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2020-10

Jonauskaite, D, Abu-Akel, A, Dael, N, Oberfeld, D, Abdel-Khalek, A M, Al-Rasheed, A S, Antonietti, J-P, Bogushevskaya, V, Chamseddine, A, Chkonia, E, Corona, V, Fonseca-Pedrero, E, Griber, Y A, Grimshaw, G, Hasan, A A, Havelka, J, Hirnstein, M, Karlsson, B S A, Laurent, E, Lindeman, M, Marquardt, L, Mefoh, P, Papadatou-Pastou, M, Perez-Albeniz, A, Pouyan, N, Roinishvili, M, Romanyuk, L, Salgado Montejó, A, Schrag, Y, Sultanova, A, Uuskuela, M, Vainio, S, Wasowicz, G, Zdravkovic, S, Zhang, M & Mohr, C 2020, 'Universal Patterns in Color-Emotion Associations Are Further Shaped by Linguistic and Geographic Proximity', *Psychological Science*, vol. 31, no. 10, 0956797620948810, pp. 1245-1260. <https://doi.org/10.1177/0956797620948810>

<http://hdl.handle.net/10138/324372>

10.1177/0956797620948810

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Running head: Universal color-emotion associations in 30 nations

Universal patterns in color-emotion associations are further shaped by linguistic and geographic proximity

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Significance statement

Why do we *see red, feel blue, or turn green* with envy? Are such associations between color and emotion fundamental to our shared cognitive architecture? Or are they cultural creations learned through our languages and traditions? To answer these questions, we tested the emotional meaning of colors in 4598 participants from 30 nations, in 22 languages. Overall, participants associated similar emotion concepts with 12 color terms. Moreover, similarity was higher between nations that share borders or languages. Color-emotion associations have universal features, further shaped by a shared language and / or geography. These results pose further theoretical and empirical questions about the affective properties of color, and may inform practice in applied domains such as well-being and design.

Abstract

Many of us *see red, feel blue, or turn green* with envy. Are such color-emotion associations fundamental to our shared cognitive architecture, or are they cultural creations learned through our languages and traditions? To answer these questions, we tested emotional associations of colors in 4598 participants from 30 nations, speaking 22 native languages. Participants associated 20 emotion concepts with 12 color terms. Pattern similarity analyses revealed universal color-emotion associations (average similarity coefficient $r = .88$). But, local differences were also apparent. A machine learning algorithm revealed that nation predicted color-emotion associations above and beyond those observed universally. Similarity was greater when nations were linguistically geographically or close. This study highlights robust universal color-emotion associations, further modulated by linguistic and geographic factors. These results pose further theoretical and empirical questions about the affective properties of color, and may inform practice in applied domains like well-being and design.

Abstract word count: 146 words (max 150)

Keywords: Affect; color perception; cross-cultural; universality; cultural relativity; pattern analysis

Word count: 5379 (all) / 1888 (counted) words (max 2000 words for introduction, discussion, footnotes, and acknowledgments, 40 references).

Introduction

Color-emotion associations are ubiquitous (Adams & Osgood, 1973; Hupka et al., 1997; Madden et al., 2000; Major, 1895; Palmer et al., 2013; Valdez & Mehrabian, 1994; Wexner, 1954; Wilms & Oberfeld, 2018). Common wisdom would suggest that we *feel blue* when sad, *see red* when angry, and are *green with envy*. Yet, envy can be yellow or red if we come from Germany or Poland, respectively (see Hupka et al., 1997). And while westerners are likely to wear white to weddings and black to funerals, people from China prefer red for weddings and white for funerals. Wherever one comes from, such color-emotion associations are intriguing because colors and emotions seem – at face value – to be fundamentally different “things”. Colors are visual experiences driven by the wavelength of light. Emotions are subjective feelings, cognitions, and physiological responses that signal value. Are these cross-modal associations cultural creations, laid down in our languages and traditions? Or are they fundamental features of our cognitive architecture? Existing studies have identified both similarities (Adams & Osgood, 1973; D’Andrade & Egan, 1974; Gao et al., 2007; Ou et al., 2018) and differences (Hupka et al., 1997; Madden et al., 2000; Soriano & Valenzuela, 2009) across cultures. However, they have done so between only a small number of individual countries, making it nearly impossible to capture global patterns. In a series of analyses, we examined to what extent color-emotion associations are universal, testing 4598 participants from 30 nations on 6 continents in 22 languages.

There are two theoretical explanations for color-emotion associations, which make different predictions about the degree to which the emotional meanings of color should be shared. According to the first view, color-emotion associations arise through environmental experiences. That is, colors may become associated with emotions because they appear in particular emotional situations of evolutionary significance (e.g., *red* face in anger; Benitez-Quiroz, Srinivasan, & Martinez, 2018). If so, color-emotion associations should be largely universal (in support, see Adams & Osgood, 1973; D’Andrade & Egan, 1974; Gao et al., 2007; Ou et al., 2018). According to the second theoretical explanation, colors and emotions may become arbitrarily associated in the language, history, religion, or folklore of one’s culture. If so, color-emotion associations should vary between cultures with different languages, symbolism, and traditions (Evarts, 1919; Soriano & Valenzuela, 2009). Such cross-cultural variations have also been reported (Hupka et al., 1997; Madden et al., 2000; Soriano & Valenzuela, 2009). While these views are often cast in opposition to each other, they are not mutually exclusive. According to the cross-modal correspondence framework (Spence, 2011), two unrelated entities (here, colors and emotions) can become cross-modally associated when they regularly appear together in one’s perceptual *or* linguistic environment, whether on a global (shared by all) or local (shared by some) scale.

It is possible, therefore, that universal tendencies to associate certain colors with certain emotions are further modulated by cultural and individual factors. Consider red, an ambivalent color that has been associated with both negative and positive emotions, depending on whether one comes from Western countries or China (Jonaskaite, Wicker, et al., 2019). The existence of both associations could be explained in evolutionary terms (e.g., red-blood pairings lead to associations with both danger and sexuality). In some countries like China, however, cultural beliefs that red is a symbol of good fortune might strengthen the link between red and positive emotions and weaken the link between red and negative emotions (see Wang, Shu, & Mo, 2014). In other countries, like the USA, the strong link between red and danger or failure could strengthen negative while weakening positive associations (Pravossoudovitch et al., 2014). Such additional variations might be maintained through

language and geographic locations (see also Jackson et al., 2019; Jonauskaite, Abdel-Khalek, et al., 2019).

Existing studies provide examples of both similarities (Adams & Osgood, 1973; D’Andrade & Egan, 1974; Gao et al., 2007; Ou et al., 2018) and differences (Hupka et al., 1997; Madden et al., 2000; Soriano & Valenzuela, 2009) across countries. But these studies have focused on just a few countries, languages, or cultures, and so global patterns are still unknown. To test for the degree of universality, we performed a large-scale, cross-cultural survey on color-emotion associations (for theoretical motivation, see Mohr, Jonauskaite, Dan-Glauser, Uusküla, & Dael, 2018). Participants completed the survey in their native language online. We exceeded previous investigations in terms of the number of tested nations, representativeness of participants, and the number of tested colors and emotions. We collected data from 4598 participants from 30 nations, located on all continents but Antarctica (Fig 1). Participants were aged between 15 and 87 years old and had normal color vision. We used 12 color terms representing the most common color categories (Berlin & Kay, 1969; Mylonas & MacDonald, 2015) and an extensive list of 20 emotion concepts varying in valence and potency (Scherer, 2005). Participants chose as many emotion concepts as they thought associated with a given color term and rated the intensity of the associated emotion from weak to strong.

In a series of analyses, we examined the degree of similarity across the 30 nations in *probabilities* of color-emotion associations and *intensities* of associated emotions. We then applied a machine learning algorithm to quantify the degree of nation-specificity in color-emotion associations. Finally, we assessed how color-emotion associations varied as a function of linguistic and geographic distances.

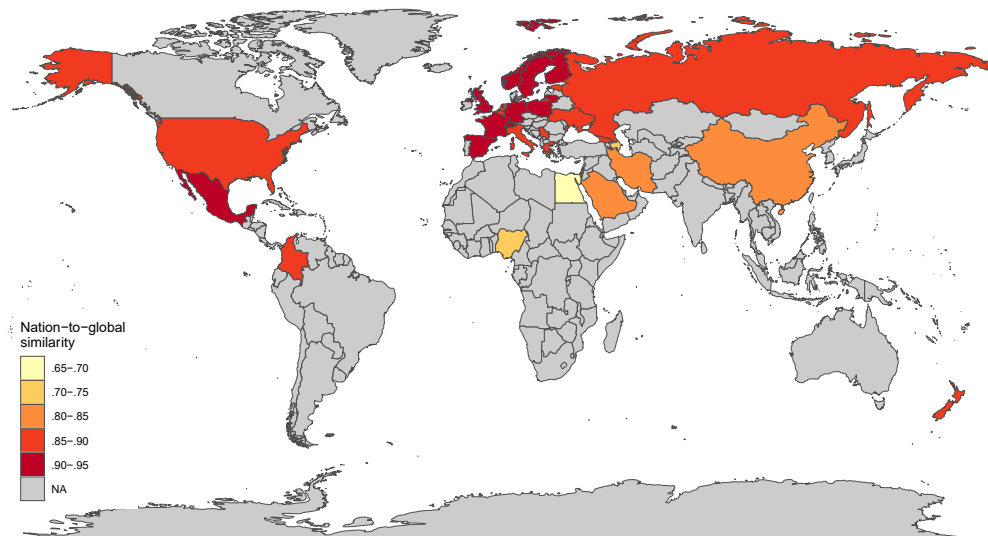


Fig 1. The world map of the 30 studied nations. The map is colored by nation similarity with the global color-emotion association pattern. Redder nations show color-emotion association patterns more similar to the global mean (also see Fig 4 A).

Materials and methods

Participants

We extracted our data from the ongoing International Color Emotion Association Survey (Mohr et al., 2018), performed online. This survey tests participants from a large age range using pre-defined age categories (15-29 years, 30-49 years, 50+ years). We started with the largest possible participant pool ($N = 4883$) consisting of data sets from countries for which we had at least 20 useable (e.g., without self-reported problems of color vision) participants per age category (see also, Simmons, Nelson, & Simonsohn, 2011). We detail additional selection criteria under *Data preparation*. Our final sample ($n = 4598$, 1114 males) consisted of participants from 30 different nations (Fig 1) with a mean age of 35.4 ($SD = 14.5$). Counts per nation ranged from 69 to 490 participants. Table S 1 provides language information and Table S 2 provides demographic information of the participants of each nation. Participation was voluntary. The study was conducted in compliance with the ethical standards described in the Declaration of Helsinki. Parts of the data have been reported previously in relation to different research questions (Jonaskaite et al., 2020; Jonaskaite, Abdel-Khalek, et al., 2019; Jonaskaite, Wicker, et al., 2019).

Material and Procedure

Emotion assessment with the Geneva Emotion Wheel (version 3.0, Fig 2 (Scherer, 2005; Scherer et al., 2013)). The Geneva Emotion Wheel is a self-report measure designed to assess the feeling component of emotional experiences elicited by particular events. It is based on theoretical categorizations of emotions and validated through research. The Geneva Emotion Wheel represents 20 discreet emotions (e.g., *anger, fear, joy*) as spokes on a wheel. Emotion concepts that are similar in valence (*positive/negative*) and power (*high/low*) are placed close to each other. Each spoke of the wheel contains five circles that extend from a central square, representing increasing intensities of each emotion.

For each color term, participants used a mouse click to indicate the associated emotions and their intensities (that is, they could indicate that a single color term is associated with more than one emotion concept, see Fig 2). At the beginning of the trial, the central square was selected, indicating no emotion. Participants were also given the option to select “Different Emotion”, which produced a pop-up window in which they could type the name of a different emotion. These responses were rare, and we did not analyze them.

Participants completed the Geneva Emotion Wheel in their native language. The translation of the Geneva Emotion Wheel was available for some languages on the Swiss Centre for Affective Sciences website. The remaining translations were created using the back-translation technique (see section *Translation of the Geneva Emotion Wheel* in *Supplementary Material* for further details). See Table S 3 for emotion terms in each language.

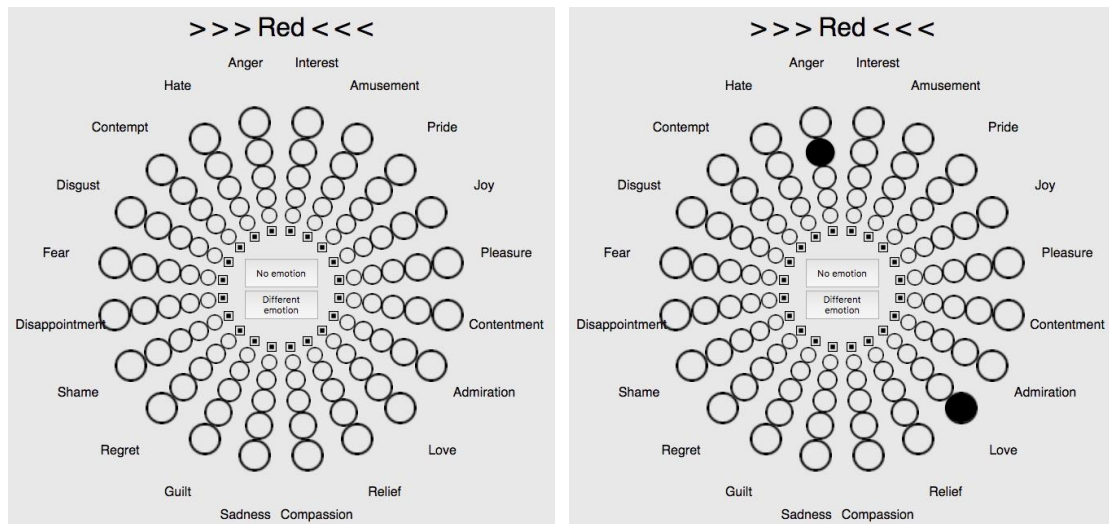


Fig 2. The Geneva Emotion Wheel with the color term *red* as an example. The wheel was used to assess associations between 20 emotion concepts and 12 color terms. Participants expressed emotion associations by selecting one of the five circles of each of the associated emotion. At the same time, they chose the intensity of the associated emotion, ranging from weak (smallest circle) to strong (largest circle). Participants could select as many or as few emotions as they thought appropriate. The right panel exemplifies a potential response from a participant for the color term *red* associated with strong *love* and relative strong *anger*.

International Color-Emotion Association Survey (<http://www2.unil.ch/onlinepsylab/colour/main.php>). We collected the current data online by sharing the survey link with potential participants via university communications, e-mails, social media, and personal contact, mainly through our collaborators (co-authors) in each country. The survey was originally constructed in English, and was translated (without back-translation) by co-authors and collaborators (see *Acknowledgments* section). We used links that automatically opened in the official language of the country to encourage participants to complete the survey in their native language. However, participants could switch to any other language provided. We only analyzed data gathered from native speakers. Online data collection naturally resulted in literate participants with access to the Internet. Some elderly participants were helped with survey completion.

The first page described the aims of the study and ethical considerations; participants consented by clicking on the “Let’s go” button. The following two instruction pages explained the task and the use of the Geneva Emotion Wheel. We then used a manipulation check to verify that participants understood the task. Participants were presented with a situation and had to identify the correct responses. The situation read: “*Peter thinks that beige strongly represents intense compassion, and believes that beige is also associated with mild relief. Accidentally, he has selected sadness and wants to correct his choice. Look at his response in the emotion wheel below and try to correct it*”. Participants saw the largest circle for *sadness* marked (emotion intensity 5). They could only move to the next page and start the survey if they successfully corrected Peter’s responses. They had to click on the square for *sadness* (no association, rating 0), the largest circle for *compassion* (emotion intensity 5), and the middle circle for *relief* (emotion intensity 3). If participants made a mistake and tried to move forward,

a pop-up window guided them to the correct responses. This manipulation check ensured that participants understood the task.

In the actual task, participants were presented with 12 color terms (not color patches): *red, orange, yellow, green, blue, turquoise, purple, pink, brown, black, grey* and *white* (see Table S 4 for the color terms in all languages). Color terms appeared one at a time above the Geneva Emotion Wheel in randomized order. For each color term, participants could select any number of the emotion concepts they thought were associated with the given color term, or indicate none. They rated the intensity of each chosen emotion (Fig 2). On average, participants associated 3.05 emotion concepts with a color term (95% CI = [3.03 – 3.08]; range = 2.25 – 3.84, see Table S 5).

After evaluating the 12 color terms, participants completed a demographic questionnaire in which they reported their age, sex, color blindness, importance of color in their life, country of origin, country of residence, native language, and fluency of the language in which they completed the color-emotion survey. Participants could select the “do not want to answer” option for any of the demographic questions. On the final page, participants were thanked and received results from a previous, related study in a graphic form. We provided an e-mail address for future contact. The survey took 31 minutes on average to complete for the current sample (survey access: <http://www2.unil.ch/onlinepsylab/colour/main.php>).

