotional and motivational causes of smiling showed that these variables are best described by a three-factor structure interpretable in terms of smile functions proposed by Niedenthal et al. (19). Specifically, the function of reward (of self and other) is represented by items such as "is in a good mood." The second factor, corresponding to social bonding, is represented by items such as "wants to be a close friend of yours." The third factor, interpretable as hierarchy negotiation, is represented by items that include "feels superior to you."

After reducing the number of examined variables, we explored similarities between participants' motives for smiling. Two separate analyses reveal that individual respondents can be grouped into two clusters corresponding to distinct "cultures of smiles." Respondents in the two clusters differed in their beliefs about the degree to which smiles serve each of the three social functions. An inspection of the mean scores and the cluster centers reveals that the social bonding motives for smiles were rated as more causal of smiling in cluster 1 (Fig. 3), whereas hierarchy management motives were rated as more causal of smiling in cluster 2.

Importantly, whether a participant was assigned to cluster 1 or cluster 2 is robustly determined by the long-history migration of the participant's country of origin. In other words, heterogeneity is the most significant predictor of cluster membership [$r(7) = 0.82$, $P = 0.007$], such that countries whose members are assigned largely to cluster 1 are relatively heterogeneous and countries whose members are assigned largely to cluster 2 are relatively homogeneous (Fig. 4). Cluster membership is also correlated with two measures of I-C (39, 40): residential mobility and the number of source countries in 2013. None of these correlations, however, remain significant when controlling for historical heterogeneity.

Consistent with this data-driven approach, heterogeneity tended to predict the endorsement of bonding smile functions [$r(7) = 0.65$, $P = 0.06$] and was negatively related to the endorsement of hierarchy motives [$r(7) = -0.82$, $P < 0.01$] (details are provided in Table S4).

Table 1. Emotional expressivity and socioecological variables for 32 countries

Country	*N*	Expressivity	Historical heterogeneity	Ethnic fractionalization	Source countries in 2013	Residential mobility	GLOBE I-C*	Hofstede's I-C	I-C (40)
Australia	128	0.510	46	0.09	227	11	3.83	90	9.00
Bangladesh	96	0.422	2	0.05	18	8		20	
Belgium	88	0.498	10	0.56	98	10		75	7.25
Brazil	111	0.495	25	0.54	160	12	2.82	38	3.90
Canada	195	0.520	63	0.71	219	14	3.74	80	8.50
China	87	0.471	1	0.15	20	7	2.20	20	2.00
Croatia	92	0.451	12	0.37	25	5		33	
Czech Republic	100	0.468	4	0.32	192	6		58	7.00
Denmark	53	0.505	5	0.08	187	11	4.47	74	7.70
Georgia	99	0.478	4	0.49	21	5	1.81		
Germany	115	0.455	7	0.17	136	10	3.98	67	7.35
Greece	90	0.452	1	0.16	187	11	2.73	35	5.25
Hong Kong	102	0.399	3	0.06	29		2.68	25	4.75
Hungary	92	0.495	12	0.15	160	7	2.75	80	6.00
India	464	0.495	3	0.42	36	11	2.08	48	4.40
Indonesia	199	0.420	2	0.74	19	8	2.32	14	2.20
Israel	87	0.442	22	0.34	57	14	3.30	54	
Italy	108	0.451	5	0.12	194	11	3.06	76	6.80
Japan	377	0.464	1	0.01	42	4	3.37	46	4.30
Malaysia	600	0.446	5	0.59	22	13	2.49	26	
Mexico	230	0.485	25	0.54	181	15	2.29	30	4.00
Netherlands	104	0.496	28	0.11	207	9	4.30	80	8.5
New Zealand	90	0.502	12	0.40	219	15	4.33	79	
Nigeria	78	0.506	3	0.85	20	30	2.45	30	3.00
Poland	162	0.477	3	0.12	157	8	2.48	60	5.00
Portugal	128	0.477	15	0.05	178	5	2.49	27	3.85
Russia	53	0.432	5	0.25	220	5	2.37	39	6.00
South Korea	152	0.449	1	0.00	27	13	2.46	18	2.40
Switzerland	66	0.446	12	0.53	194	10	4.15	68	7.90
Turkey	221	0.467	6	0.32	188	13	2.12	37	3.85
United States	691	0.519	83	0.49	214	17	3.75	91	9.55
Zimbabwe	82	0.523	3	0.39	9	23	2.43		3.00

This table is based on a study by Matsumoto et al. (36).
*Scores of GLOBE I-C were recoded such that higher scores indicate higher individualism.

Discussion

In the present research, we show that the historical heterogeneity of populations arising from long-history migration from numerous source countries is a unique determinant of culture that is sensibly related to, but not identical to, the constructs of I-C, residential mobility, and present ethnic diversity. As predicted, historical heterogeneity explained important aspects of cultural differences in beliefs about facial expressivity and smiling in particular. Our first study reveals that the number of source countries in which the ancestors of a given population lived in A.D. 1500 accounts for display rules for emotional expressivity, such that heterogeneity is related to pressures for greater expression of emotion. Results of our second study provide initial evidence in favor of the social-functional theory of smiles. As predicted, positive and negative feelings related to reward, social bonding, and the negotiation of social hierarchy are believed to be fundamental causes of smiling. As expected, the relative importance of these types of smiles shows significant cultural differences. Individuals in heterogeneous societies link social bonding to smiling more than individuals in homogeneous countries. Individuals in homogeneous countries link the management of hierarchies to smiling behavior more than individuals in heterogeneous countries. This last result may be related to the fact that societies whose populations remained stable over history tend to exhibit higher levels of power distance (39) [$r(28) = -0.376$, $P = 0.04$], suggesting that historical homogeneity is associated with elaborate and socially accepted hierarchies.

Together, our findings underscore the significance of historical demographic factors for future cross-cultural research. Importantly, the observed relationship between historical heterogeneity, emotional expressivity, and beliefs about smile functions also persisted after controlling for other cultural and ecological variables, such as power distance (39), tightness (41), population density (42), and gross domestic product (GDP) per capita (43). Historical heterogeneity may be especially useful for explaining differences between Old and New World countries, because the latter are typically more heterogeneous than the former [$t(30) = 3.22$, $P = 0.023$ in the present sample]. The historical heterogeneity construct is more rigorously defined, however, and specifies a social mechanism responsible for influences in emotional and potentially other nonverbal types of communication.