Data preparation

We applied the following inclusion and exclusion criteria to clean the data. We included participants who i) finished the survey, ii) completed the survey in their native language, and iii) this language was the official language of their country of origin. Taking Norway as an example, we included native Norwegian speakers who completed the survey in Norwegian (Bokmål) and their country of origin was Norway. An exception was made for participants from Nigeria, who completed the survey in English (national language). Nigerian participants had high English proficiency levels ($M = 7.02$, $SD = .29$, out of 8; see Table S 1 for other languages and countries). As we stated above, we excluded participants who might have been color-blind by self-report (i.e., responded “yes”, “do not know”, or “do not want to answer” to the question “Do you have trouble seeing colors?”). There were 285 (5.8%) potentially color-blind participants across all the nations.

Statistical analyses

With 20 emotion concepts and 12 color terms, we obtained 240 ratings of color-emotion associations per participant. From these associations, we extracted two dependent variables. The first dependent variable was the **probability** of color-emotion associations. The second dependent variable was **emotion intensity** (see below). The alpha level was set to .050 for all statistical analyses. Statistical analyses were performed and graphs created with SPSS v.25 and R Studio v. 1.1.4 (R version 3.4.0).

Global probabilities. To evaluate the probability of color-emotion associations, we assessed which emotion(s) are associated with each color term without considering emotion intensity. To this end, all selected emotion associations were coded as 1 (regardless of intensity), and all non-selected emotion associations were coded as 0. We used a Bayesian method to estimate probabilities of each emotion being associated with each color term (see section *Bayesian probabilities* in *Supplementary material*). We used the mean estimated probabilities of all participants for each color-emotion pair to construct a global matrix of color-emotion

association probabilities (12×20 ; Fig 3). The same procedure was repeated for each of the 30 nations separately to obtain mean probabilities of associating every emotion with every color term in each of the 30 nations (see 30 nation-specific color-emotion association matrices in Table S 6). We used nation-specific matrices for further cross-cultural comparisons.

Cultural probabilities and their comparisons. We first determined the degrees of similarity between nation-specific patterns of color-emotion associations and the global pattern of color-emotion associations – *nation-to-global pattern similarity*. The underlying values were Bayesian probabilities. The degrees of similarity were calculated by computing Pearson’s correlations between the 12×20 color-emotion association probabilities of each nation (nation-specific matrix) and the corresponding global 12×20 color-emotion association probabilities (global matrix without that nation). The global probabilities were always based on data from 29 nations, that is, all nations but the nation of comparison. These 30 global matrices including the data from 29 nations correlated from .9983 to .9993 with the global matrix including the data from all 30 nations. Hence, no single nation unduly influenced the global pattern. See the full list of nation-specific and global matrices in Table S 6. Next, we estimated *nation-to-nation pattern similarity* by correlating all nation-specific matrices with each other (900 matrix correlations, Table S 7). We also looked at the effects of sex (Table S 8) and age (Table S 9), reported in the *Results* sub-section *Socio-demographic factors*. Finally, we repeated the pattern similarity analyses per color term. That is, we correlated nation-specific patterns of color-emotion association probabilities with global patterns excluding that nation for each color term (e.g., nation-specific pattern of *red* vs. global pattern of *red*, excluding that nation; Table S 10). In all of these comparisons, a score of 1.0 indicates perfect color-emotion association pattern similarity, while a score of 0.0 indicates complete color-emotion association pattern dissimilarity.

In addition to color-emotion association pattern similarity, we calculated the average probabilities of associating any color with any emotion – *color-emotion association average probability*. The nation-specific color-emotion association average probability was calculated by averaging all the 240 Bayesian probabilities of color-emotion associations of each nation. The unweighted global color-emotion association average probability was calculated by averaging all nation-specific color-emotion association average probabilities (global average probability score = .161, 95% CI = [.150-.174]). We compared the global color-emotion association average probability with nation-specific color-emotion association average probabilities using one-sample *t*-tests. To account for multiple comparisons, *p*-values were FDR corrected, using $q = 0.05$ as threshold. As in the pattern similarity analyses, we repeated the comparisons per color term as well as for sex and age (see the *Results* sub-section *Socio-demographic factors*). A color-emotion association average probability score of 1.0 indicates that all color terms were associated with all emotion concepts, while a score of 0.0 indicates that no color term was associated with any emotion concept.

The emotion intensity variable provides information about the average intensity of all emotions associated with each color term. To calculate *emotion intensity similarities*, we took all emotion concepts associated with a given color term (previously coded as 1) by a given participant and averaged the intensities assigned to these emotions. Emotion intensities are reported per color term and not per color-emotion association. They varied from 1 (weak) to 5 (intense), unless no emotion was chosen for a given color term (coded as missing value). We had 12 emotion intensity scores per participant (one score per color term) and compared these scores across nations. We computed Pearson’s correlations between the 12 emotion intensity scores of each nation and the corresponding global emotion intensity scores, each time leaving out that nation, when calculating nation-to-global emotion intensity similarities

(see Table S 11). The resulting 29 global emotion intensity matrices including the data from 29 nations correlated from 0.9967 to 0.9999 with the global emotion intensity matrix including the data from all 30 nations. Hence, no single nation unduly influenced the global pattern. An emotion intensity similarity score of 1.0 indicates perfect emotion intensity pattern similarity, while a score of 0.0 indicates complete pattern dissimilarity.

Multivariate pattern classification. We used a supervised machine learning approach to predict the nation of each participant from his or her set of 240 ratings of color-emotion association (also see, Jonauskaite, Wicker, et al., 2019). The accuracy of the classifier provides a quantitative measure of nation-specificity in color-emotion associations. If the accuracy is equal to chance, this indicates an absence of nation-specificity in the color-emotion associations (i.e., perfect universality). In contrast, high accuracy indicates a high degree of nation-specificity. For details of the classifier algorithm, fitting and evaluation, see *Multivariate pattern classification in Supplementary material*.

A quantitative measure of the similarity between a pair of nations in terms of their color-emotion associations can be readily computed from the classifiers' confusion matrix, based on the assumption that nations that are more similar will be more frequently confused by the classifier than nations that are less similar. We used Luce's biased choice model (Eq. 5 in Luce, 1963) to estimate similarity values for each pair of nations from the confusion matrix. By convention, a similarity value between a nation and itself is set to 1.0 (representing maximum similarity), while a similarity value of 0.0 means that the two nations are completely dissimilar. The estimated similarity values are displayed in Fig S 1.

Linguistic and geographic distances. In addition to assessing cultural similarities, we tested whether two factors – linguistic distance and geographic distance – explain part of the similarity between the color-emotion associations of different nations. We extracted linguistic distances for each nation-nation pair from Jäger (2018) (see *Linguistic distances in Supplementary Material* for language codes). These distances are suggested to capture phylogenetic distances that quantify the degree of similarity between the languages of our nation pairs.

The linguistic distances in Jäger (2018) range from 0 to 1, with lower linguistic distance scores indicating higher linguistic similarities. In this dataset, the linguistic distances are not evenly spread across this range because there are more unrelated than related language pairs in the world. This was true in our sample of languages too. In fact, the first 25% of distances fell between 0 and .75 while the remaining 75% of distances were concentrated between .75 and .90. To make the spread more homogeneous, we transformed the original distances by raising the power. At the fourth power, the transformed linguistic distances resulted in a more homogeneous spread (quantiles at 0.00, 0.32, 0.41, 0.53, and 0.65). Jäger (2018) proposed that language pairs with distances below .7 should be considered as related. Using the transformed linguistic distances, the criterion for related languages became .24 (i.e., $.7^4$). From here onwards, we refer to these transformed linguistic distances as “linguistic distances” (see these linguistic distances in Table S 12).

We also calculated geographic distances for all nation pairs. We used population-weighted centers to reflect the location within each country where participants were most likely to originate. If we could not find population-weighted centers, we used the geographic coordinates of the most populated city of that nation (see Table S13). Using these centers, we calculated distances (in kilometers) on a sphere between all pairs of nations (see Table S14). In two linear regression models, we used linguistic and geographic distances to predict 1)

nation-to-nation pattern similarity scores (see *Cultural probabilities and their comparisons*) and 2) Luce’s similarity scores (see *Multivariate pattern classification*). We argue that comparable results using both approaches provide stronger evidence for the role of linguistic and/or geographic distance, not least because scores are extracted using very different statistical methods – correlations and multivariate pattern classification.

Results

Global probabilities

We determined the *global matrix* of the color-emotion association probabilities based on the unweighted means of the estimated Bayesian probabilities for each color-emotion pair across our 30 nations. Prominent color-emotion associations (probabilities ≥ 0.4 , based on our data) were *black and sadness, black and fear, black and hate, red and love, red and anger, pink and love, pink and joy, pink and pleasure, grey and sadness, grey and disappointment, yellow and joy, orange and joy, orange and amusement, and white and relief* (Fig 3 & Table S 6).

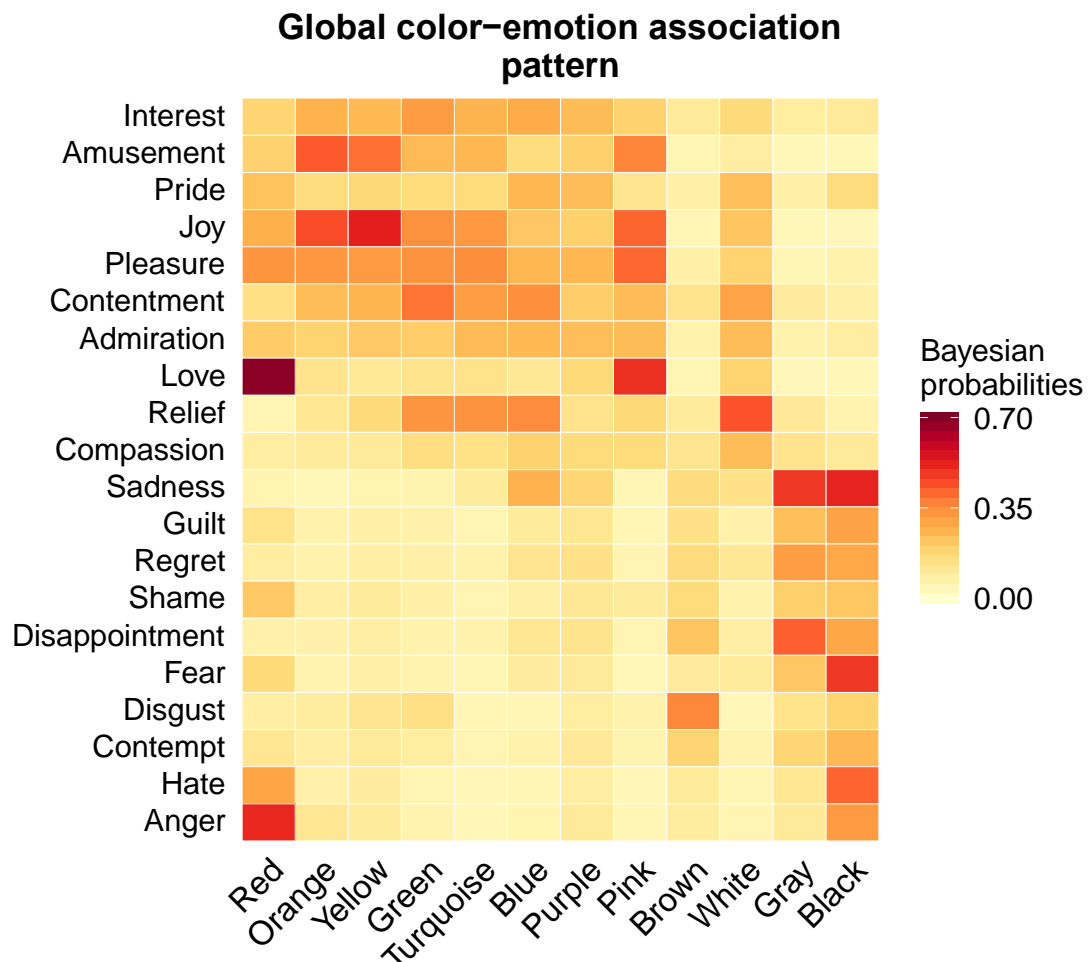


Fig 3. Heatmap of the unweighted averages of the color-emotion association probabilities across our 30 nations. More saturated orange or red indicate a higher probability of a

specific color-emotion association. The cells are not exclusive, meaning that the same participant could have contributed to none, one, or several emotion associations for a given color term (many-to-many associations).

Cultural probabilities

Color-emotion association pattern similarities

The nation-to-global color-emotion association pattern similarities were high and significant for all 30 nations. The average nation-to-global pattern similarity was $r_{average} = .880$, 95% CI = [.857-.903], $p < .001$. All nation-to-global pattern similarities ranged from $r = .684$ (Egypt vs. global) to $r = .941$ (Spain vs. global), all p -values $< .001$, FDR corrected (Fig 1 & Fig 4 A). The high pattern similarity indicates that all individual nations associated color terms with emotion concepts similarly to the global pattern. Nation-to-nation pattern similarities were also high and significant ($ps < .001$). They had a mean of $r_{average} = .781$, 95%CI = [.773-.789], and ranged from $r = .501$ (The Netherlands vs. Azerbaijan) to $r = .951$ (Switzerland vs. France), all p -values $< .001$, FDR corrected (see Fig S 2, Table S 7). Half of all nation-to-nation correlations fell between .738 and .839, with the median correlation of .799. Fig 4B shows distributions of nation-to-global and nation-to-nation pattern similarities.

Nation-to-global pattern similarities per color term were also high. Average similarities ranged from $r_{average} = .659$, 95% CI = [.548-.769] (*purple*) to $r_{average} = .925$, 95% CI = [.910-.940] (*pink*) (Fig S3 & Table S 10). Across all nations, *purple* and *yellow* had the highest variance in similarities and *pink*, *green*, *turquoise*, and *black* had the lowest variance in similarities, suggesting that associations with the former colors were the least similar while associations with the latter colors were the most similar across the 30 nations. We also observed certain nation-specific color-emotion associations (Table S 6 & Fig S3). For instance, Nigerians associated *red* with *fear* in addition to *love* and *anger*; Chinese associated *white* with *sadness* in addition to *relief*. Unlike other nations, Egyptians did not associate *joy* and other positive emotions with *yellow*. Greeks associated *purple* with *sadness* while other nations, on average, associated *purple* with positive emotions.

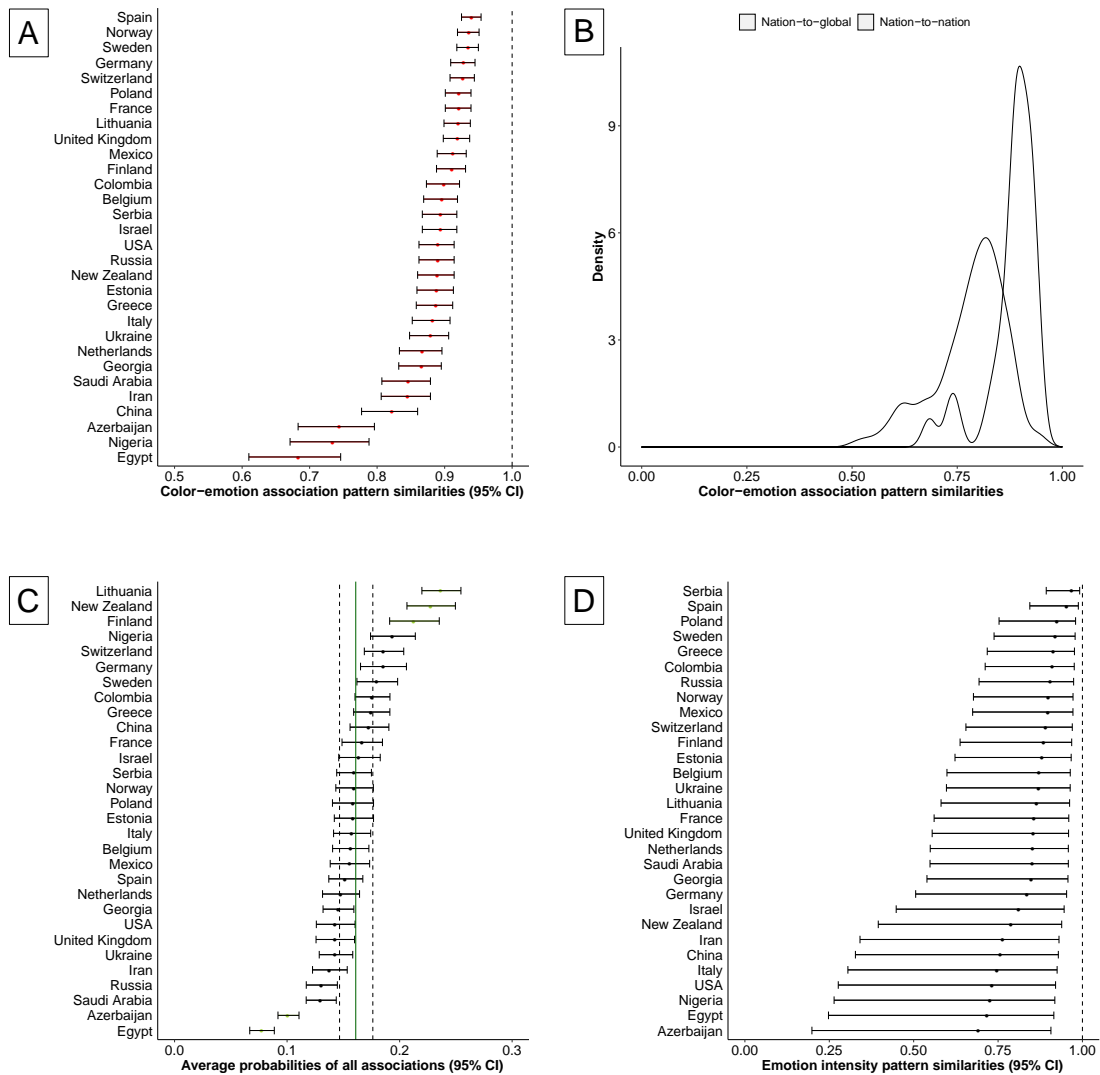


Fig 4. Nation comparisons. (A) Nation-to-global color-emotion association pattern similarities (correlations). The dotted line marks perfect pattern similarity ($r = 1$). (B) Density plots of nation-to-global and nation-to-nation color-emotion association pattern similarities (correlations). (C) Average probabilities of all color-emotion associations in each nation. The average probability of each nation was compared to the global average probability, which is the unweighted average of all average probabilities (dark green line; grey area = 95% CI). Nations marked in green are significantly different from the global average probability, after FDR correction. A higher score indicates a higher probability of associating any color term with any emotion concept. (D) Nation-to-global emotion intensity pattern similarities (correlations). The dotted line marks perfect pattern similarity ($r = 1$).

Average probabilities of color-emotion associations

One-sample *t*-tests showed that the color-emotion association average probabilities were not significantly different from the global average color-emotion association probability in 25 out of 30 nations (Fig 4 C), $ps > .604$. Only five nations differed significantly from the global average color-emotion association probability. Relative to the global average probability, participants from Finland, Lithuania, and New Zealand were significantly more likely while participants

from Azerbaijan and Egypt were significantly less likely to associate color terms with emotion concepts, $ps < .005$, FDR corrected (Fig 4 C, nations in green). When visually inspecting color-emotion association average probabilities per color term (Fig S 4), we found that, in every nation, *red* and *black* had the highest and *brown* the lowest average probability of being associated with any emotion concept.

Emotion intensity pattern similarities

Emotion intensity pattern similarities were high and significant for all 30 nations. The average nation-to-global emotion intensity similarity was $r_{average} = .709$, 95% CI = [.666-.752], $p < .001$, and ranged from $r = .693$ (Azerbaijan vs. global) to $r = .970$ (Serbia vs. global), $ps \leq .012$, FDR corrected (Fig 4 D).

Multivariate pattern classification

The machine learning classifier correctly predicted the nation for 34.4% of the participants, area under the receiver operating characteristic curve (AUC) = 0.85. This proportion correctly classified instances well above the random guessing rate of 9.7% that can be obtained by always choosing the nation contained most frequently in our data set (Azerbaijan). The AUC of 0.85 was also considerably higher than the AUC for the randomly permuted data sets (0.51). Thus, the classifier performance demonstrates a systematic amount of nation-specificity in color-emotion associations. The confusion matrix (Fig 5) shows that participants from Nigeria were the easiest to predict (true positive rate TPR = .811) while participants from Spain were the most difficult to predict (TPR = .071).

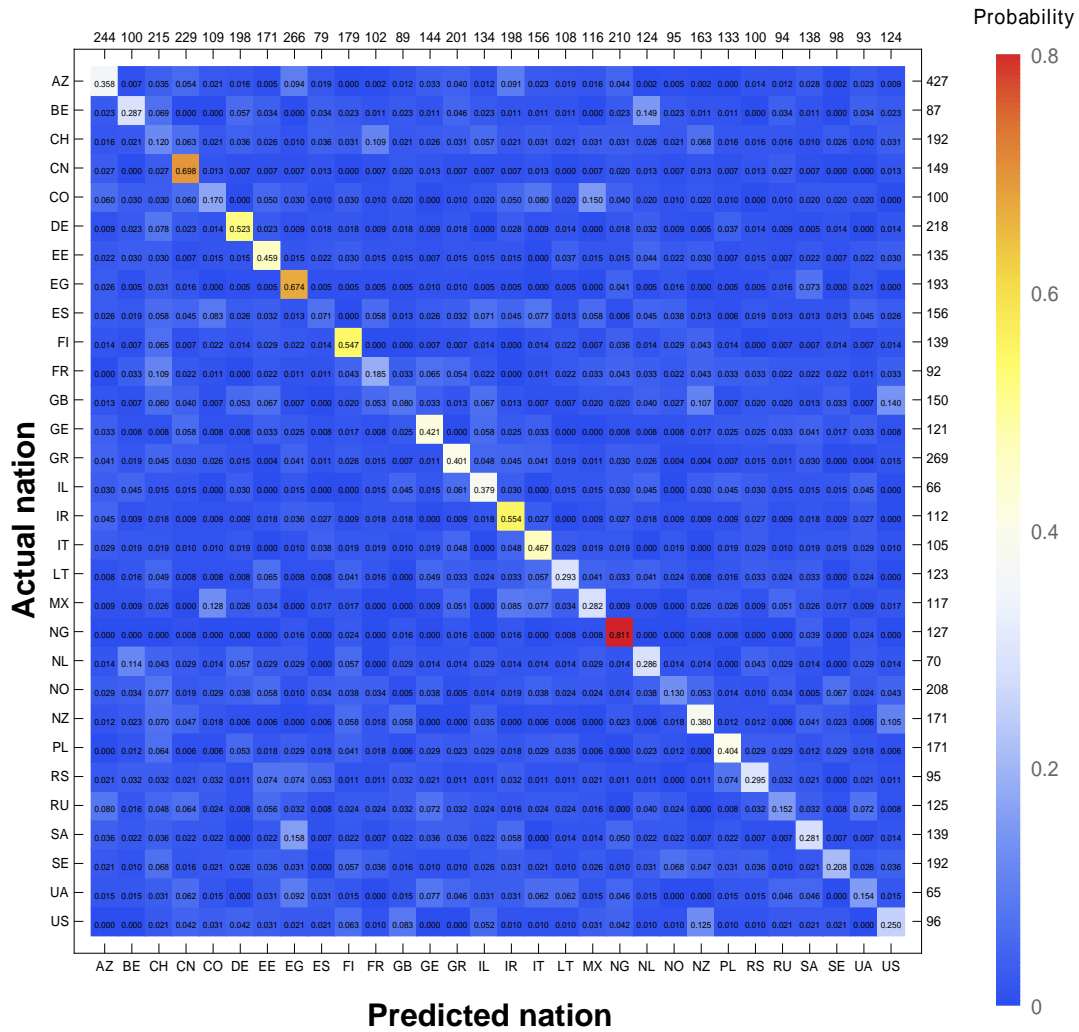


Fig 5. Confusion matrix for the prediction of the participants' nation (machine learning, multivariate pattern classification approach). Rows represent the actual and columns the predicted nations, respectively (Table S 1 for nation codes). Cells represent the probability that participants originating from the nations specified in rows were classified by the machine learning algorithm as originating from the nations specified in columns, based on their individual 240 color-emotion associations. Thus, proportions on the main diagonal represent the true positive rate, or recall. The numbers on the right-hand side represent the absolute frequency of participants originating from a given nation. The numbers on the top represent the absolute frequency of participants predicted to originate from a given nation.

Linguistic and geographic distances

We fitted a linear regression model with linguistic and geographic distance measures as predictors of nation-to-nation color-emotion association pattern similarity scores, once with and once without the interaction between the two distance measures. The inclusion of the interaction did not improve the model ($p = .389$). Therefore, we report the model without the interaction term. The model was overall significant, $F(2, 432) = 39.9, p < .001$, and explained 15.2% of variance (adjusted R^2). A shorter linguistic distance, $\beta = -0.37, p < .001$, and a shorter

geographic distance, $\beta = -0.13$, $p = .003$, both predicted higher nation-to-nation color-emotion association pattern similarity scores (Fig 6 A&B).

The analogous linear regression model with linguistic and geographic distances as predictors of Luce's similarity scores in multivariate pattern classification was also significant, $F(2, 432) = 37.4$, $p < .001$. The model explained 14.4% of variance (adjusted R^2). Again, shorter linguistic, $\beta = -0.36$, $p < .001$, and geographic distances, $\beta = -0.13$, $p = .003$, predicted higher Luce's similarity scores (Fig 6 C&D).

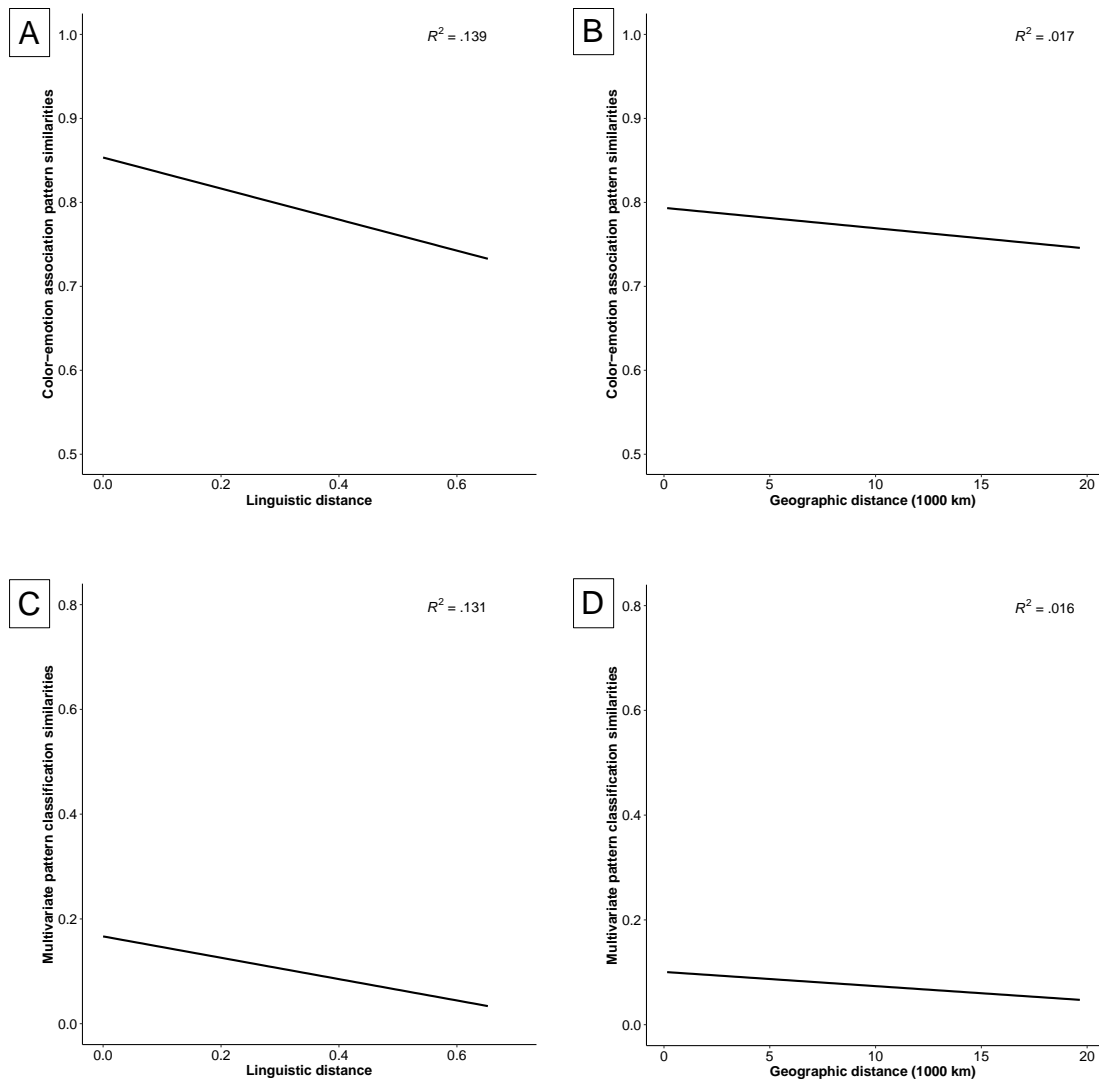


Fig 6. Scatter plots of linguistic and geographic distances predicting nation-to-nation similarities. (A & B) Linguistic and geographic distances predict nation-to-nation association pattern similarities (also see, Fig 4 B & Fig S2). (C & D) Linguistic and geographic distances predict estimated similarity between pairs of nations according to the Luce's biased choice model applied to the classifier confusion matrix (multivariate pattern classification similarities; also see Fig S1). Shaded area indicates 95% CI.

Socio-demographic factors

We examined the influence of two key socio-demographic factors – sex and age – on color-emotion association pattern similarities and on average probabilities of color-emotion associations. Color-emotion association patterns of men and women were almost identical, $r = .987$; $p < .001$ (Table S 8) and there were no age-related pattern differences, $r_{range} = .901 - .991$; $ps < .001$ (Table S 9). Men and women also did not differ on their average probability of color-emotion associations, $t(478) = 0.49$, $p = .624$ (Fig S 5 A). Notably, however, age was non-linearly related with average probabilities of color-emotion associations. A curve estimation analysis revealed that the association of age with average probabilities followed a U-shaped pattern such that the average probability gradually decreased from early adulthood, that is, from 15-20 years old to 50-60 years old, and then started increasing from 50-60 years of age onwards; $F(2, 1677) = 55.22$, $p < .001$, $R^2_{adj} = .061$ (Fig S 5 B). In other words, 50-60-year-old participants were the least likely to associate any color term with any emotion concept.

Discussion

The cross-modal association of color with emotion is a universal phenomenon. Moreover, there is global similarity in how specific emotion concepts are associated with specific color terms, although these universal associations are modulated by geographic and linguistic factors. Across 30 nations and 22 languages on 6 continents, the pattern of color-emotion associations in each country coincided highly with the global pattern (mean $r = .88$). In other words, participants from different nations shared the relative tendencies to favor certain color-emotion associations (e.g., *love* and *anger* with *red*) over others (e.g., *shame* with *red*). Furthermore, participants from different nations agreed on which colors were the most (i.e., *black* and *red*) and the least (i.e., *brown*) emotional. Finally, they rated emotion intensities in a similar manner. Hence, we demonstrate robust agreement across 30 nations in color-emotion associations, providing strong evidence that such associations might represent a psychological human universal (in agreement with Adams & Osgood, 1973; D'Andrade & Egan, 1974; Gao et al., 2007; Ou et al., 2018). Potential mechanisms for these universal associations may be found in a lasting shared human history, regularities in human languages and environments, and/or shared cognitive biases (Spence, 2011).

But beyond these global similarities, certain color-emotion associations additionally varied locally, (also see Hupka et al., 1997; Madden et al., 2000; Soriano & Valenzuela, 2009). In particular, nations which were linguistically or geographically closer had more similar color-emotion association patterns. Such nations were predicted with lower accuracy by the machine learning algorithm, even though the algorithm could still predict any participant's nation from the ratings of color-emotion associations above chance level (see also, Jonauskaitė, Wicker, et al., 2019). These variations might originate from cultural or linguistic differences in how emotion terms or color terms are understood across nations (Jackson et al., 2019). But these variations might also stem from differences in physical environments themselves. For instance, we have recently reported that exposure to sunshine modulated the degree to which yellow was perceived as a color of joy (Jonauskaitė, Abdel-Khalek, et al., 2019).

While the majority of nations did not vary in the *extent* to which color-emotion associations were endorsed, specific variations were nevertheless observed. Finns, Lithuanians, and New Zealanders endorsed color-emotion associations to a greater extent, while Azerbaijanis and Egyptians did so to a lesser extent than the global average. The source of these differences requires further study. Moreover, some nations exhibited idiosyncratic color-emotion associations. For instance, while *sadness* was universally associated with *black*, Greeks also associated it with *purple* and Chinese also associated it with *white*. Likely, these divergent

color-emotion associations reflect different cultural traditions. *White* is commonly worn at funerals in China, while Greeks occasionally wear darker shades of *purple* during mourning periods. Hence, cultural pairings of *white*, *purple*, or *black* with funerals may explain why specific colors are associated with *sadness* in some nations but not other.