It is worth noting that the number of source countries is only one among the possible measures of historical homogeneity. The previously mentioned indigeneity index, computed by Putterman and Weil (6), reflects the proportion of a country's population in the year 2000 originating from people living in the same territory in A.D. 1500. This second measure, capturing to a greater extent the magnitude, rather than the diversity, of the migration flows, is also a significant predictor of emotional expressivity [$r(29) = -0.46$, $P = 0.01$] and the endorsement of smile motives [$r(7) = -0.95$, $P < 0.001$] (a detailed analysis is provided in *Supporting*

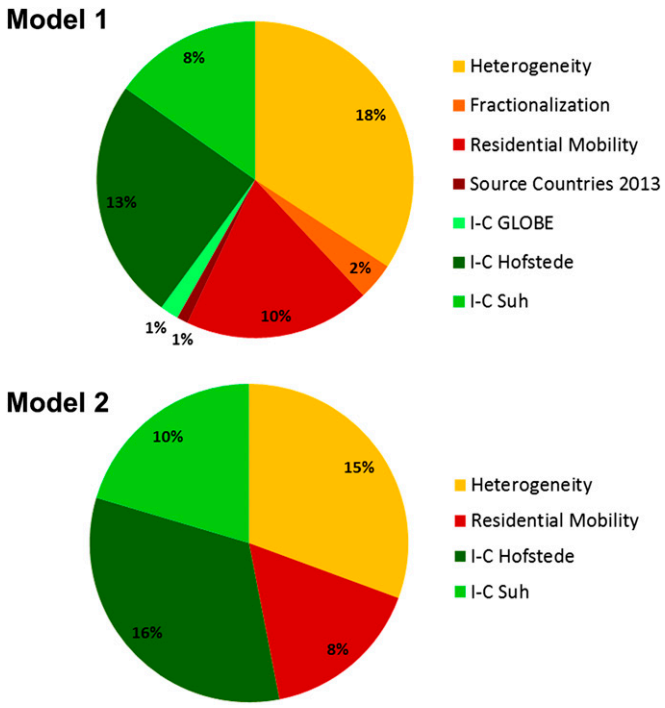

Fig. 2. Historical heterogeneity and other cultural variables as predictors of emotional expressivity. Model 1 shows the results of a multiple regression using heterogeneity, three measures of I-C, residential mobility, source countries in 2013, and ethnic fractionalization. Model 2 emerged in a backward regression and contained four predictors: two measures of I-C, heterogeneity, and residential mobility.

Information, *Appendix A*). Moreover, the number of source countries is negatively correlated with the spread in the proportions of foreign ancestors [$r(26) = -0.74$, $P < 0.001$]. In other words, in the nations that originate from numerous source countries, proportions of nonlocal ancestors are more uniform (have smaller SDs) than in the nations originating from few source countries (larger SDs). Smaller SDs also predict higher emotional expressivity [$(r(26) = -0.46$, $P = 0.015$].

Future research will account for the timing of migration and shed more light on the exact mechanism underlying the impact of the population flows on beliefs governing expressive behavior across cultures. Whether the observed phenomena are due to cross-cultural contact per se or to a long-term impact of inclusive, egalitarian, and trust-promoting institutions (44), findings reported here suggest that (*i*) 500 y of migration can create a culture of smiles and (*ii*) in such a culture, rules for nonverbal behavior are different from rules for nonverbal behavior in societies in which consensual emotional rules and expectations allow for predictability of emotional response and emotion regulation. These insights will be of relevance for the future of international relations and commerce.

Materials and Methods

Participants.

Study 1. The study was a reanalysis of a study by Matsumoto et al. (36) involving 5,340 participants from 32 countries (mean age = 22.66 y, 61.06% female and 38.93% male; details are provided in Table 1).

Study 2. Seven hundred twenty-six subjects from Canada, France, Germany, India, Indonesia, Israel, Japan, New Zealand, and the United States participated in the study (details of the procedure are provided in Table S1). We discarded data from 18 participants who were not natives of the country of measurement.

Materials and Measures.

Study 1.

Emotional expressivity. Participants completed the Display Rule Assessment Inventory, a psychometrically valid instrument that measures the regulation of expressive behavior (45). The instrument asks respondents about social norms governing expressions of emotions when the participants are alone and with 21 different interaction partners in two settings: public and private. Respondents select one of six theoretically derived behaviors that they think they should show when feeling anger, contempt, disgust, fear, happiness, sadness, or surprise. For example, a respondent could be asked what she should do when feeling a given emotion toward a female acquaintance at a restaurant. The response alternatives corresponded to the six expression management modes described by Ekman and Friesen (46, 47): "show more than you feel it" (amplification), "express it as you feel it" (expression), "show the emotion while smiling in the same time" (qualification), "show less than you feel it" (deamplification), "hide your feelings by smiling" (masking), and "show nothing" (neutralization). The option "other" was available but was almost never selected by the participants. Participants' responses about the expression modes judged as most appropriate were reduced to a single, psychometrically equivalent dimension of Overall Expressivity (36, 48), based on the response frequencies for each alternative. One pole corresponded to not displaying anything ("express nothing"), and the other pole corresponded to displaying more than one feels ("amplify"). The scores ranged from 0 to 1.10, with higher values indicating more expressivity.

Historical heterogeneity. Long-history homogeneity vs. heterogeneity was operationalized by the number of countries in which the ancestors of a given country's modern inhabitants lived in A.D. 1500 (6). Scores varied between 1 and 83. This variable will be called Heterogeneity.

I-C. We used three indicators of collectivism: practices of In-Group Collectivism published in the GLOBE survey (38), Hofstede's measure of individualism (39), and individualism scores computed by Suh et al. (40).

The GLOBE study, conducted in the period from 1994–1997, was a collaborative effort of about 170 researchers who investigated ~951 nonmultinational organizations. The GLOBE survey assessed collectivism as a multidimensional and multilevel construct. In the present study, we used ratings of practices of societal In-Group I-C. The measure has a good convergent validity; it is strongly ($r = -0.82$, $P < 0.01$) negatively correlated with Hofstede's (36) individualism and focuses on family integrity, one of the key

Table 2. Cultural and socioecological variables: Study 2

Country	Historical heterogeneity	Ethnic fractionalization	Source countries in 2013	Residential mobility	GLOBE I-C*	Hofstede's I-C	I-C (40)
Canada	63	0.71	219	14	3.74	80	8.50
France	11	0.10	209	19	3.63	71	7.05
Germany	7	0.17	136	10	3.98	67	7.35
India	3	0.42	36	11	2.08	48	4.40
Indonesia	2	0.74	19	8	2.32	14	2.20
Israel	22	0.34	57	14	3.30	54	
Japan	1	0.01	42	4	3.37	46	4.30
New Zealand	12	0.40	219	15	4.33	79	
United States	83	0.49	214	17	3.75	91	9.55

*Scores of GLOBE I-C were recoded such that higher scores indicate higher individualism.