In this study, we asked participants about their associations between color terms and emotion terms, allowing us to capture the conceptual relationship between them (see also, Hupka et al., 1997; Ou et al., 2018; Palmer et al., 2013; Wexner, 1954). However, we do not know if that relationship also plays out in emotional experiences associated with color perception. That is, people may universally associate the concepts of *red* and *anger*, but may not universally feel angry when seeing red objects. Within cultures, colors do induce specific subjective and physiological emotional responses (e.g., Wilms & Oberfeld, 2018), and similar emotion concepts are associated with color terms and their best perceptual examples (Jonaskaite et al., 2020). It remains to be seen whether the direct association between color and emotion shows the same patterns of linguistic and geographic modulation we have described here.

Our results suggest there is a universal basis for color-emotion associations, shared by all. Numerous other human universals exist (Brown, 1991). In the domains of color and affect, such universals include but are not limited to the shared understanding of facial emotion expressions (Ekman et al., 1969, but see Gendron et al., 2014), of emotions perceived in music (Cowen et al., 2020), of emotions expressed in human songs (Mehr et al., 2019) and shared loci of focal colors (Regier et al., 2005, but see Uusküla & Bimler, 2016). This universal foundation of color-emotion association is further modulated by language, geography, and culture. Some might understand the modulation as evidence against universality, because color-emotion associations were not shared at 100%. Yet, no human psychological universal is shared at 100% (Mehr et al., 2019; Norenzayan & Heine, 2005; Regier et al., 2005). Gladly, they are not. Scope for dissimilarities seems essential for dynamic adaptations to immediate and lasting changes in one's environment (Lupyan & Dale, 2016). Others might interpret our overall conclusions as evidence for a globalized world. This concern might be justified, because we mainly tested computer-literate participants who completed the survey online. Potentially, our color-emotion associations become increasingly similar as we share more and more information globally via the Internet and other communication channels. To test the generalizability of our results, we would need further data from small-scale societies (e.g., Davidoff et al., 1999; Groyecka et al., 2019). With our current knowledge at hand, we suggest that color-emotion associations represent a human psychological universal that likely contributes to shared communication and comprehension. Thus, next time you *feel blue* or *see red*, know the world is with you.

Acknowledgements:

We wish to thank Agnieszka Gawda (Polish), Aurika Jonauskienė (Lithuanian), Afrodite Kapsaridi (Greek), Bruno Kemm (Spanish and Portuguese), Richard Klein (French), Riina Martinson (Estonian), Galina Paramei (Russian), Angeliki Theodoridou (Greek), Evelina Thunell (Swedish), Alessandro Tremea (Italian), and Yaffa Yeshurun (Hebrew) for their help with the translation of the International Color-Emotion Survey into their respective languages. We further wish to thank Sanne Brederoo (Netherlands), Cornelis B. Doorenbos (Netherlands), Tinatin Gamkrelidze (Georgia), Lise Lesafre (France), Arzu Memmedova (Azerbaijan), Mariam Okruashvili (Georgia), C. Alejandro Párraga (Spain), Vilde Johanna Solheim Lie (Norway), Halvor Stavland (Norway), Hedda Andrea Struksnæs Sjørdal (Norway), and Zumrud Sultanova (Azerbaijan) for their help in distributing and promoting the survey in their countries.

Funding. This research has been made possible thanks to the support of the Swiss National Science Foundation, providing a Doc.CH fellowship grant to DJ (POLAP1_175055) and a project funding grant to CM & ND (100014_182138). MH was supported by a research grant from the Bergen Research Foundation (BFS2016REK03). YG was supported by Russian Foundation for Basic Research (17-29-09145). The initiation of this research was possible through the support of AkzoNobel, Imperial Chemical Industries (ICI) Limited, and in particular David Elliott and Tom Curwen, Color R&I team, Slough, UK, and Stephanie Kraneveld, Sassenheim, the Netherlands.

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Competing interests. No conflicts of interest are declared.

Open science statement. The study reported in this article was not formally preregistered. The data can be accessed following this link: <https://forsbase.unil.ch/datasets/dataset-public-detail/15126/1474/> and materials following this link: <http://www2.unil.ch/onlinepsylab/colour/main.php>

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Supplementary material

Supplementary method details

Translation of the Geneva Emotion Wheel. The English, Dutch, Estonian, Finnish, French, German, Italian, Traditional Mandarin Chinese, and Polish versions of the Geneva Emotion Wheel are available from the Swiss Centre for Affective Sciences (<http://www.affective-sciences.org/gew> <https://www.affective-sciences.org/research/topics/specific-research-projects/language-and-culture/grid-project/emotion-words/>). For all other nations, our collaborators and co-authors translated the Geneva Emotion Wheel into their respective national languages (i.e., Arabic, Azerbaijani, Georgian, Greek, Hebrew, Lithuanian, Norwegian, Persian, Russian, Serbian, Simplified Mandarin Chinese, Spanish, Swedish, and Ukrainian; see Table S 3 for the emotion concepts in all languages). To ensure that the meaning of the translated emotion concepts was as close as possible to the meaning of the original emotion concepts, we followed the back-translation technique. Following this technique, one translator (a bilingual person in the target and reference language) translated the emotion concepts into the target language. Then, the second translator (a bilingual person in the target and reference language) translated the emotion concepts from the target to the reference language without knowing the original reference version. Then, the two versions – the reference and the back translated version – were compared, and the discrepancies were resolved through discussion and consultation of dictionaries. Although we cannot guarantee that the original meaning of the emotion terms remained unchanged in the translations (similar concerns were expressed in Adams & Osgood, 1973), all efforts were made to bring the translations as close as possible to the original meaning, and as similar as possible across languages.

Bayesian probabilities. We constructed Bayesian models with Monte-Carlo Markov Chains (MCMC) to estimate the average probability that participants associated each emotion concept with the given color term (Lee & Wagenmakers, 2013). The Bayesian method consists of comparing an a-priori distribution of the probabilities of parameter values (without taking into account the data, i.e., the prior distribution) with a posterior distribution (when taking into account the data). The parameter values were 240 color-emotion associations. Participants' raw responses were recoded as 1 if an emotion was associated with the given color term (irrespective of emotion intensity), and 0 if an emotion was not associated with the given color term, and were fitted to a Bernoulli distribution.

We used a uniform prior distribution, which provides a neutral and un-biased starting point, due to the lack of more informative priors in the literature. The uniform distribution assumes that each emotion parameter value (between 0 and 1) is equally probable across all participants for a given color term. We constructed the posterior distribution using the MCMC method with 10,000 iterations and three chains (thinning interval was 1). We used a JAGS code to generate three MCMC chains, each comprised of 10,000 iterations. After discarding the first 5,000 iterations from each chain burn-in and confirming convergence by visual inspection and the \tilde{R} statistic (Gelman & Rubin, 1992), we collapsed the samples across the three chains so that our inference was based on a total of 30,000 samples from the joint posterior. MCMC is a computer-driven sampling method that efficiently produces samples from a probability distribution that is otherwise difficult to sample from directly (van Ravenzwaaij et al., 2018). Bayesian analyses were implemented in R with the help of "MASS" (Venables & Ripley, 2002) and "rjags" packages.

Multivariate pattern classification. Only participants who had provided ratings for all of the 240 color-emotion associations were included in the analysis ($N = 4410$). For the classification algorithm, we selected a support vector machines (SVM; (Platt, 1998)) with a radial basis function (RBF) kernel, and used error-correcting output codes (ECOC) for the multiclass classification (Dietterich & Bakiri, 1995). To optimize the hyperparameters of the SVM (complexity constant C and the λ -parameter of the RBF kernel), we used Bayesian optimization based on 5-fold cross validation. Because the sample sizes differed between our 30 nations, we used a uniform prior when training and evaluating the classifier, so that the results were not affected by the differing prior probabilities of the 30 classes (i.e., nations). To evaluate the accuracy of the classifier, a ten-fold cross-validation (CV) was conducted. The analyses were implemented in Matlab (function *fitcecoc*). A summary measure of the predictive power of a classifier is the area under the receiver operating characteristic (ROC) curve (AUC). This measure provides information about the degree to which the predicted nation is concordant with the actual nation. Areas of 0.5 and 1.0 correspond to performances at chance level and perfect performance of the classifier, respectively. AUC is not affected by response bias or by prior probabilities of the classes.

We compared the performance of the classifier to the performance of the same method on randomized data sets. The randomized data sets were generated by randomly permuting the class values (i.e., nation labels) of the data set (Good, 2005).

Linguistic distances. We have included the following languages from Jäger (2018) in our analyses: AZERBAIJANI_NORTH_2, DUTCH, ENGLISH, ESTONIAN, FINNISH, FRENCH, GEORGIAN, GREEK, HEBREW, ITALIAN, LITHUANIAN, MANDARIN, NORWEGIAN_BOKMAAL, PERSIAN, POLISH, RUSSIAN, SERBOCROATIAN, SPANISH, STANDARD_ARABIC, STANDARD_GERMAN, SWEDISH, and UKRAINIAN.

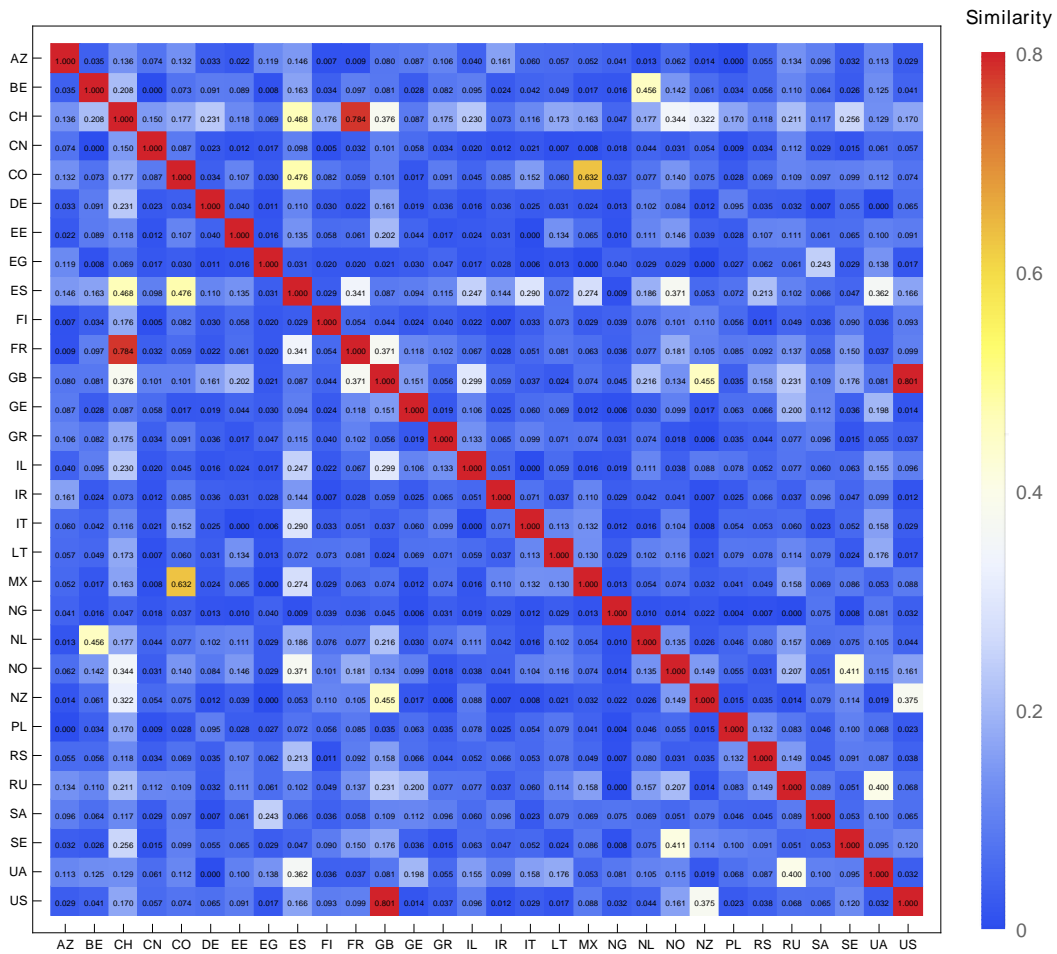


Fig S 1. Estimated similarity between pairs of nations according to Luce’s biased choice model applied to the classifier confusion matrix. Similarity is coded on a temperature scale ranging from blue (0, no similarity) to red (1, perfect similarity). Nation codes are available in Table S 1.

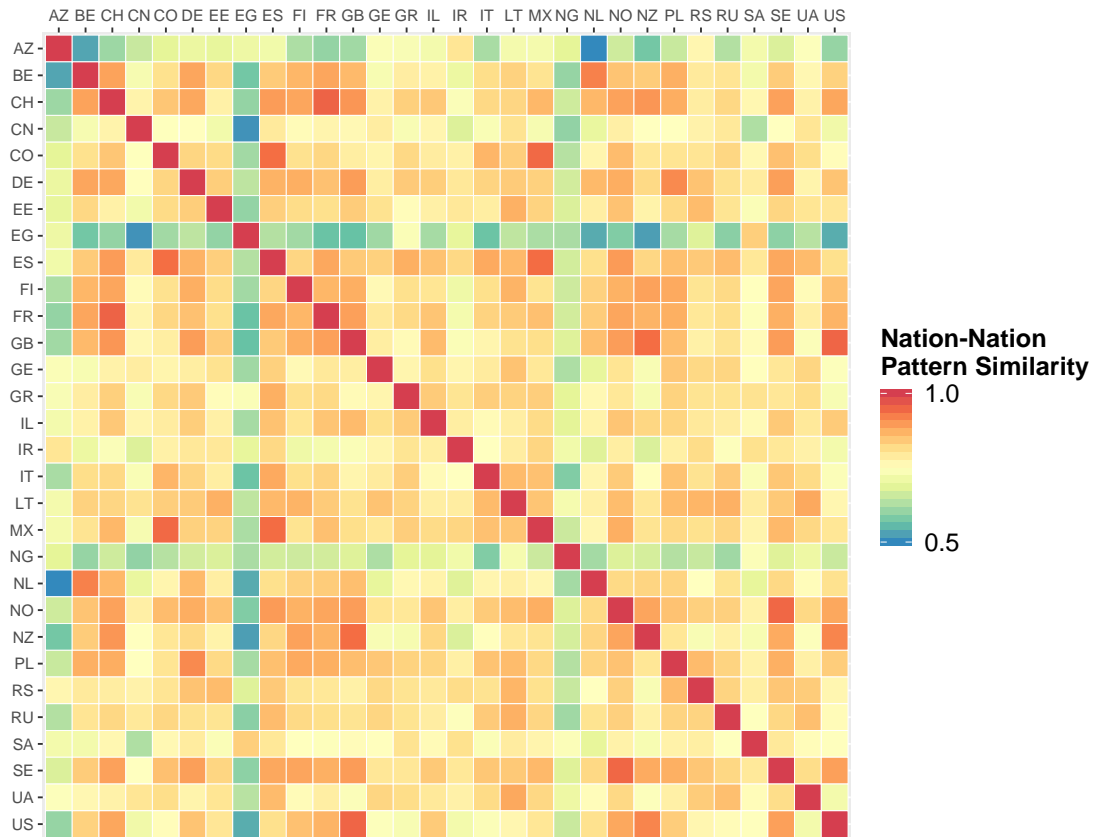


Fig S 2. Nation-to-nation color-emotion association pattern similarity. Same data as in Fig 4 B. Redder cells indicate higher pattern similarity (correlation). Nation codes are available in Table S 1. Actual correlation coefficients are available in Table S 7.

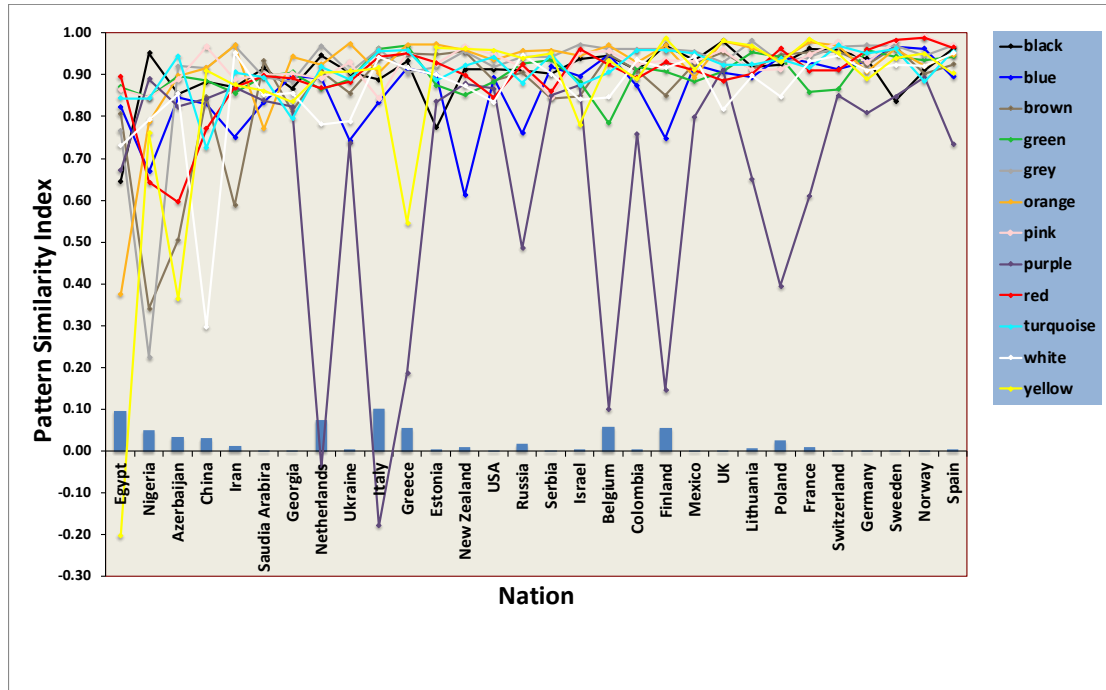


Fig S 3. Color-emotion association pattern similarities by nation and color term. These correlation values indicate the degree of similarity between the pattern of associations of a specific nation to the global association pattern for each color term (nation-to-global comparisons for each color term separately). Blue bars represent the variance in the pattern similarities across the color terms for each nation. Nations have been ordered in the same order as in Fig 4 B.