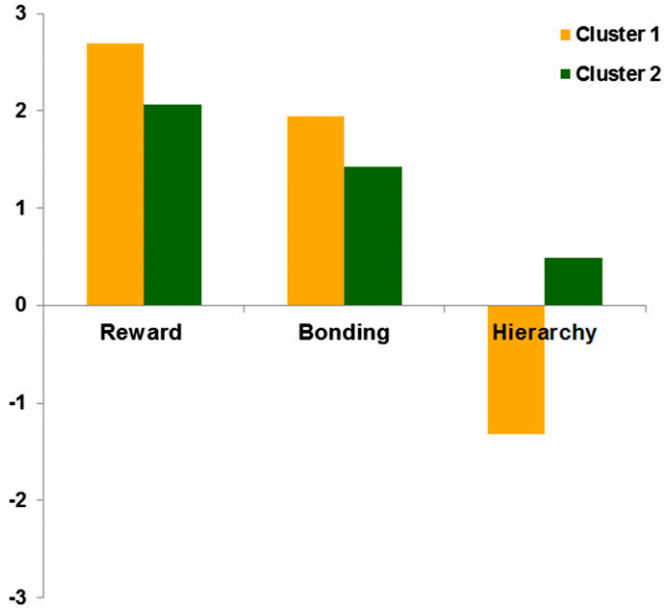

Fig. 3. Endorsement of the reward, bonding, and hierarchy motives in cluster 1 and cluster 2. Bars represent mean scores (TwoStep algorithm).

components of collectivism (49). The construct was measured with four questions assessing the extent to which people are proud of the individual achievements of members of their families and whether aging parents lived with their children and adult children lived with their parents. Participants responded on seven-point scales. For more consistency in interpreting the meaning of scores, we reverse-coded the original scores such that higher values now indicate stronger endorsement of individualistic values. Scores of GLOBE I-C were available for 27 countries.

The second measure was published in Hofstede's classic study (39) of cultural dimensions conducted among employees of a multinational company in 50 countries. The construct of I-C was operationalized in terms of values important for an ideal job. Such values could include personal sense of accomplishment, living in a desirable area, high earnings, freedom to adapt one's own approach to the job, full use of skills and abilities, or good working relationship with the manager (39). Hofstede's I-C scores (39) were available for 29 countries. The scores ranged from 0 to 100, with higher values indicating stronger endorsement of individualism.

Our final measure was computed by Suh and colleagues (40) and is an average of Hofstede's I-C scores (39) and ratings proposed by Triandis (■■■). The latter measure was based on Triandis' personal judgment and observations (40). Scores of Suh's I-C were available for 25 countries and ranged from 2 (China) to 9.55 (United States), with higher values indicating more individualistic societies.

Present ethnic diversity. The first construct of ethnic fractionalization was operationalized in terms of the scores published by Alesina et al. (11), which represent the ethnic diversity of a country, accounting for factors such as language and religion. For a given country, the score stands for the probability that two randomly selected individuals belong to different ethnic groups and is computed as 1 minus the Herfindahl index of ethnic group shares. Population data used to compute the variable were provided by the sources published between 1997 and 2001 or directly obtained from national censuses. Importantly, this variable reflects the judgment of ethnologists and anthropologists on the appropriate definition of ethnicity. Scores of ethnic fractionalization vary between 0 and 1, and were available for all 32 countries examined in the present study. Henceforth, this variable will be called Fractionalization.

A second indicator of present ethnic diversity was the number of source countries contributing to the population of a given country in the year 2013, based on the United Nations' report "Trends in International Migrant Stock" (12). Estimates of immigration were based on census data, population registers, and nationally representative surveys. Migrants were identified based on their place of birth and country of citizenship.

Residential mobility. Our measure of residential mobility was provided by the World Poll conducted by the Gallup Organization from 2005 to 2012 with 132,516 respondents from 128 countries (10). The construct was assessed with a single question: "In the next 12 mo, are you likely or unlikely to move away from the city or area where you live?" The country-level scores represent the percentage of respondents who selected the answer "Likely to move." (The two other response options were "Unlikely to move" and "Don't know." Participants could also refuse to answer the question.) Scores varied from 1 to 100 and were available for 31 countries, with the exception of Hong Kong.

Study 2. Participants responded to a 15-item questionnaire investigating possible feelings and motives that would cause a person to smile (the full survey is discussed in *Supporting Information, Appendix B*). The possible feelings and motives were culled from existing descriptions of smiles in the literature (e.g., refs. 50–52) and are generally believed to represent the diversity of the smile (e.g., ref. 53). The Simulation of Smiles model of Niedenthal et al. (19) had not yet been developed at the time of the questionnaire construction, and so the theory did not guide the development of the list. Respondents used Likert-type scales ranging from −3 (strongly disagree) to 3 (strongly agree). They also answered demographic questions asking about age, gender, mother tongue, nationality, and country of origin. Finally, the survey included four unrelated questions used for the needs of another project. Participants were tested in their home countries in their native language. Translations of the questionnaire were created by bilingual speakers in each country. Independent bilingual speakers provided back-translations so that we could assess the quality of the initial translations.

Statistical Analyses.