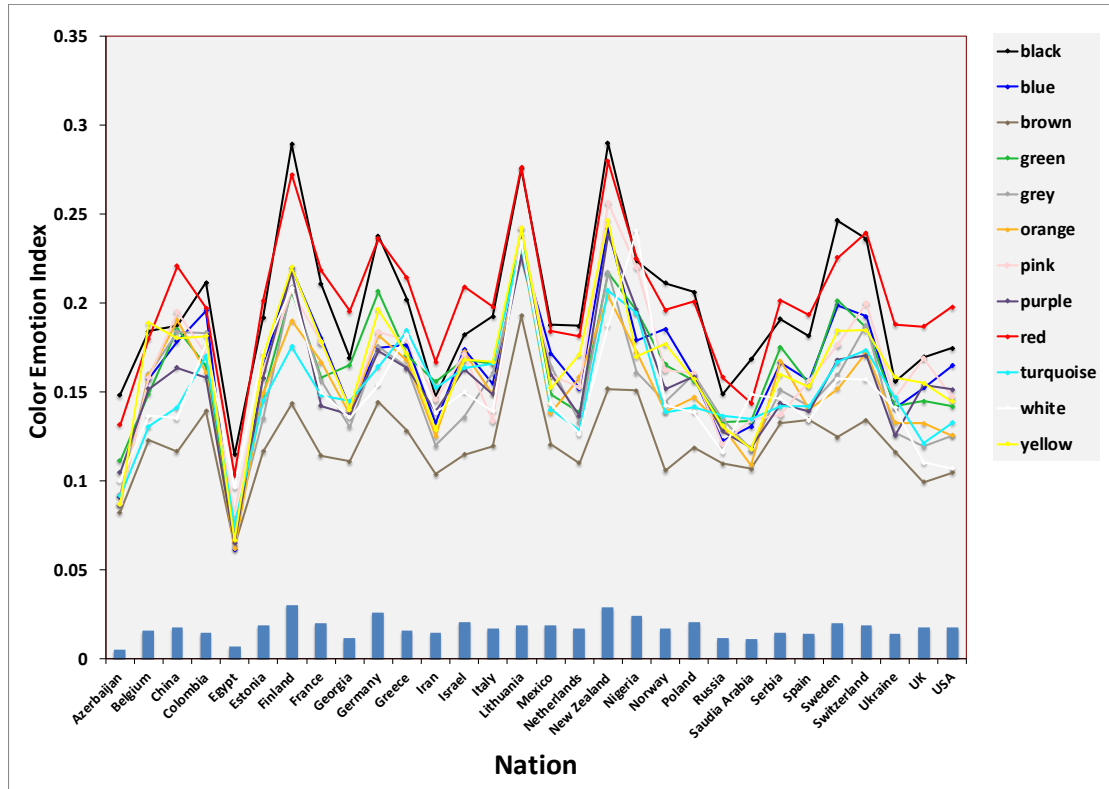


Fig S 4. Average probabilities of color-emotion associations by nation and color term. Higher average probabilities indicate a higher probability that a particular color term is associated with any emotion among the participants of each nation. Bars represent the variance in the average probability scores across the 12 color terms of each nation per color term.

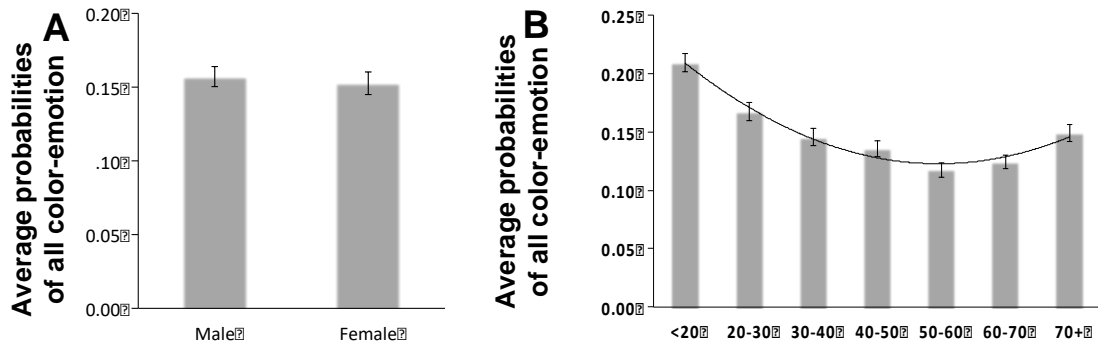


Fig S 5. Average probabilities of all color-emotion associations by sex (A) and age (B). Higher numbers indicate a higher average probability that any color term is associated with any emotion in that particular group of participants. We observed no sex difference. Age followed a U-shaped pattern. Error bars represent standard error of the mean.

Table captions: TO BE DELETED BEFORE SUBMISSION

Table S 1. Language information of the participants by nation.

Table S 2. Demographic information of the participants by nation. Note, 15 participants did not wish to report their gender and 55 participants did not wish to report their age (missing values).

Table S 3. Emotion terms in all the languages used in this study (divided into three tables).

Table S 4. Color terms in all the languages used in this study (divided into three tables).

Table S 5. Mean number of associated emotions with each color term for all nations together. Standard deviations (SD), standard errors (SE), and 95% confidence intervals (CI) are also displayed.

Table S 6. Color-emotion association matrices in 30 nations. Cells in each matrix contain Bayesian-derived probabilities of associating a particular color with a particular emotion. They are color-coded so that cells in deeper red indicate higher Bayesian probabilities. The first matrix represents the global matrix (all nations together). This is followed with 30 pairs of matrices ordered alphabetically from Azerbaijan to USA. Subsequently, for each nation, the top panel of each pair of matrices represents the global color-emotion association matrix, excluding the nation whose specific pattern is presented in the bottom panel. Underneath each pair of matrices, we present nation-to-global color-emotion association pattern similarity scores of each color and overall (correlations, marked as PSI – pattern similarity index).

Table S 7. Nation-to-nation color-emotion association pattern similarities (correlations). Nations with more similar color-emotion association patterns have values closer to 1.0. By definition, the correlation of the nation's matrix with itself is 1.0. Also see the same data displayed visually in Fig S 2

Table S 8. Color-emotion association matrices by sex. The men-specific matrix (averaged across all 30 nations) is presented above the women-specific matrix (average across all 30 nations). Color-emotion association pattern similarity, comparing men and women matrices, is indicated. Cells in each matrix contain Bayesian-derived probabilities of associating a particular color with a particular emotion. They are color-coded so that redder cells indicate higher Bayesian probabilities.

Table S 9. Color-emotion association matrices by age group. Age-specific matrices are presented by approximately 10-year bins – 15-20 years old, 20-30 years old, 30-40 years old, 40-50 years old, 50-60 years old, 60-70 years old, and 70-87 years old. They are compared to the global matrix. Cells in each matrix contain Bayesian-derived probabilities of associating a particular color with a particular emotion. They are color-coded so that redder cells indicate higher Bayesian probabilities.

Table S 10. Average color-emotion association pattern similarities for each of the 12 color terms across all nations

Table S 11. Emotion intensity pattern similarities by nation and color term. Panel A represents the global matrix averaged across the 30-nations (top line), followed by the

global matrices, leaving-out one nation at a time. Each cell represents the global emotion intensity given to each color term. Panel B represents nation-specific emotion intensities per color. Each cell represents the average emotion intensity given to each color term within each nation. Redder cells indicate higher emotion intensities; greener cells indicate lower emotion intensities.

Table S 12. Linguistics distances for each nation-nation pair of the current study. Distances were derived from Jäger (2018) and raised to the fourth power. Linguistic distances below .240 indicate related languages. We used the following languages from Jäger (2018) for our nations: AZERBAIJANI_NORTH_2 (AZ), DUTCH (NL & BE), ENGLISH (GB, NG, NZ & US), ESTONIAN (EE), FINNISH (FI), FRENCH (FR & CH), GEORGIAN (GE), GREEK (GR), HEBREW (IL), ITALIAN (IT), LITHUANIAN (LT), MANDARIN (CN), NORWEGIAN_BOKMAAL (NO), PERSIAN (IR), POLISH (PL), RUSSIAN (RU), SERBOCROATIAN (RS), SPANISH (CO, ES & MX), STANDARD_ARABIC (EG & SA), STANDARD_GERMAN (DE), SWEDISH (SE), and UKRAINIAN (UA). Nation codes are available in Table S1.

Table S 13. Geographic distances for each nation-nation pair of the current study. Distances were calculated by taking population-weighted mean of each country, or the most populated city when the former data was unavailable (see Table S 14). Distances are presented in kilometers (km).

Table S 14. Coordinates of the population-weighted mean geographical centers of each nation or coordinates of the most populated cities. Column “source” indicates the source of the data.

Table S1. Language information of the participants by nation.

Country code	Nation (country of origin)	Region	Native language & language of the survey	Language family	Language sub-groups
AZ	Azerbaijan	West & Central Asia	Azerbaijani	Turkic	Oghuz
BE	Belgium	Europe	Dutch	Indo-European	Germanic
CN	China	East Asia	Mandarin Chinese (simplified)	Sino-Tibetan	Chinese
CO	Colombia	South America	Spanish	Indo-European	Romance
EG	Egypt	North Africa	Arabic	Afro-Asiatic	Semitic
EE	Estonia	Europe	Estonian	Uralic	Finnic
FI	Finland	Europe	Finnish	Uralic	Finnic
FR	France	Europe	French	Indo-European	Romance
GE	Georgia	West & Central Asia	Georgian	Kartvelian	Karto-Zan
DE	Germany	Europe	German	Indo-European	Germanic
GR	Greece	Europe	Greek	Indo-European	Hellenic
IR	Iran	West & Central Asia	Persian	Indo-European	Indo-Iranian
IL	Israel	Middle East	Hebrew	Afro-Asiatic	Semitic
IT	Italy	Europe	Italian	Indo-European	Romance
LT	Lithuania	Europe	Lithuanian	Indo-European	Baltic
MX	Mexico	Central America	Spanish	Indo-European	Romance
NL	Netherlands	Europe	Dutch	Indo-European	Germanic
NZ	New Zealand	Zealand	English	Indo-European	Germanic
NG	Nigeria	Africa	Igbo & English	Indo-European	Germanic
NO	Norway	Europe	Norwegian (Bokmål)	Indo-European	Germanic
PL	Poland	Europe	Polish	Indo-European	Slavic

RU	Russia	North Asia	Russian	Indo-European	Slavic
SA	Saudi Arabia	West & Central Asia	Arabic	Afro-Asiatic	Semitic
RS	Serbia	Europe	Serbian	Indo-European	Slavic
ES	Spain	Europe	Spanish	Indo-European	Romance
SE	Sweden	Europe	Swedish	Indo-European	Germanic
CH	Switzerland	Europe	French	Indo-European	Romance
UA	Ukraine	Europe	Ukrainian	Indo-European	Slavic
GB	United Kingdom	Europe	English	Indo-European	Germanic
US	United States	North America	English	Indo-European	Germanic

Table S2. Demographic information of the participants by nation. Note, 15 participants did not wish to report their gender and 55 participants did not wish to report their age (missing values).

Nation	Participant count	Youngest	Oldest	Mean age	SD of age	Males	Females	% of males	% of pps for whom color is important in their lives	% of pps for whom color is NOT important in their lives
Azerbaijan	490	17	70	36.22	13.71	128	361	26.12	85.71	9.18
Belgium	88	19	87	38.82	16.68	20	68	22.73	81.82	15.91
China	163	17	80	37.90	19.26	43	119	26.38	77.30	16.56
Colombia	108	15	74	36.16	15.06	51	57	47.22	83.33	13.89
Egypt	209	16	73	30.53	12.45	64	145	30.62	93.30	6.22
Estonia	140	19	70	38.93	11.97	17	123	12.14	76.43	20.00
Finland	140	19	71	32.38	13.94	17	122	12.14	77.86	18.57
France	93	20	71	38.17	15.64	22	70	23.66	86.02	12.90
Georgia	127	16	73	32.73	15.04	36	90	28.35	71.65	25.98
Germany	219	16	82	33.45	15.98	29	189	13.24	83.11	14.16
Greece	275	15	76	30.53	11.50	34	240	12.36	94.18	4.73
Iran	121	16	63	31.49	9.94	14	107	11.57	88.43	6.61
Israel	69	21	67	38.04	11.29	11	58	15.94	60.87	36.23
Italy	108	20	80	38.98	15.50	38	70	35.19	79.63	10.19
Lithuania	124	15	77	36.50	15.97	27	97	21.77	86.29	11.29
Mexico	127	16	78	36.39	15.43	53	74	41.73	85.04	11.02
Netherlands	72	17	71	38.63	15.83	26	46	36.11	73.61	25.00
New Zealand	173	18	73	25.10	10.59	43	129	24.86	79.19	18.50

Nigeria	127	19	65	37.92	12.63	55	72	43.31	66.14	15.75
Norway	211	18	79	34.71	14.09	25	183	11.85	84.36	13.27
Poland	177	17	70	30.72	12.75	40	137	22.60	81.92	15.25
Russia	127	16	78	37.02	16.68	49	78	38.58	47.24	49.61
Saudi Arabia	143	15	85	32.55	13.62	48	94	33.57	86.71	11.89
Serbia	97	19	78	40.85	17.02	24	73	24.74	76.29	21.65
Spain	164	19	75	33.90	13.20	36	127	21.95	81.10	18.29
Sweden	196	20	82	34.63	12.11	35	160	17.86	86.22	13.27
Switzerland	193	18	79	29.35	13.95	47	145	24.35	81.35	18.13
Ukraine	65	18	87	43.37	24.35	8	57	12.31	75.38	21.54
United Kingdom	156	16	71	40.12	13.93	50	106	32.05	84.62	13.46
United States	96	19	75	42.90	14.26	24	70	25.00	87.50	12.50
Global average	4598	15	87	34.81	14.74	1114	3467	24.23	81.65	15.13

Table S3. Emotion terms in all the languages used in this study (divided into three tables).

English	Chinese (Simplified)						
	Arabic	Azerbaijani	Mandarin	Dutch	Estonian	Finnish	French
Interest		اهتمام Maraq	感兴趣	Interesse	Huvi	Kiinnostus	Intérêt
Amusement		تسلية Əyləncə	欢愉	Amusement	lõbu	Huvittuneisuus	Amusement
Pride		كبرياء Qürur	自豪	Trots	Uhkus	Ylpeys	Fierté
Joy		فرح Sevinc	欢乐	Blijheid	Rõõm	Ilo	Joie
Pleasure		سرور Həzz	愉快	Plezier	Nauding	Mielihyvä	Plaisir
Contentment		قناعة Məmnunluq	满足	Tevredenheid	Rahulolu	Tyytyväisyys	Contentement
Admiration		إعجاب Heyranlıq	赞赏	Bewondering	Imetlus	Ihailu	Admiration
Love		حب Sevgi	爱	Liefde	Armastus	Rakkaus	Amour
Relief		Rahatlama					
Compassion		طمأنينة (yungullesme)	如释重负	Opluchting	Kergendus	Helpotus	Soulagement
Sadness		شفقة Mərhəmət	同情	Medelijden	Kaastunne	Myötätunto	Compassion
Guilt		حزن Kədər	悲伤	Verdriet	Kurbus	Suru	Tristesse
Regret		ندم Günah	内疚	Schuld	Süü	Syylisyys	Culpabilité
Shame		عار Təəssüf	后悔	Spijt	Kahetsus	Katumus	Regret
Disappointment		حيرة أمل Utanma	羞愧	Schaamte	Häbi	Häpeä	Honte
Fear		خوف Məyusluq	失望	Ontgoocheling	Pettumus	Pettymys	Déception
Disgust		قرف Qorxu	恐惧	Angst	Hirm	Pelko	Peur
Contempt		احتقار İyranma	厌恶	Walging	Vastikus	Inho	Dégoût
Hate		كراهية İkraha	轻视	Minachting	Pölgus	Halveksunta	Mépris
Anger		غضب Nifrət	憎恨	Haat	Vihkamine	Viha	Haine
		غضب Hirs	忿怒	Kwaadheid	Viha	Suuttuminen	Colère

German	Georgian	Greek	Hebrew	Italian	Lithuanian	Norwegian
Interesse	ინტერესი	Ενδιαφέρον	עניין	Interesse	Susidomėjimas	Interesse
Belustigung	ხალისიანობა	Διασκέδαση	שעשוע	Divertimento	Linksmumas	fornyøvelse
Stolz	სიამბაყე	Υπερηφάνεια	גאווה	Orgoglio	Išdidumas	Stolthet
Freude	სიხარული	Χαρά	שמחה	Gioia	Džiaugsmas	Glede
Vergnügen	სიამოვნება	Ευχαρίστηση	הנאה	Piacere	Malonumas	nyttelse
Zufriedenheit	კმაყოფილება	Ικανοποίηση	שביעות רצון	Contentezza	Pasitenkinimas	tilfredshet
Bewunderung	აღფრთხილება	Θαυμασμός	הערצה	Ammirazione	Žavėjimas	Beundring
Liebe	სიყვარული	Αγάπη	אהבה	Amore	Meilė	Kjærlighet
Erleichterung	შეება	Ανακούφιση	הקלה	Sollievo	Palengvėjimas	Letteise
Mitgefühl	თანაგრძნობა	Συμπάθεια	המלה	Compassione	Užsujauta	medfølelse
Trauer	სევლა	Θλίψη	עצבות	Tristezza	Liūdesys	Tristhet
Schuld	დამნაშავეობა	Ενοχή	השמה	Colpa	Kaltė	Skyldfølelse
Bereuen	სინანული	Μετάνοια	חרטה	Rimpianto	Apgailestavimas	Anger
Scham	სირცხვილი	Ντροπή	בושה	Vergogna	Gėda	Skam
Enttäuschung	გაწბილება	Απογοήτευση	אכזבה	Delusione	Nusivylimas	Skuffelse
Angst	შიში	Φόβος	פחד	Paura	Baimė	Frykt
Ekel	ზიზღი	Αηδία	גועל	Disgusto	Pasibjaurėjimas	Avsky
Verachtung	უბრაფიერებლობა	Περιφρόνηση	בוז	Disprezzo	Panieka	Forakt
Hass	სიძულვილი	Μίσος	האזנה	Odio	Neapykanta	Hat
Wut	მრისხანება	Θυμός	כעס	Collera	Pyktis	Sinne

Persian	Polish	Russian	Serbian	Spanish	Swedish	Ukrainian
علاقه و توجه	Zainteresowanie	Заинтересованность	Interesovanje	Interés	Intresse	Зацікавленість
سرگرمی	Rozbawienie	Веселость	Zabava	Diversión	Underhållning	Веселість
افتخار	Duma	Гордость	Ponos	Orgullo	Stolthet	Гордість
مسرت	Radość	Радость	Radost	Alegría	Glädje	Радість
لذت	Przyjemność	Удовольствие	Zadovoljstvo	Placer	Njutning	Задоволення
خرسندی	Zadowolenie	Удовлетворенность	Ispunjenost	Satisfacción	Belåtenhet	Задоволеність
تحسين	Podziw	Восхищение	Divljenje	Admiración	Beundran	Захоплення
عشق	Miłość	Любовь`	Ljubav	Amor	Kärlek	Любов
آمودگی	Uczucie ulgi	Облегчение	Olakšanje	Alivio	Lättnad	Полегшення
دلسواری و شفقت	Współczucie	Сострадание	Sažaljenje	Compasión	Medkänsla	Співчуття
اندوه	Smutek	Грусть	Tuga	Tristeza	Ledsamhet	Смуток
گناه	Poczucie winy	Чувство вины	Krivica	Culpabilidad	Skuld	Вина
پشیمانی	Żal/Żałowanie	Сожаление	Žaljenje	Arrepentimiento	Ånger	Жаль
خجالت و شرم	Wstyd	Стыд	Sramota	Vergüenza	Skam	Сором
سرخورگی	Rozczarowanie	Разочарование	Razočaranje	Decepción	Besvikelse	Розчарування
ترس	Strach	Страх	Strah	Miedo	Rädsla	Страх
انزجار	Obrzydzenie	Отвращение	Gađenje	Asco	Avsmak	Відраза
خوار شمردن	Pogarda	Презрение	Prezir	Desprecio	Förakt	Презирство
نفرت	Nienawiść	Ненависть	Mržnja	Odio	Hat	Ненависть
خشم	Złość	Гнев	Ljutnja	Cólera	Ilska	Гнів

Table S4. Color terms in all the languages used in this study (divided into three tables).

English	Arabic	Azerbaijani	Chinese (Simplified)		Dutch	Estonian	Finnish	French
			Mandarin)	Mandarin)				
White	ابيض Ag	Ağ	白色	白色	Wit	Valge	Valkoinen	Blanc
Black	اسود Qara	Qara	黑色	黑色	Zwart	Must	Musta	Noir
Grey	رمادي Boz	Boz	灰色	灰色	Grijs	Hall	Harmaa	Gris
Red	احمر Qırmızı	Qırmızı	红色	红色	Rood	Punane	Punainen	Rouge
Orange	برتقالي Narıncı	Narıncı	桔色	桔色	Oranje	Oranž	Oranssi	Orange
Yellow	اصفر Sari	Sarı	黄色	黄色	Geel	Kollane	Keltainen	Jaune
Green	اخضر Yaşıl	Yaşıl	绿色	绿色	Groen	Roheline	Vihreä	Vert
Turquoise	ازرق سماوي Mavi	Mavi	青色	青色	Turquoise	Türkiis	Turkoosi	Turquoise
Blue	ازرق Göy	Göy	蓝色	蓝色	Blauw	Sinine	Sininen	Bleu
Purple	بنفسجي Bənövşəyi	Bənövşəyi	紫色	紫色	Paars	Lilla	Violetti	Violet
Brown	بني Qəhvəyi	Qəhvəyi	棕色	棕色	Bruin	Pruun	Ruskea	Brun
Pink	زهري Çəhrayı	Çəhrayı	粉色	粉色	Roze	Roosa	Pinkki	Rose

German	Georgian	Greek	Hebrew	Italian	Lithuanian	Norwegian
Schwarz	თეთრი	Μαύρο	לבן	Bianco	Balta	Hvit
Blau	შავი	Μπλέ	שחור	Nero	Juoda	Svart
Braun	ნაცრისფერი	Καφέ	אפור	Grigio	Pilka	Grå
Grün	წითელი	Πράσινο	אדום	Rosso	Raudona	Rød
Grau	ნარინჯისფერი	Γκρι	כתום	Arancione	Oranžinė	Oransje
Orange	ყვითელი	Πορτοκάλι	צהוב	Giallo	Geltona	Gul
Gelb	მწვანე	Ροζ	ירוק	Verde	Žalia	Grøn
Lila	ცისფერი	Μαύ	תכלת	Turchese	Žydra/Turkio	Turkis
Rot	ლურჯი	Κόκκινο	כחול	Blu	Mėlyna	Blå
Türkis	ოსაშვისფერი	Γαλάζιο	סגול	Viola	Violetinė	Lilla
Weiss	ყავისფერი	Λευκό	חום	Marrone	Ruda	Brun
Rosa	ვარდისფერი	Κίτρινο	ורוד	Rosa	Rožinė	Rosa

Persian	Polish	Russian	Serbian	Spanish	Swedish	Ukrainian
سفید	Biały	Белый	Bela	Blanco	Vit	Білий
سیاه	Czarny	Чёрный	Crna	Negro	Svart	Чорний
خاکستری	Szary	Серый	Siva	Gris	Grå	Сірий
قرمز	Czerwony	Красный	Crvena	Rojo	Röd	Червоний
نارنجی	Pomarańczowy	Оранжевый	Narandzasta	Naranja	Orange	Померанчевий
زرد	Żółty	Жёлтый	Zuta	Amarillo	Gul	Жовтий
سبز	Zielony	Зелёный	Zelena	Verde	Grön	Зелений
فیروزه ای	Turkusowy	Голубой	Tirkizna	Turquesa	Turkos	Блакитний
آبی	Niebieski	Синий	Plava	Azul	Blå	Синій
بنفش	Fioletowy	Фиолетовый	Ljubicasta	Violeta	Li la	Фіолетовий
قهوه ای	Brazowy	Коричневый	Smedja	Marron	Brun	Коричневий
صورتی	Różowy	Розовый	Roza	Rosa	Rosa	Рожевий

Table S 5. Mean number of associated emotions with each color term for all nations together. Standard deviations (SD), standard errors (SE), and 95% confidence intervals (CI) are also displayed.

Colour	Mean	95%CI lower	95%CI higher
black	3.83	3.73	3.94
blue	3.1	3	3.2
brown	2.25	2.16	2.35
green	3.11	3.01	3.21
grey	2.86	2.76	2.96
orange	2.83	2.73	2.93
pink	3.1	3.01	3.2
purple	2.94	2.84	3.04
red	3.84	3.74	3.95
turquoise	2.84	2.75	2.94
white	2.85	2.75	2.95
yellow	3.09	2.99	3.18

Table S6. Color-emotion association matrices in 30 nations.

Cells in each matrix contain Bayesian-derived probabilities of associating a particular color with a particular emotion. They are color-coded so that cells in deeper red indicate higher Bayesian probabilities. The first matrix represents the global matrix (all nations together). This is followed with 30 pairs of matrices ordered alphabetically from Azerbaijan to USA. Subsequently, for each nation, the top panel of each pair of matrices represents the global color-emotion association matrix, excluding the nation whose specific pattern is presented in the bottom panel. Underneath each pair of matrices, we present nation-to-global color-emotion association pattern similarity scores of each color and overall (correlations, marked as PSI – pattern similarity index).

Global	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.100	0.250	0.090	0.300	0.080	0.250	0.190	0.230	0.180	0.250	0.150	0.230
Amusement	0.040	0.150	0.040	0.230	0.030	0.390	0.330	0.190	0.180	0.230	0.080	0.350
Pride	0.160	0.240	0.070	0.160	0.070	0.140	0.110	0.220	0.210	0.150	0.220	0.160
Joy	0.030	0.200	0.040	0.320	0.030	0.400	0.390	0.190	0.270	0.310	0.230	0.470
Pleasure	0.060	0.240	0.070	0.330	0.040	0.300	0.380	0.240	0.320	0.340	0.180	0.280
Contentment	0.070	0.330	0.130	0.370	0.090	0.220	0.230	0.190	0.140	0.300	0.290	0.230
Admiration	0.080	0.230	0.060	0.190	0.050	0.180	0.230	0.230	0.200	0.220	0.220	0.190
Love	0.040	0.100	0.040	0.120	0.030	0.110	0.470	0.160	0.660	0.130	0.180	0.090
Relief	0.050	0.330	0.090	0.330	0.090	0.100	0.170	0.120	0.050	0.330	0.420	0.150
Compassion	0.090	0.180	0.110	0.150	0.110	0.090	0.160	0.150	0.080	0.130	0.230	0.100
Sadness	0.530	0.240	0.150	0.050	0.450	0.030	0.040	0.170	0.050	0.080	0.120	0.050
Guilt	0.300	0.090	0.130	0.060	0.230	0.060	0.040	0.110	0.120	0.040	0.060	0.070
Regret	0.280	0.110	0.150	0.060	0.290	0.060	0.050	0.130	0.070	0.060	0.090	0.080
Shame	0.200	0.070	0.150	0.060	0.180	0.070	0.090	0.100	0.190	0.050	0.060	0.090
Disappointment	0.290	0.110	0.200	0.050	0.400	0.060	0.040	0.110	0.060	0.050	0.070	0.080
Fear	0.460	0.080	0.080	0.050	0.200	0.050	0.030	0.090	0.150	0.040	0.090	0.070
Disgust	0.170	0.040	0.330	0.130	0.120	0.080	0.050	0.080	0.070	0.040	0.040	0.120
Contempt	0.230	0.050	0.170	0.070	0.170	0.080	0.050	0.090	0.110	0.050	0.050	0.100
Hate	0.390	0.040	0.090	0.040	0.110	0.060	0.030	0.070	0.270	0.040	0.040	0.100
Anger	0.300	0.050	0.080	0.050	0.090	0.110	0.040	0.090	0.480	0.030	0.040	0.090

Global-Switzerland	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.10	0.27	0.10	0.31	0.08	0.26	0.19	0.24	0.18	0.25	0.17	0.24
Amusement	0.04	0.15	0.05	0.24	0.04	0.42	0.35	0.19	0.19	0.25	0.08	0.39
Pride	0.16	0.24	0.07	0.16	0.07	0.15	0.12	0.23	0.22	0.16	0.23	0.17
Joy	0.04	0.21	0.05	0.33	0.04	0.43	0.40	0.19	0.27	0.32	0.23	0.50
Pleasure	0.06	0.25	0.07	0.33	0.05	0.32	0.39	0.25	0.32	0.35	0.19	0.31
Contentment	0.07	0.34	0.13	0.38	0.09	0.23	0.24	0.19	0.14	0.30	0.30	0.25
Admiration	0.08	0.24	0.06	0.19	0.06	0.18	0.24	0.23	0.20	0.24	0.23	0.20
Love	0.04	0.11	0.05	0.12	0.04	0.12	0.48	0.17	0.68	0.13	0.19	0.10
Relief	0.06	0.34	0.10	0.34	0.10	0.11	0.17	0.13	0.05	0.34	0.43	0.16
Compassion	0.10	0.18	0.12	0.15	0.13	0.09	0.16	0.16	0.08	0.14	0.23	0.10
Sadness	0.52	0.26	0.16	0.05	0.46	0.04	0.04	0.17	0.05	0.09	0.13	0.05
Guilt	0.29	0.09	0.14	0.07	0.23	0.06	0.05	0.11	0.13	0.05	0.07	0.07
Regret	0.28	0.12	0.16	0.07	0.30	0.06	0.05	0.13	0.08	0.06	0.11	0.08
Shame	0.21	0.07	0.16	0.07	0.19	0.08	0.09	0.11	0.20	0.05	0.06	0.09
Disappointment	0.28	0.11	0.22	0.06	0.41	0.06	0.05	0.12	0.07	0.06	0.08	0.08
Fear	0.47	0.09	0.09	0.05	0.21	0.06	0.04	0.10	0.17	0.05	0.09	0.07
Disgust	0.18	0.04	0.35	0.14	0.12	0.09	0.06	0.09	0.08	0.05	0.04	0.12
Contempt	0.24	0.06	0.18	0.08	0.17	0.08	0.05	0.10	0.11	0.05	0.06	0.10
Hate	0.40	0.04	0.10	0.05	0.11	0.07	0.04	0.08	0.28	0.04	0.05	0.09
Anger	0.31	0.06	0.09	0.05	0.10	0.11	0.04	0.10	0.49	0.04	0.05	0.09

Switzerland	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.11	0.24	0.12	0.34	0.10	0.23	0.13	0.19	0.17	0.24	0.17	0.21
Amusement	0.04	0.21	0.06	0.32	0.04	0.39	0.51	0.21	0.16	0.27	0.07	0.35
Pride	0.10	0.24	0.06	0.21	0.05	0.18	0.13	0.18	0.22	0.21	0.22	0.21
Joy	0.05	0.29	0.06	0.28	0.04	0.50	0.51	0.18	0.19	0.39	0.18	0.54
Pleasure	0.05	0.23	0.07	0.27	0.05	0.37	0.58	0.27	0.40	0.37	0.12	0.33
Contentment	0.05	0.31	0.12	0.31	0.07	0.26	0.25	0.19	0.10	0.38	0.25	0.24
Admiration	0.07	0.29	0.07	0.22	0.07	0.22	0.27	0.22	0.16	0.31	0.24	0.23
Love	0.05	0.11	0.05	0.10	0.05	0.10	0.62	0.17	0.69	0.12	0.21	0.08
Relief	0.06	0.36	0.07	0.23	0.06	0.11	0.18	0.17	0.05	0.29	0.46	0.14
Compassion	0.07	0.27	0.11	0.20	0.11	0.18	0.25	0.20	0.13	0.16	0.30	0.14
Sadness	0.56	0.28	0.12	0.07	0.60	0.05	0.05	0.19	0.07	0.10	0.12	0.06
Guilt	0.30	0.15	0.15	0.12	0.29	0.09	0.06	0.16	0.15	0.07	0.08	0.17
Regret	0.43	0.18	0.19	0.11	0.50	0.09	0.05	0.17	0.11	0.08	0.12	0.12
Shame	0.28	0.10	0.22	0.14	0.20	0.08	0.06	0.14	0.34	0.07	0.09	0.10
Disappointment	0.40	0.15	0.21	0.08	0.51	0.08	0.05	0.17	0.08	0.09	0.12	0.12
Fear	0.50	0.20	0.08	0.14	0.27	0.07	0.04	0.12	0.16	0.07	0.12	0.10
Disgust	0.27	0.06	0.47	0.27	0.21	0.09	0.06	0.10	0.11	0.07	0.07	0.21
Contempt	0.37	0.10	0.23	0.11	0.32	0.12	0.08	0.11	0.19	0.06	0.09	0.14
Hate	0.54	0.05	0.11	0.10	0.12	0.10	0.05	0.12	0.50	0.06	0.05	0.08
Anger	0.44	0.05	0.12	0.11	0.13	0.12	0.05	0.13	0.78	0.07	0.05	0.11