Study 1. Regressing Expressivity on Heterogeneity confirmed that the latter was a significant predictor [R^2 change = 0.252, $F(1,30) = 10.08$, $P = 0.003$]. A JZS Bayes factor analysis (54) with default mixture-of-variance priors, and with reference to the null model, further supported the role of Heterogeneity (B_{01} = 10.23, in favor of the alternative hypothesis). We also conducted a country-level multiple regression analysis predicting Expressivity from Heterogeneity, utilizing the three measures of individualism: Residential Mobility, Source Countries in 2013, and Fractionalization (Fig. 2, model 1). The model explained 70% of the variance [$F(7,14) = 4.58$ $P = 0.007$]. Heterogeneity was a significant predictor of emotional expressivity [$B = 0.001$, $F(1,14) = 8.30$, $P = 0.012$], and explained 18% of the variance. Hofstede's I-C and Residential Mobility were also related to Expressivity [$B = 0.001$, $F(1,14) = 6.18$, $P = 0.03$ and $B = 0.002$, $F(1,14) = 4.67$, $P = 0.50$, respectively]. None of the other predictors were significant (all F values <4.0, all P values >0.07). (To assess the role of Heterogeneity, we also performed a series of partial correlation analyses. Heterogeneity was significantly or marginally significantly correlated with Expressivity after controlling for GLOBE I-C [$r_{partial}(25) = 0.45$, $P = 0.019$], Hofstede's I-C [$r_{partial}(27) = 0.34$, $P = 0.068$], Suh's I-C [$r_{partial}(23) = 0.46$, $P = 0.020$], Residential Mobility [$r_{partial}(28) = 0.48$, $P = 0.008$], Fractionalization [$r_{partial}(29) = 0.47$,

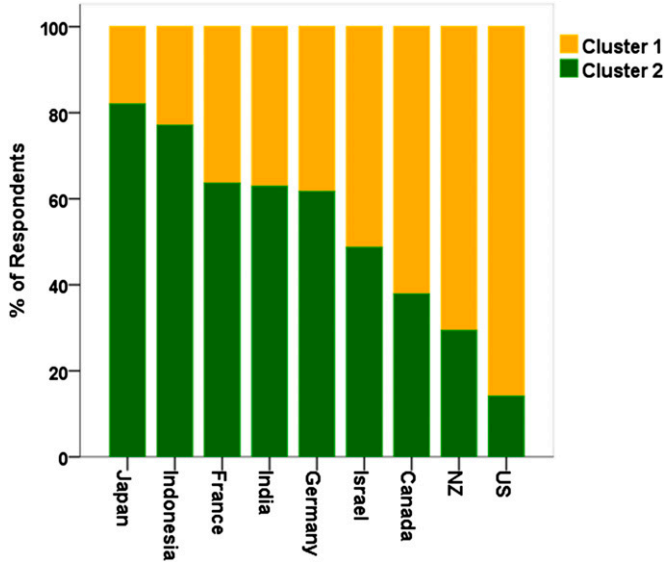

Fig. 4. Clustering the motivations for smiling in the nine countries. Bar graphs represent proportions of respondents in each cluster by country. Percentages of respondents are computed by averaging the two cluster solutions. NZ, New Zealand, US, United States.

$P = 0.008$], and Source Countries in 2013 [$r_{partial}(29) = 0.41$, $P = 0.023$].) Given that this result may be partially due to multicollinearity because three measures of individualism were included in the model, we conducted an additional analysis using backward regression, removing each predictor sequentially from the full model (Fig. 2, model 2). The *P* values were fixed to 0.05 (entry) and 0.10 (removal). The final model emerged after three iterations and contained four predictors: Heterogeneity [$B = 0.001$, $F(1,17) = 7.72$, $P = 0.01$, 15% variance explained], Hofstede's I-C [$B = 0.001$, $F(1,17) = 7.79$, $P = 0.01$, 16% variance explained], Suh's I-C [$B = -0.012$, $F(1,17) = 5.20$, $P = 0.04$, 10% variance explained], and Residential Mobility [$B = 0.002$, $F(1,17) = 3.91$, $P = 0.06$, 8% variance explained]. [It is worth noting that an identical analysis using a combined I-C index yielded very similar results. The index was computed as the average of standardized I-C scores when all three of them were available ($N = 23$). In the first model, predicting Expressivity from Heterogeneity, I-C index, Residential Mobility, Source Countries in 2013, and Fractionalization, Heterogeneity and Residential Mobility were the only significant predictors [$B = 0.001$, $F(1,16) = 6.39$, $P = 0.022$, 17% of the variance explained and $B = 0.002$, $F(1,16) = 4.61$, $P = 0.047$, 12% of the variance explained, respectively]. Other effects were not significant (all *F* values <1.7, all *P* values >0.200). The backward regression model yielded a similar result with Heterogeneity and Residential Mobility as final predictors [$B = 0.001$, $F(1,19) = 11.48$, $P = 0.003$, 30% of the variance explained and $B = 0.002$, $F(1,19) = 3.15$, $P = 0.092$, 8% of the variance explained, respectively].]

Additional analyses. We finally conducted a series of correlational analyses relating Expressivity to four potentially relevant variables, namely, population density per square kilometer (42), GDP per capita (43), tightness (41), and power distance (39). The analyses yielded significant effects for density [$r(30) = -0.48$, $P = 0.005$], such that lower density predicted higher expressivity. Moreover, countries that displayed higher levels of power distance tended to be less expressive [$r(30) = -0.35$, $P = 0.06$]. However, the relationship between Heterogeneity and Expressivity remained significant even after controlling for these variables [$r_{partial}(29) = 0.50$, $P = 0.005$ and $r_{partial}(27) = 0.37$, $P = 0.05$, respectively]. Neither the GDP nor tightness was significantly related to emotional expressivity [$r(30) = 0.004$, $P = 0.98$ and $r(18) = -0.30$, $P = 0.20$, respectively]. Finally, a multiple regression analysis predicting Expressivity from Heterogeneity, the three measures of I-C, Residential Mobility, Source Countries in 2013, Fractionalization, population density, GDP, tightness, and power distance showed a significant effect of Heterogeneity [$B = 0.001$, $F(1,3) = 50.60$, $P = 0.006$, 37% of the variance explained]. (An identical regression analysis using the combined I-C index instead of the three original measures showed a similar pattern of results, with significant effects of Heterogeneity and GDP [$B = 0.001$, $F(1,5) = 70.79$, $P < 0.001$ and $B < -0.001$, $F(1,5) = 25.93$, $P = 0.004$, respectively] and a marginally significant effect of the combined I-C index [$B = 0.013$, $F(1,5) = 5.12$, $P = 0.073$].) Among other variables, GDP was the only significant predictor [$B < -0.001$, $F(1,3) = 12.38$, $P = 0.039$, 9% of the variance explained; all other *F* values <2, all other *P* values >0.250].

Study 2.

Composite indexes: Three smile types. Responses to the 15 items assessing emotional/motivational states that produce smiling were submitted to a factor analysis (principal axis factoring) using oblique rotation (Promax), where the number of factors was specified as three. The solution was interpretable in terms of the social functions of reward, bonding, and hierarchy negotiation proposed by Niedenthal et al. (19). The first factor (eigenvalue of 3.10) explained 20.65% of the variance and was represented by the items "wants to manipulate or control you," "wants to sell you something," "feels superior to you," "wants you to like them," "feels inferior to you," and "is embarrassed about something." The factor was labeled "hierarchy." The second factor (eigenvalue of 2.79) explained 18.62% of the variance and was represented by the items "wants to be a close friend of yours," "accepts you as an equal," "wants to acknowledge that you are in the same situation," "cares about you," "wants to make you comfortable," "has a friendly intention," and "wants to ask you for help." The factor was thus labeled "bonding." The third factor (eigenvalue of 1.16) explained 7.71% of the variance and was represented by the items "is a happy person" and "is in a good mood." This factor was thus labeled "reward." Factor 2 (bonding) was moderately correlated ($r = 0.41$) with factor 3 (reward). The other two correlations were small in magnitude ($r = 0.03$ for factors 1 and 2, $r = -0.13$ between factors 1 and 3). For ease of interpretation, three composite scores were constructed by averaging over the items representing each factor if their factor loadings were higher than 0.40. [Two items were not included in the composite scores: "wants to ask you for help" (factor loading of 0.35) and "is embarrassed about something" (factor loading of 0.31).] For the reward, bonding, and hierarchy smiles, alpha values were equal to 0.64, 0.68, and 0.73, respectively. These three indexes were then used in further analyses.

Cluster analysis. Patterns of responses were explored in two separate cluster analyses. First, we applied the SPSS TwoStep clustering analysis to participants' ratings of the three composite indexes of reward, bonding, and hierarchy motives for smiling. Cluster solutions were estimated in two analyses using the Bayesian information criterion and Akaike information criterion. In both analyses, the same stable two-cluster solution emerged after three iterations. The average silhouette coefficient was 0.4, indicating an acceptable solution. Of the 708 respondents to the survey, 699 were included in the cluster solution (nine remaining cases were excluded by the outlier-handling feature of the clustering algorithm). The solution assigned 287 respondents to cluster 1 and 412 respondents to cluster 2. The quality of this two-step cluster solution was assessed with another technique, namely, the K-Means clustering algorithm. This additional analysis produced very similar cluster profiles (details are provided in *Supporting Information, Appendix C*). Most respondents from the United States, New Zealand, and Canada were assigned to cluster 1, and most respondents from Japan, Indonesia, India, France, and Germany were assigned to cluster 2. Approximately equal proportions of Israeli respondents were assigned to each cluster (details are provided in Fig. 4 and Table S5).

Predicting cluster membership. We correlated the percentage of participants classified in cluster 1 with the scores for Heterogeneity, Fractionalization, Source Countries in 2013, Residential Mobility, and the three measures of individualism (Hofstede's I-C, Suh's I-C, and GLOBE I-C; details are provided in Table S4). Cluster membership, or the proportion of respondents assigned to cluster 1, was predicted by Heterogeneity [$r(7) = 0.82$, $P = 0.007$; $R^2 = 0.665$, $B = 0.636$, $F(1,7) = 13.91$, $B_{01} = 4.25$], Source Countries in 2013 [$r(7) = 0.72$, $P = 0.03$], Residential Mobility [$r(7) = 0.68$, $P = 0.04$], Hofstede's I-C [$r(7) = 0.78$, $P = 0.01$], and Suh's I-C [$r(5) = 0.83$, $P = 0.02$]. Partial correlations indicated that when controlling for Heterogeneity, all other culture constructs no longer remained significantly correlated with cluster membership ($r_{partial} < 0.55$, $P > 0.16$). Heterogeneity significantly or marginally significantly predicted cluster membership when controlling for Source Countries in 2013 [$r_{partial}(6) = 0.69$, $P = 0.06$], Residential Mobility [$r_{partial}(6) = 0.74$, $P = 0.04$], Hofstede's I-C [$r_{partial}(6) = 0.63$, $P = 0.09$], and Suh's I-C [$r_{partial}(4) = 0.93$, $P = 0.008$].

Heterogeneity and beliefs about reasons for smiling. To assess the relationship between Heterogeneity and the endorsement of smile functions further, we conducted three regression analyses. Heterogeneity was a marginally significant predictor of the bonding motives [$R^2 = 0.422$, $B = 0.007$, $F(1,7) = 5.12$, $P = 0.058$, $B_{01} = 1.45$] and of the hierarchy motives, such that historically homogeneous countries endorsed the hierarchy motives to a greater extent than heterogeneous countries [$R^2 = 0.669$, $B = -0.014$, $F(1,7) = 14.122$, $P = 0.007$, $B_{01} = 4.35$] (the full correlation matrix is provided in Table S4).

Additional analyses. Finally, we examined whether the cluster membership could be predicted by other potentially relevant variables, such as population density per square kilometer (42), GDP per capita (43), tightness (41), and power distance (39). Population density was significantly related to cluster membership [$r(7) = -0.67$, $P = 0.05$], such that less densely populated countries were more likely to be assigned to cluster 1. Moreover, participants from countries displaying lower levels of power distance tended to be less frequently assigned to cluster 1 [$r(7) = -0.61$, $P = 0.08$]. Partial correlations, however, revealed that the link between Heterogeneity and cluster membership remained significant and marginally significant after controlling for these variables [$r_{partial}(6) = 0.69$, $P = 0.06$ (density) and $r_{partial}(6) = 0.82$, $P = 0.01$ (power distance)]. Neither the GDP nor tightness was significantly related to cluster membership [$r(7) = 0.56$, $P = 0.11$ and $r(7) = -0.66$, $P = 0.10$, respectively].

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behavior in a given situation. This second measure was significantly correlated with the dimension of Overall Expressivity [$r(30) = 0.797$, $P < 0.000$] and with the number of source countries [$r(30) = 0.555$, $P = 0.001$].).

Q: 19_This former footnote has been incorporated directly into text per PNAS policy [The same was true for participants' individual scores of Overall Expressivity: A linear mixed model analysis with individuals nested within countries showed that country-level heterogeneity was positively related with participants' norms of Expressivity ($b = 0.001$, SE < 0.001, $t = 3.78$, $P < 0.001$).]. Also, is "*b*" or "*B*" correct in this expression and throughout remaining text? Both "*b*" and "*B*" are currently used in the context of statistical expressions throughout your paper; should "*b*" or "*B*" be standardized consistently throughout your paper? Please make these revisions as appropriate.