PSIColor	0.958	0.914	0.955	0.865	0.967	0.970	0.977	0.850	0.911	0.971	0.946	0.952
PSI	0.931											

Table S7. Nation-to-nation color-emotion association pattern similarities (correlations). Nations with more similar color-emotion association patterns have values closer to 1.0. By definition, the correlation of the nation's matrix with itself is 1.0. Also see the same data displayed visually in Fig S 2

	AZ	BE	CH	CN	CO	DE	EE	EG	ES	FI	FR	GB	GE	GR	IL	IR	IT	LT	MX	NG	NL	NO	NZ	PL	RS	RU	SA	SE	UA	US
AZ	1	0.532	0.611	0.655	0.688	0.702	0.693	0.708	0.716	0.627	0.603	0.615	0.738	0.734	0.72	0.8	0.623	0.722	0.721	0.687	0.501	0.662	0.574	0.655	0.768	0.633	0.719	0.675	0.743	0.605
BE	0.532	1	0.886	0.727	0.809	0.883	0.822	0.573	0.838	0.864	0.883	0.861	0.729	0.785	0.777	0.704	0.814	0.83	0.804	0.605	0.919	0.848	0.837	0.872	0.792	0.802	0.72	0.838	0.766	0.83
CH	0.611	0.886	1	0.774	0.845	0.881	0.779	0.602	0.893	0.883	0.951	0.899	0.776	0.833	0.842	0.738	0.821	0.825	0.863	0.662	0.863	0.888	0.899	0.874	0.786	0.823	0.766	0.888	0.776	0.882
CN	0.655	0.727	0.774	1	0.747	0.753	0.718	0.511	0.792	0.759	0.772	0.764	0.786	0.733	0.769	0.677	0.735	0.806	0.728	0.601	0.698	0.781	0.75	0.75	0.775	0.795	0.629	0.75	0.8	0.715
CO	0.688	0.809	0.845	0.747	1	0.825	0.818	0.616	0.937	0.808	0.824	0.784	0.771	0.822	0.787	0.778	0.865	0.835	0.944	0.636	0.771	0.857	0.799	0.802	0.801	0.824	0.764	0.852	0.813	0.756
DE	0.702	0.883	0.881	0.753	0.825	1	0.836	0.644	0.868	0.874	0.851	0.892	0.785	0.84	0.835	0.796	0.828	0.839	0.832	0.665	0.861	0.875	0.82	0.911	0.849	0.808	0.789	0.891	0.773	0.848
EE	0.693	0.822	0.779	0.718	0.818	0.836	1	0.601	0.833	0.816	0.81	0.838	0.806	0.756	0.78	0.795	0.784	0.871	0.828	0.675	0.784	0.85	0.775	0.82	0.858	0.803	0.737	0.825	0.801	0.8
EG	0.708	0.573	0.602	0.511	0.616	0.644	0.601	1	0.634	0.616	0.566	0.564	0.614	0.737	0.62	0.693	0.568	0.645	0.625	0.624	0.538	0.585	0.524	0.62	0.679	0.593	0.834	0.596	0.638	0.54
ES	0.716	0.838	0.893	0.792	0.937	0.868	0.833	0.634	1	0.825	0.881	0.84	0.831	0.873	0.85	0.822	0.879	0.862	0.939	0.666	0.81	0.895	0.823	0.853	0.841	0.857	0.797	0.881	0.859	0.811
FI	0.627	0.864	0.883	0.759	0.808	0.874	0.816	0.616	0.825	1	0.864	0.873	0.762	0.811	0.801	0.711	0.811	0.867	0.805	0.66	0.831	0.871	0.887	0.879	0.803	0.82	0.751	0.884	0.758	0.851
FR	0.603	0.883	0.951	0.772	0.824	0.851	0.81	0.566	0.881	0.864	1	0.889	0.795	0.82	0.847	0.723	0.829	0.839	0.852	0.665	0.838	0.883	0.868	0.873	0.797	0.813	0.744	0.872	0.784	0.867
GB	0.615	0.861	0.899	0.764	0.784	0.892	0.838	0.564	0.84	0.873	0.889	1	0.785	0.76	0.859	0.737	0.771	0.806	0.813	0.68	0.854	0.892	0.937	0.856	0.779	0.804	0.758	0.894	0.74	0.948
GE	0.738	0.729	0.776	0.786	0.771	0.785	0.806	0.614	0.831	0.762	0.795	0.785	1	0.77	0.811	0.77	0.79	0.849	0.797	0.627	0.693	0.802	0.732	0.844	0.822	0.825	0.753	0.798	0.825	0.743
GR	0.734	0.785	0.833	0.733	0.822	0.84	0.756	0.737	0.873	0.811	0.82	0.76	0.77	1	0.839	0.803	0.835	0.828	0.835	0.688	0.765	0.797	0.726	0.829	0.804	0.805	0.805	0.798	0.815	0.73
IL	0.72	0.777	0.842	0.769	0.787	0.835	0.78	0.62	0.85	0.801	0.847	0.859	0.811	0.839	1	0.784	0.76	0.783	0.817	0.686	0.775	0.847	0.824	0.827	0.794	0.785	0.76	0.842	0.795	0.839
IR	0.8	0.704	0.738	0.677	0.778	0.796	0.795	0.693	0.822	0.711	0.723	0.737	0.77	0.803	0.784	1	0.75	0.786	0.825	0.716	0.681	0.785	0.675	0.781	0.816	0.745	0.809	0.797	0.778	0.72
IT	0.623	0.814	0.821	0.735	0.865	0.828	0.784	0.568	0.879	0.811	0.829	0.771	0.79	0.835	0.76	0.75	1	0.859	0.851	0.585	0.77	0.839	0.753	0.849	0.806	0.84	0.738	0.844	0.818	0.739
LT	0.722	0.83	0.825	0.806	0.835	0.839	0.871	0.645	0.862	0.867	0.839	0.806	0.849	0.828	0.783	0.786	0.859	1	0.846	0.725	0.78	0.857	0.799	0.858	0.866	0.871	0.788	0.841	0.88	0.767
MX	0.721	0.804	0.863	0.728	0.944	0.832	0.828	0.625	0.939	0.805	0.852	0.813	0.797	0.835	0.817	0.825	0.851	0.846	1	0.658	0.767	0.874	0.804	0.822	0.809	0.825	0.772	0.862	0.823	0.799
NG	0.687	0.605	0.662	0.601	0.636	0.665	0.675	0.624	0.666	0.66	0.665	0.68	0.627	0.688	0.686	0.716	0.585	0.725	0.658	1	0.618	0.678	0.669	0.634	0.654	0.614	0.739	0.681	0.707	0.656
NL	0.501	0.919	0.863	0.698	0.771	0.861	0.784	0.538	0.81	0.831	0.838	0.854	0.693	0.765	0.775	0.681	0.77	0.78	0.767	0.618	1	0.82	0.826	0.828	0.751	0.805	0.693	0.821	0.756	0.808
NO	0.662	0.848	0.888	0.781	0.857	0.875	0.85	0.585	0.895	0.871	0.883	0.892	0.802	0.797	0.847	0.785	0.839	0.857	0.874	0.678	0.82	1	0.884	0.85	0.832	0.832	0.776	0.946	0.821	0.881
NZ	0.574	0.837	0.899	0.75	0.799	0.82	0.775	0.524	0.823	0.887	0.868	0.937	0.732	0.726	0.824	0.675	0.753	0.799	0.804	0.669	0.826	0.884	1	0.799	0.732	0.779	0.729	0.878	0.743	0.916
PL	0.655	0.872	0.874	0.75	0.802	0.911	0.82	0.62	0.853	0.879	0.873	0.856	0.844	0.829	0.827	0.781	0.849	0.858	0.822	0.634	0.828	0.85	0.799	1	0.859	0.827	0.776	0.872	0.78	0.837
RS	0.768	0.792	0.786	0.775	0.801	0.849	0.858	0.679	0.841	0.803	0.797	0.779	0.822	0.804	0.794	0.816	0.806	0.866	0.809	0.654	0.751	0.832	0.732	0.859	1	0.827	0.783	0.845	0.838	0.768
RU	0.633	0.802	0.823	0.795	0.824	0.808	0.803	0.593	0.857	0.82	0.813	0.804	0.825	0.805	0.785	0.745	0.84	0.871	0.825	0.614	0.805	0.832	0.779	0.827	0.827	1	0.748	0.823	0.854	0.759
SA	0.719	0.72	0.766	0.629	0.764	0.789	0.737	0.834	0.797	0.751	0.744	0.758	0.753	0.805	0.76	0.809	0.738	0.788	0.772	0.739	0.693	0.776	0.729	0.776	0.783	0.748	1	0.794	0.757	0.747
SE	0.675	0.838	0.888	0.75	0.852	0.891	0.825	0.596	0.881	0.884	0.872	0.894	0.798	0.798	0.842	0.797	0.844	0.841	0.862	0.681	0.821	0.946	0.878	0.872	0.845	0.823	0.794	1	0.815	0.889
UA	0.743	0.766	0.776	0.8	0.813	0.773	0.801	0.638	0.859	0.758	0.784	0.74	0.825	0.815	0.795	0.778	0.818	0.88	0.823	0.707	0.756	0.821	0.743	0.78	0.838	0.854	0.757	0.815	1	0.719
US	0.605	0.83	0.882	0.715	0.756	0.848	0.8	0.54	0.811	0.851	0.867	0.948	0.743	0.73	0.839	0.72	0.739	0.767	0.799	0.656	0.808	0.881	0.916	0.837	0.768	0.759	0.747	0.889	0.719	1

Table S 8. Color-emotion association matrices by sex. The men-specific matrix (averaged across all 30 nations) is presented above the women-specific matrix (average across all 30 nations). Color-emotion association pattern similarity, comparing men and women matrices, is indicated. Cells in each matrix contain Bayesian-derived probabilities of associating a particular color with a particular emotion. They are color-coded so that redder cells indicate higher Bayesian probabilities.

Men	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.11	0.27	0.11	0.30	0.10	0.25	0.20	0.22	0.17	0.23	0.19	0.22
Amusement	0.04	0.18	0.06	0.24	0.05	0.38	0.31	0.18	0.18	0.22	0.09	0.35
Pride	0.17	0.26	0.08	0.17	0.08	0.15	0.12	0.21	0.21	0.14	0.22	0.15
Joy	0.04	0.22	0.05	0.32	0.04	0.37	0.33	0.18	0.26	0.27	0.25	0.39
Pleasure	0.06	0.26	0.08	0.34	0.06	0.31	0.36	0.22	0.34	0.32	0.20	0.27
Contentment	0.08	0.31	0.13	0.35	0.11	0.23	0.19	0.18	0.15	0.28	0.28	0.21
Admiration	0.10	0.24	0.07	0.21	0.07	0.19	0.22	0.22	0.19	0.22	0.23	0.20
Love	0.05	0.13	0.05	0.13	0.04	0.15	0.47	0.20	0.61	0.14	0.19	0.12
Relief	0.06	0.30	0.10	0.34	0.09	0.12	0.16	0.12	0.06	0.29	0.38	0.14
Compassion	0.10	0.17	0.11	0.14	0.10	0.10	0.16	0.17	0.10	0.15	0.23	0.11
Sadness	0.52	0.20	0.15	0.06	0.41	0.04	0.05	0.16	0.07	0.08	0.10	0.06
Guilt	0.27	0.09	0.14	0.06	0.24	0.06	0.05	0.12	0.13	0.05	0.06	0.08
Regret	0.26	0.12	0.17	0.07	0.29	0.06	0.06	0.13	0.08	0.05	0.10	0.09
Shame	0.20	0.07	0.17	0.07	0.18	0.07	0.10	0.12	0.19	0.07	0.05	0.12
Disappointment	0.28	0.11	0.20	0.06	0.39	0.07	0.06	0.12	0.08	0.07	0.07	0.09
Fear	0.48	0.08	0.09	0.05	0.18	0.06	0.04	0.09	0.19	0.05	0.09	0.10
Disgust	0.19	0.04	0.35	0.13	0.12	0.07	0.08	0.10	0.09	0.05	0.05	0.14
Contempt	0.23	0.06	0.17	0.08	0.18	0.07	0.07	0.08	0.11	0.05	0.06	0.11
Hate	0.39	0.05	0.10	0.05	0.11	0.06	0.04	0.08	0.29	0.05	0.04	0.09
Anger	0.30	0.05	0.09	0.05	0.10	0.10	0.05	0.11	0.49	0.04	0.05	0.11

Women	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.09	0.25	0.09	0.30	0.07	0.25	0.18	0.23	0.18	0.25	0.14	0.23
Amusement	0.03	0.14	0.04	0.23	0.03	0.39	0.34	0.19	0.18	0.23	0.07	0.36
Pride	0.15	0.23	0.06	0.15	0.06	0.14	0.11	0.23	0.21	0.16	0.23	0.16
Joy	0.03	0.19	0.04	0.32	0.03	0.41	0.41	0.19	0.28	0.32	0.22	0.50
Pleasure	0.06	0.23	0.06	0.32	0.04	0.30	0.39	0.25	0.31	0.35	0.17	0.28
Contentment	0.07	0.33	0.12	0.38	0.08	0.22	0.25	0.19	0.14	0.30	0.29	0.24
Admiration	0.07	0.22	0.05	0.19	0.05	0.17	0.24	0.23	0.20	0.22	0.22	0.18
Love	0.04	0.10	0.04	0.12	0.03	0.10	0.47	0.15	0.68	0.12	0.18	0.09
Relief	0.05	0.34	0.08	0.33	0.09	0.10	0.17	0.13	0.05	0.34	0.44	0.16
Compassion	0.09	0.18	0.11	0.16	0.12	0.09	0.15	0.15	0.08	0.12	0.23	0.09
Sadness	0.53	0.25	0.15	0.04	0.46	0.03	0.03	0.17	0.04	0.08	0.13	0.04
Guilt	0.31	0.09	0.12	0.06	0.23	0.05	0.04	0.11	0.11	0.04	0.06	0.07
Regret	0.28	0.11	0.15	0.06	0.29	0.06	0.04	0.13	0.07	0.06	0.09	0.07
Shame	0.20	0.07	0.14	0.06	0.18	0.07	0.08	0.09	0.19	0.04	0.06	0.08
Disappointment	0.29	0.11	0.20	0.05	0.41	0.06	0.04	0.11	0.05	0.05	0.07	0.07
Fear	0.46	0.08	0.08	0.05	0.21	0.05	0.03	0.09	0.14	0.04	0.09	0.06
Disgust	0.17	0.04	0.33	0.13	0.12	0.09	0.05	0.07	0.07	0.04	0.03	0.12
Contempt	0.23	0.05	0.17	0.07	0.16	0.08	0.04	0.10	0.11	0.04	0.05	0.10
Hate	0.39	0.03	0.09	0.04	0.11	0.06	0.03	0.07	0.26	0.03	0.04	0.10
Anger	0.30	0.05	0.08	0.05	0.09	0.11	0.03	0.08	0.48	0.03	0.04	0.09

PSI_{sex} 0.987

Table S9. Color-emotion association matrices by age group. Age-specific matrices are presented by approximately 10-year bins – 15-20 years old, 20-30 years old, 30-40 years old, 40-50 years old, 50-60 years old, 60-70 years old, and 70-87 years old. They are compared to the global matrix. Cells in each matrix contain Bayesian-derived probabilities of associating a particular color with a particular emotion. They are color-coded so that redder cells indicate higher Bayesian probabilities.