Q: 20_Is this sentence correct as revised (such that countries whose members are assigned largely to cluster 1 are relatively heterogeneous and those countries whose members are assigned largely to cluster 2 are relatively homogeneous)? Please make additional changes as necessary.

Q: 21_Per PNAS policy, if one numbered piece of SI is cited in the main article text, all the numbered pieces (composed and noncomposed) must be cited and must be cited in numerical order. Because Table S5 was cited before Table S4 in the original version of your paper, these two tables have been renumbered and recited in correct order in the main text. Original Table S5 is now Table S4, and original Table S4 is now Table S5. In addition, Tables S2 and S3 are not currently cited in main text. Please cite Tables S2 and S3 at appropriate sequential locations in main text.

Q: 22_PNAS articles should be accessible to a broad scientific audience. As such, please spell out GLOBE at first use (We used three indicators of collectivism: practices of In-Group Collectivism published in the GLOBE survey), and follow immediately with (GLOBE).

Q: 23_Is citation of reference 36 or 39 correct in this sentence [it is strongly ($r = -0.82$, $P < 0.01$) negatively correlated with Hofstede's (36) individualism and focuses on family integrity]? Please revise as necessary.

Q: 24_Please cite a reference number for Triandis in this statement [Our final measure was computed by Suh and colleagues (40) and is an average of Hofstede's I-C scores (39) and ratings proposed by Triandis (■■■)], and insert in the parentheses (instead of the three boxes) immediately following "Triandis (■■■)".

Q: 25_Is citation of reference 40 correct in this sentence [The latter measure was based on Triandis' personal judgment and observations (40)]? Please revise as necessary.

Q: 26_This former footnote has been directly into text per PNAS policy (The two other response options were "Unlikely to move" and "Don't know." Participants could also refuse to answer the question.).

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Q: 27_PNAS articles should be accessible to a broad scientific audience. As such, please spell out JZS [A JZS Bayes factor analysis (54) with default mixture-of-variance priors, and with reference to the null model, further supported the role of Heterogeneity].

Q: 28_This former footnote was incorporated directly into text per PNAS policy (To assess the role of Heterogeneity, we also performed a series of partial correlation analyses. Heterogeneity was significantly, or marginally significantly, correlated with Expressivity after controlling for GLOBE I-C [$r_{partial}(25) = 0.45$, $P = 0.019$], Hofstede's I-C [$r_{partial}(27) = 0.34$, $P = 0.068$], Suh's I-C [$r_{partial}(23) = 0.46$, $P = 0.020$], Residential Mobility [$r_{partial}(28) = 0.48$, $P = 0.008$], Fractionalization [$r_{partial}(29) = 0.47$, $P = 0.008$], and Source Countries in 2013 [$r_{partial}(29) = 0.41$, $P = 0.023$].).

Q: 29_Is "$N = 23$" or "$n = 23$" correct in this sentence [The index was computed as the average of standardized I-C scores when all three of them were available ($N = 23$)]? Please revise as appropriate.

Q: 30_This former footnote has been incorporated directly into text per PNAS policy [It is worth noting that an identical analysis using a combined I-C index yielded very similar results. The index was computed as the average of standardized I-C scores when all three of them were available ($N = 23$). In the first model, predicting Expressivity from Heterogeneity, I-C index, Residential Mobility, Source Countries in 2013, and Fractionalization, Heterogeneity and Residential Mobility were the only significant predictors [$B = 0.001$, $F(1,16) = 6.39$, $P = 0.022$, 17% of the variance explained and $B = 0.002$, $F(1,16) = 4.61$, $P = 0.047$, 12% of the variance explained, respectively]. Other effects were not significant (all F values <1.7, all P values >0.200). The backward regression model yielded a similar result with Heterogeneity and Residential Mobility as final predictors [$B = 0.001$, $F(1,19) = 11.48$, $P = 0.003$, 30% of the variance explained and $B = 0.002$, $F(1,19) = 3.15$, $P = 0.092$, 8% of the variance explained, respectively].].

Q: 31_The use of a single level 4 in a level 3 section should be avoided per PNAS policy. Please provide a second level 4 heading in this level 3 section (*Study 1*) or delete this single level 4 heading (*Additional analyses*).

Q: 32_This former footnote has been incorporated directly into text per PNAS policy (An identical regression analysis using the combined I-C index instead of the three original measures showed a similar pattern of results, with significant effects of Heterogeneity and GDP [$B = 0.001$, $F(1,5) = 70.79$, $P < 0.001$ and $B < -0.001$, $F(1,5) = 25.93$, $P = 0.004$, respectively] and a marginally significant effect of the combined I-C index [$B = 0.013$, $F(1,5) = 5.12$, $P = 0.073$].).

Q: 33_Please clarify the meaning of the word "Promax" in this sentence [Responses to the 15 items assessing emotional/motivational states that produce smiling were submitted to a factor analysis (principal axis factoring) using oblique rotation (Promax)].

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Q: 34_This former footnote has been incorporated directly into text per PNAS policy [Two items were not included in the composite scores: "wants to ask you for help" (factor loading of 0.35) and "is embarrassed about something" (factor loading of 0.31).].

Q: 35_PNAS articles should be accessible to a broad scientific audience. As such, BIC has been spelled out as "Bayesian information criterion" and AIC has been spelled out as "Akaike information criterion" (Cluster solutions were estimated in two analyses using the Bayesian information criterion and Akaike information criterion). Please revise as necessary.

Q: 36_Please add issue number in parentheses for all journal references in main text reference list in which the issue number is missing and the journal assigns one.

Q: 37_Is "*Individualism & Collectivism*" or "*Individualism and Collectivism*" correct title of book cited in reference 8 in main text reference list? Please revise as necessary.

Q: 38_The URL in reference 10 in main text reference list, http://www.gallup.com/strategicconsulting/worldpoll.aspx, has been redirected to http://www.gallup.com/sorry/FileNotFound.aspx?aspxerrorpath=/strategicconsulting/worldpoll.aspx. Please provide the correct URL for this website.

Q: 39_Please provide name and location (city and state/country) of publisher and/or URL and date site was accessed (whichever is correct) in reference 12 in main text reference list.

Q: 40_Is article title in reference 36 in main text reference list correct as written? Please revise as necessary.

Q: 41_Please provide year of publication in reference 42 in main text reference list.

Q: 42_Please provide year of publication in reference 43 in main text reference list.

Q: 43_Please note that the main text reference list (References 50–54) has been renumbered to address numbering problems present in the original manuscript.

Q: 44_Should "residential mobility" and "source countries in 2013" be "Residential Mobility" and "Source Countries in 2013" in legend for Fig. 2 (residential mobility, source countries in 2013)? Please revise as appropriate.

Q: 45_Should "heterogeneity" and "residential mobility" be "Heterogeneity" and "Residential Mobility" in legend for Fig. 2 (heterogeneity, and residential mobility)? Please revise as appropriate.

Supporting Information

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Appendix A

Study 1: Emotional Expressivity and Indigeneity. In addition to our main measure of historical heterogeneity (i.e., the number of source countries contributing to a given society between the years A.D. 1500 and A.D. 2000, we analyzed the relationships between emotional expressivity and the index of nonindigeneity, or the approximation of the extent to which a country's population in the year A.D. 2000 descended from people living within the borders of that country in the year A.D. 1500 (1).

Importantly, the analyses reported below do not include Hong Kong because of the atypical status, size, and population structure of this region (details are provided in ref. 1). During its history, the territory was mostly deserted due to the Great Clearance (1661–1669) (2) and was repopulated by mainland Chinese. Indeed, according to the matrix, 97% of the population of Hong Kong originates from the neighboring country of China. Its population turnover score of 0 is thus misleading and not representative of nonindigeneity.

Analyses revealed that mean scores of Overall Expressivity for each of the 31 countries sampled in the study were significantly correlated with indigeneity on both individual and group levels [$r(29) = -0.46$, $P = 0.01$; $b = -0.06$, SE = 0.02, $t = 2.78$, $P = 0.001$ (linear mixed model with individuals nested within countries)], such that display rules favoring the expression of emotion were endorsed less in the countries whose populations largely descended from indigenous populations. Importantly, this correlation did not persist when Hong Kong was included in the dataset [$r(30) = -0.23$, $P = 0.22$].

We also conducted a country-level multiple regression analysis predicting Expressivity from indigeneity, the three measures of individualism, residential mobility, percentage of immigrants in each country's population (3), and ethnic fractionalization. The model explained 69% of the variance [$F(7,14) = 4.43$, $P < 0.01$]. Indigeneity was the only significant predictor of emotional expressivity [$B = -0.04$, $F(1,14) = 7.69$, $P = 0.01$] and explained 17% of the variance. Residential mobility was marginally significantly related to Expressivity [$B = 0.002$, $F(1,14) = 3.91$, $P = 0.07$]. None of the other predictors was significant (all F values <3.0, all P values >0.12). Given that this result may be partially due to multicollinearity because three measures of individualism were included in the model, we conducted an additional analysis using backward regression, removing each predictor sequentially from the full model. The P values were fixed to 0.05 (entry) and 0.10 (removal). The final model emerged after three iterations and contained four predictors: Indigeneity [$B = -0.04$, $F(1,17) = 7.39$, $P = 0.01$, 15% variance explained], Hofstede's I-C [$B = 0.001$, $F(1,17) = 10.47$, $P < 0.01$, 21% variance explained], Immigrants [$B = -0.001$, $F(1,17) = 5.61$, $P = 0.03$, 11% variance explained], and Residential Mobility [$B = 0.002$, $F(1,17) = 3.65$, $P = 0.07$, 7% variance explained].

Appendix B

Study 2: Questionnaire Assessing Feelings and Motives Producing Smiles.

> Here is a list of possible reasons for a person to smile at you. Rate the degree to which you think that the cause listed is a good reason to smile. There are no right answers. If you strongly disagree that the reason is a good one, circle −3. If you neither agree nor disagree, circle 0. If you strongly agree that the reason is good, circle 3. Intermediate numbers correspond to intermediate degrees of agreement and disagreement.

A person smiles at you for good reason because he or she...

	Strongly disagree			Neither agree nor disagree			Strongly agree
a) Is in a good mood	−3	−2	−1	0	1	2	3
b) Is a happy person	−3	−2	−1	0	1	2	3
c) Wants to sell you something	−3	−2	−1	0	1	2	3
d) Has a friendly intention	−3	−2	−1	0	1	2	3
e) Cares about you	−3	−2	−1	0	1	2	3
f) Wants to manipulate or control you	−3	−2	−1	0	1	2	3
g) Accepts you as an equal	−3	−2	−1	0	1	2	3
h) Wants to acknowledge that you are in the same situation	−3	−2	−1	0	1	2	3
i) Feels inferior to you	−3	−2	−1	0	1	2	3
j) Wants you to like them	−3	−2	−1	0	1	2	3
k) Wants to make you comfortable	−3	−2	−1	0	1	2	3
l) Wants to be a close friend of yours	−3	−2	−1	0	1	2	3
m) Wants to ask you for help	−3	−2	−1	0	1	2	3
n) Feels superior to you	−3	−2	−1	0	1	2	3
o) Is embarrassed about something	−3	−2	−1	0	1	2	3

Appendix C

Study 2: Details of the K-Means Clustering Procedure. The validity of the TwoStep cluster solution was assessed with a second analysis using the K-Means clustering algorithm. This method is also adapted to large sample sizes but requires prior specification of the number of clusters. The analysis was performed on the three indexes of motives for smiling. The number of clusters was specified as two. Convergence was achieved in 17 iterations. All 708 respondents were included in the K-Means solution. Cluster 1 included 366 participants, and cluster 2 included 342 participants (details are provided in Table S5). The differences between clusters were similar to those differences obtained in the TwoStep procedure. Accordingly, respondents from cluster 1 rated hierarchy motives as less important for the generation of a smile compared with respondents from cluster 2. They also rated reward and bonding motives as more important compared with respondents from cluster 2 (cluster centers are provided in Tables S2 and S3). Even when the cluster composition with the K-Means algorithm was slightly different from the one obtained with the TwoStep procedure, both analyses yielded similar cluster profiles: Cluster 1 was lower than cluster 2 on hierarchy and higher in bonding and reward motives. In both solutions, hierarchy motives were the strongest predictors of cluster membership, followed, respectively, by reward and bonding motives. Proportions of respondents in each country were also similar (details are provided in Table S5): In both solutions, most respondents in the United States, New Zealand, and Canada were classified in cluster 1, whereas most respondents in Japan, Indonesia, France, Germany, and India were assigned to cluster 2. Percentages of respondents assigned to cluster 1 by both algorithms were also strongly correlated [$r(7) = 0.98$, $P < 0.001$].

1. Putterman L, Weil DN (2010) Post-1500 Population Flows and the Long Run Determinants of Economic Growth and Inequality. *Q J Econ* 125(4):1627–1682.
2. Hayes J (1974) The Hong Kong Region: Its Place in Traditional Chinese Historiography and Principal Events Since the Establishment of Hsin-an County in 1573. *J Roy Asiatic Soc Hong Kong Branch* 14:108–135.
3. United Nations, Department of Economic and Social Affairs Population Division (2014) Trends in International Migrant Stock: The 2013 Revision: Migrants by Destination and Origin (United Nations database, POP/DB/MIG/Stock/Rev 2013).

Table S1. Study 2: Details of the procedure

Canada	University of Alberta	English	70	23	47	19.31	7	Individual/laboratory sessions	Course credit	With an unrelated study
France	Clermont University	French (back-translation)	72	32	40	23.50	34	Collective/in class	Volunteers	
Germany	University of Cologne	German (back-translation)	71	34	37	25.39	15	Collective/in class	Volunteers	
India	Karnatak University	English	73	21	52	25.07	43	Individual/laboratory sessions	Volunteers	
Indonesia	Universitas Indonesia	Indonesia (back-translation)	94	51	43	20.26	12	Collective/in class	Volunteers	
Israel	Bar Ilan University	Hebrew (back-translation)	100	35	65	28.19	43	Individual/at home	Volunteers	
Japan	Waseda University	Japanese (back-translation)	76	41	35	19.83	8	Collective (up to five participants)/ laboratory sessions	Book coupon	With an unrelated study
New Zealand	University of Otago	English	85	35	50	19.94	12	Individual/ laboratory sessions	Course credit	With an unrelated study
United States	University of Wisconsin-Madison	English	67	27	40	18.70	3	Collective (up to five participants)/ laboratory sessions	Course credit	With an unrelated study

Table S2. Predictor importance and mean scores of the three smile indexes for the two clusters (TwoStep clustering)

Smile index	Predictor importance	Cluster 1 (heterogeneous countries) (n = 287, 41.1%)	Cluster 2 (homogeneous countries) (n = 412, 58.9%)
Hierarchy	1.00	−1.32	0.49
Reward	0.26	2.69	2.06
Bonding	0.16	1.94	1.43

Table S3. Final cluster centers for the three smile indexes (K-Means clustering)

Smile index	Cluster 1 (heterogeneous) (n = 366, 51.7%)	Cluster 2 (homogeneous) (n = 342, 48.3%)	$F(1,206)$	P
Hierarchy	−1.24	0.80	1,410.69	<0.001
Reward	2.43	2.12	26.02	<0.001
Bonding	1.74	1.47	18.95	<0.001

Table S4. Cluster membership and endorsement of reward, bonding, and hierarchy motives as a function of heterogeneity and related construct

	1	2	3	4	5	6	7	8	9	10	11
1) Cluster 1 membership	1										
2) Reward motives	0.653	1									
3) Bonding motives	0.803*	0.643	1								
4) Dominance motives	−0.998**	−0.606	−0.722*	1							
5) Historical heterogeneity	0.816**	0.530	0.650	−0.818**	1						
6) Ethnic fractionalization	0.373	0.402	0.796*	−0.268	0.440	1					
7) Source countries in 2013	0.716*	0.795*	0.455	−0.747*	0.605	0.051	1				
8) Residential mobility	0.680*	0.818**	0.457	−0.700*	0.518	0.126	0.756*	1			
9) GLOBE I-C*	0.541	0.485	0.239	−0.576	0.352	−0.293	0.790*	0.411	1		
10) Hofstede's I-C	0.781*	0.540	0.389	−0.850**	0.672*	−0.117	0.896**	0.695*	0.782*	1	
11) I-C (1)	0.830*	0.590	0.457	−0.876**	0.797*	−0.030	0.932**	0.706	0.804*	0.983**	1

*$P < 0.05$.
**$P < 0.01$.

1. Suh E, Diener E, Oishi S, Triandis H (1998) The shifting basis of life satisfaction judgments across cultures: Emotions versus norms. *J Pers Soc Psychol* 74:482–493.

Table S5. Frequency and proportion of respondents for cluster 1 and cluster 2 by country

	TwoStep					K-Means				
Country	Cluster 1		Cluster 2		*N*	Cluster 1		Cluster 2		*N*
	N	%	*N*	%		*N*	%	*N*	%	
Canada	40	57.1	30	42.9	70	47	67.1	23	32.9	70
France	21	29.6	50	70.4	71	31	43.1	41	56.9	72
Germany	21	30.0	49	70.0	70	33	46.5	38	53.5	71
India	19	27.5	50	72.5	69	34	46.6	39	53.4	73
Indonesia	18	19.1	76	80.9	94	25	26.6	69	73.4	94
Israel	47	47.5	52	52.5	99	55	55.0	45	45.0	100
Japan	10	13.5	64	86.5	74	17	22.4	59	77.6	76
New Zealand	56	65.9	29	34.1	85	64	75.3	21	24.7	85
United States	55	82.1	12	17.9	67	60	89.6	7	10.4	67
Total	287	41.1	412	58.9	699	366	51.7	342	48.3	708

AUTHOR QUERIES

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Q: 1_Is "residential mobility" or "Residential Mobility" correct in this sentence in SI text (We also conducted a country-level multiple regression analysis predicting Expressivity from indigeneity, the three measures of individualism, residential mobility, percentage of immigrants in each country's population. . .), and throughout remaining SI text? Please revise as appropriate at each use of this term.

Q: 2_Please spell out name of journal in reference 2 in SI reference list; not indexed in PubMed, CASSI, or PNAS list of journal abbreviations.

Q: 3_Please provide name and location (city and state/country) of publisher and/or URL and date site was accessed (whichever is correct) in reference 3 in SI text reference list.

Q: 4_Please provide heading for column 1 in revised Table S4.

Q: 5_Is the asterisk following "GLOBE I-C" correct as written in body of revised Table S4? As written, the asterisk is a footnote citation and means $P < 0.05$.

Q: 6_Per PNAS style, a reference not cited in the SI text has been placed with the legend of the SI table in which it is cited. Note that this reference is numbered independently in this table (revised Table S4). Please check this citation carefully.