All ages	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.10	0.25	0.10	0.31	0.08	0.25	0.19	0.23	0.19	0.25	0.16	0.22
Amusement	0.04	0.16	0.05	0.22	0.05	0.37	0.33	0.18	0.21	0.22	0.09	0.32
Pride	0.14	0.23	0.07	0.16	0.07	0.15	0.11	0.20	0.21	0.15	0.21	0.15
Joy	0.04	0.21	0.05	0.31	0.04	0.38	0.37	0.19	0.31	0.28	0.22	0.43
Pleasure	0.05	0.25	0.07	0.34	0.05	0.30	0.36	0.22	0.31	0.32	0.19	0.28
Contentment	0.07	0.34	0.13	0.37	0.09	0.22	0.24	0.19	0.15	0.28	0.27	0.22
Admiration	0.08	0.23	0.06	0.21	0.06	0.20	0.23	0.22	0.22	0.23	0.21	0.20
Love	0.04	0.11	0.05	0.13	0.04	0.12	0.42	0.15	0.62	0.14	0.18	0.10
Relief	0.05	0.30	0.09	0.31	0.09	0.10	0.16	0.11	0.06	0.28	0.38	0.14
Compassion	0.10	0.16	0.12	0.14	0.12	0.10	0.13	0.14	0.08	0.12	0.21	0.10
Sadness	0.53	0.19	0.16	0.05	0.43	0.04	0.04	0.16	0.05	0.08	0.12	0.05
Guilt	0.27	0.08	0.13	0.06	0.21	0.06	0.04	0.10	0.11	0.05	0.07	0.07
Regret	0.25	0.10	0.15	0.06	0.27	0.06	0.05	0.12	0.07	0.06	0.09	0.08
Shame	0.18	0.06	0.13	0.06	0.17	0.07	0.07	0.10	0.17	0.05	0.06	0.09
Disappointment	0.27	0.10	0.20	0.05	0.38	0.06	0.05	0.11	0.05	0.07	0.08	0.08
Fear	0.45	0.07	0.09	0.05	0.19	0.06	0.04	0.08	0.14	0.05	0.08	0.06
Disgust	0.17	0.04	0.30	0.11	0.13	0.07	0.05	0.08	0.06	0.05	0.04	0.10
Contempt	0.21	0.06	0.15	0.06	0.16	0.07	0.05	0.09	0.09	0.05	0.05	0.10
Hate	0.34	0.04	0.09	0.04	0.12	0.06	0.04	0.07	0.22	0.04	0.04	0.09
Anger	0.27	0.05	0.08	0.05	0.09	0.10	0.04	0.08	0.41	0.04	0.05	0.08

15-20	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.15	0.32	0.14	0.31	0.10	0.30	0.24	0.28	0.19	0.34	0.21	0.28
Amusement	0.07	0.21	0.08	0.29	0.07	0.43	0.41	0.24	0.19	0.30	0.12	0.40
Pride	0.20	0.27	0.12	0.22	0.13	0.24	0.17	0.28	0.25	0.19	0.27	0.22
Joy	0.07	0.24	0.08	0.33	0.07	0.36	0.48	0.26	0.27	0.34	0.24	0.53
Pleasure	0.09	0.33	0.09	0.33	0.09	0.29	0.44	0.28	0.31	0.38	0.22	0.35
Contentment	0.14	0.36	0.15	0.37	0.10	0.24	0.32	0.24	0.17	0.37	0.33	0.29
Admiration	0.12	0.32	0.08	0.26	0.09	0.24	0.37	0.26	0.29	0.33	0.23	0.25
Love	0.08	0.15	0.07	0.12	0.07	0.14	0.60	0.20	0.74	0.19	0.22	0.14
Relief	0.11	0.33	0.12	0.38	0.14	0.14	0.25	0.16	0.10	0.42	0.47	0.18
Compassion	0.12	0.22	0.14	0.19	0.16	0.17	0.21	0.16	0.17	0.22	0.34	0.16
Sadness	0.54	0.37	0.18	0.09	0.52	0.07	0.07	0.17	0.09	0.13	0.21	0.11
Guilt	0.46	0.17	0.19	0.12	0.34	0.11	0.08	0.17	0.19	0.10	0.15	0.16
Regret	0.37	0.18	0.21	0.12	0.38	0.10	0.09	0.14	0.12	0.14	0.18	0.12
Shame	0.28	0.14	0.21	0.12	0.27	0.12	0.12	0.19	0.27	0.10	0.13	0.14
Disappointment	0.40	0.19	0.28	0.09	0.51	0.12	0.09	0.15	0.10	0.13	0.14	0.14
Fear	0.58	0.17	0.13	0.12	0.32	0.12	0.08	0.15	0.19	0.10	0.16	0.12
Disgust	0.27	0.08	0.50	0.28	0.18	0.15	0.11	0.14	0.11	0.08	0.08	0.19
Contempt	0.30	0.09	0.23	0.12	0.24	0.15	0.10	0.17	0.16	0.09	0.11	0.17
Hate	0.47	0.09	0.17	0.08	0.22	0.11	0.08	0.12	0.41	0.07	0.08	0.13
Anger	0.36	0.11	0.15	0.10	0.15	0.16	0.09	0.12	0.56	0.07	0.10	0.10

20-30	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.09	0.27	0.09	0.32	0.08	0.25	0.21	0.23	0.20	0.26	0.15	0.25
Amusement	0.03	0.16	0.04	0.26	0.03	0.41	0.35	0.21	0.18	0.25	0.08	0.39
Pride	0.18	0.25	0.07	0.18	0.07	0.14	0.11	0.23	0.22	0.16	0.25	0.17
Joy	0.03	0.22	0.05	0.35	0.03	0.41	0.44	0.19	0.25	0.35	0.24	0.51
Pleasure	0.07	0.26	0.07	0.34	0.05	0.32	0.41	0.27	0.34	0.36	0.19	0.30
Contentment	0.08	0.32	0.13	0.39	0.09	0.24	0.23	0.20	0.14	0.31	0.31	0.25
Admiration	0.08	0.24	0.05	0.20	0.05	0.16	0.25	0.24	0.21	0.22	0.24	0.20
Love	0.05	0.09	0.04	0.12	0.03	0.10	0.52	0.17	0.72	0.12	0.19	0.09
Relief	0.06	0.38	0.09	0.35	0.10	0.12	0.19	0.13	0.05	0.38	0.47	0.17
Compassion	0.09	0.22	0.10	0.17	0.12	0.10	0.18	0.16	0.09	0.16	0.25	0.11
Sadness	0.55	0.29	0.14	0.05	0.47	0.03	0.04	0.18	0.05	0.10	0.13	0.04
Guilt	0.35	0.10	0.14	0.06	0.26	0.07	0.04	0.12	0.14	0.05	0.07	0.09
Regret	0.33	0.14	0.16	0.07	0.34	0.07	0.05	0.14	0.09	0.06	0.11	0.08
Shame	0.25	0.08	0.16	0.08	0.22	0.09	0.11	0.11	0.22	0.06	0.06	0.11
Disappointment	0.32	0.13	0.21	0.05	0.45	0.07	0.05	0.13	0.07	0.06	0.07	0.08
Fear	0.51	0.10	0.09	0.06	0.23	0.05	0.04	0.10	0.17	0.05	0.10	0.08
Disgust	0.20	0.04	0.38	0.17	0.13	0.11	0.06	0.09	0.08	0.04	0.03	0.16
Contempt	0.28	0.06	0.19	0.09	0.20	0.10	0.05	0.11	0.13	0.05	0.05	0.11
Hate	0.45	0.04	0.10	0.05	0.12	0.08	0.04	0.08	0.33	0.03	0.04	0.10
Anger	0.34	0.06	0.09	0.05	0.11	0.12	0.04	0.09	0.55	0.04	0.04	0.10

30-40	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.10	0.25	0.09	0.29	0.08	0.25	0.19	0.23	0.17	0.22	0.15	0.24
Amusement	0.05	0.13	0.04	0.23	0.02	0.39	0.35	0.20	0.19	0.24	0.06	0.33
Pride	0.16	0.24	0.06	0.15	0.06	0.14	0.10	0.22	0.20	0.15	0.21	0.16
Joy	0.03	0.18	0.04	0.32	0.03	0.42	0.39	0.20	0.30	0.30	0.22	0.45
Pleasure	0.07	0.23	0.07	0.32	0.03	0.31	0.39	0.24	0.33	0.33	0.18	0.27
Contentment	0.07	0.34	0.13	0.39	0.08	0.21	0.22	0.20	0.13	0.28	0.28	0.23
Admiration	0.09	0.23	0.06	0.19	0.04	0.16	0.21	0.22	0.19	0.21	0.24	0.17
Love	0.03	0.11	0.04	0.13	0.03	0.11	0.47	0.16	0.63	0.14	0.18	0.11
Relief	0.04	0.35	0.09	0.35	0.08	0.07	0.15	0.14	0.04	0.34	0.43	0.14
Compassion	0.09	0.17	0.12	0.17	0.10	0.07	0.15	0.16	0.07	0.13	0.23	0.10
Sadness	0.53	0.21	0.15	0.04	0.48	0.03	0.03	0.16	0.04	0.06	0.11	0.04
Guilt	0.28	0.06	0.10	0.05	0.22	0.05	0.03	0.09	0.11	0.02	0.04	0.06
Regret	0.24	0.08	0.14	0.04	0.25	0.04	0.04	0.12	0.06	0.04	0.08	0.07
Shame	0.16	0.06	0.15	0.05	0.15	0.06	0.07	0.08	0.17	0.03	0.05	0.09
Disappointment	0.25	0.08	0.18	0.04	0.37	0.06	0.03	0.10	0.05	0.04	0.05	0.08
Fear	0.43	0.06	0.09	0.03	0.18	0.05	0.02	0.06	0.14	0.03	0.07	0.06
Disgust	0.13	0.03	0.32	0.10	0.11	0.05	0.04	0.07	0.06	0.03	0.03	0.10
Contempt	0.19	0.04	0.15	0.06	0.13	0.05	0.04	0.08	0.09	0.02	0.04	0.08
Hate	0.37	0.03	0.07	0.04	0.08	0.06	0.02	0.05	0.23	0.04	0.04	0.09
Anger	0.29	0.05	0.07	0.04	0.08	0.12	0.03	0.09	0.48	0.03	0.05	0.11

40-50	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.09	0.23	0.08	0.29	0.08	0.26	0.14	0.21	0.19	0.21	0.14	0.19
Amusement	0.04	0.10	0.05	0.20	0.05	0.36	0.29	0.15	0.21	0.17	0.08	0.32
Pride	0.15	0.23	0.07	0.13	0.07	0.12	0.10	0.19	0.19	0.14	0.19	0.14
Joy	0.05	0.16	0.06	0.32	0.04	0.40	0.31	0.14	0.29	0.25	0.20	0.43
Pleasure	0.05	0.22	0.07	0.29	0.05	0.28	0.36	0.21	0.30	0.31	0.17	0.24
Contentment	0.06	0.35	0.14	0.37	0.08	0.20	0.22	0.16	0.16	0.28	0.28	0.20
Admiration	0.08	0.19	0.08	0.17	0.07	0.18	0.18	0.21	0.20	0.21	0.18	0.13
Love	0.05	0.09	0.05	0.12	0.03	0.12	0.39	0.14	0.58	0.12	0.17	0.08
Relief	0.05	0.27	0.10	0.29	0.09	0.10	0.16	0.11	0.07	0.26	0.38	0.12
Compassion	0.10	0.14	0.12	0.15	0.12	0.08	0.12	0.14	0.08	0.09	0.20	0.06
Sadness	0.52	0.18	0.15	0.04	0.39	0.04	0.03	0.15	0.04	0.05	0.09	0.05
Guilt	0.27	0.07	0.12	0.05	0.19	0.05	0.04	0.09	0.09	0.03	0.05	0.05
Regret	0.22	0.08	0.11	0.05	0.22	0.05	0.04	0.12	0.07	0.05	0.07	0.07
Shame	0.17	0.05	0.11	0.05	0.15	0.06	0.06	0.07	0.16	0.04	0.05	0.07
Disappointment	0.22	0.08	0.19	0.04	0.36	0.04	0.04	0.11	0.05	0.05	0.06	0.06
Fear	0.39	0.06	0.06	0.03	0.17	0.05	0.03	0.07	0.11	0.03	0.06	0.05
Disgust	0.14	0.04	0.27	0.06	0.11	0.05	0.05	0.08	0.04	0.04	0.03	0.09
Contempt	0.19	0.05	0.14	0.06	0.11	0.05	0.04	0.09	0.08	0.04	0.04	0.09
Hate	0.32	0.03	0.08	0.04	0.09	0.05	0.04	0.06	0.17	0.04	0.03	0.09
Anger	0.24	0.05	0.06	0.04	0.08	0.08	0.04	0.08	0.43	0.03	0.04	0.09

50-60	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.08	0.24	0.09	0.25	0.06	0.20	0.15	0.22	0.13	0.22	0.15	0.16
Amusement	0.01	0.11	0.02	0.13	0.03	0.35	0.29	0.12	0.14	0.17	0.07	0.28
Pride	0.10	0.19	0.05	0.13	0.04	0.11	0.07	0.16	0.15	0.15	0.21	0.10
Joy	0.03	0.18	0.03	0.24	0.02	0.41	0.29	0.17	0.25	0.24	0.21	0.41
Pleasure	0.04	0.21	0.06	0.31	0.03	0.26	0.32	0.21	0.24	0.31	0.15	0.26
Contentment	0.04	0.31	0.11	0.33	0.10	0.20	0.21	0.16	0.10	0.27	0.22	0.17
Admiration	0.07	0.21	0.04	0.16	0.06	0.17	0.18	0.22	0.16	0.22	0.20	0.18
Love	0.02	0.12	0.03	0.11	0.03	0.11	0.33	0.16	0.53	0.11	0.16	0.08
Relief	0.03	0.25	0.07	0.30	0.07	0.09	0.14	0.11	0.04	0.22	0.32	0.11
Compassion	0.06	0.12	0.10	0.12	0.09	0.07	0.09	0.14	0.03	0.08	0.17	0.07
Sadness	0.49	0.12	0.16	0.04	0.32	0.01	0.03	0.16	0.04	0.04	0.08	0.04
Guilt	0.19	0.04	0.09	0.02	0.18	0.02	0.02	0.06	0.06	0.02	0.03	0.04
Regret	0.20	0.05	0.12	0.04	0.24	0.04	0.02	0.10	0.04	0.02	0.06	0.06
Shame	0.14	0.02	0.11	0.03	0.11	0.03	0.04	0.06	0.12	0.02	0.02	0.04
Disappointment	0.21	0.05	0.17	0.04	0.32	0.03	0.02	0.09	0.04	0.04	0.04	0.06
Fear	0.37	0.05	0.05	0.02	0.12	0.02	0.02	0.05	0.16	0.02	0.05	0.03
Disgust	0.13	0.02	0.20	0.05	0.09	0.03	0.03	0.04	0.05	0.02	0.02	0.06
Contempt	0.15	0.03	0.13	0.04	0.11	0.03	0.03	0.04	0.06	0.03	0.03	0.07
Hate	0.27	0.02	0.05	0.02	0.06	0.02	0.02	0.04	0.16	0.02	0.02	0.07
Anger	0.20	0.03	0.06	0.03	0.05	0.07	0.02	0.06	0.35	0.02	0.03	0.07

60-70	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.08	0.18	0.08	0.28	0.08	0.22	0.13	0.18	0.15	0.18	0.13	0.18
Amusement	0.04	0.16	0.04	0.18	0.05	0.28	0.27	0.14	0.17	0.21	0.09	0.27
Pride	0.11	0.21	0.04	0.14	0.05	0.13	0.09	0.15	0.24	0.13	0.19	0.11
Joy	0.03	0.24	0.04	0.29	0.04	0.33	0.27	0.12	0.31	0.23	0.21	0.36
Pleasure	0.03	0.21	0.05	0.34	0.05	0.28	0.28	0.18	0.27	0.30	0.19	0.26
Contentment	0.05	0.35	0.11	0.39	0.09	0.17	0.22	0.14	0.12	0.29	0.24	0.19
Admiration	0.06	0.16	0.03	0.15	0.05	0.15	0.18	0.17	0.16	0.19	0.18	0.15
Love	0.04	0.10	0.03	0.13	0.03	0.10	0.28	0.09	0.52	0.10	0.18	0.07
Relief	0.04	0.22	0.09	0.26	0.06	0.13	0.14	0.06	0.06	0.21	0.27	0.17
Compassion	0.10	0.11	0.10	0.12	0.11	0.08	0.10	0.11	0.05	0.07	0.15	0.07
Sadness	0.49	0.10	0.16	0.05	0.42	0.04	0.05	0.13	0.04	0.04	0.08	0.03
Guilt	0.21	0.07	0.13	0.05	0.16	0.04	0.04	0.10	0.10	0.04	0.05	0.03
Regret	0.20	0.09	0.14	0.04	0.23	0.05	0.05	0.11	0.08	0.04	0.07	0.07
Shame	0.14	0.04	0.11	0.04	0.10	0.05	0.05	0.08	0.14	0.03	0.04	0.08
Disappointment	0.22	0.07	0.21	0.04	0.32	0.06	0.04	0.08	0.06	0.04	0.05	0.07
Fear	0.38	0.05	0.09	0.05	0.15	0.05	0.04	0.07	0.12	0.03	0.05	0.05
Disgust	0.15	0.05	0.19	0.06	0.12	0.05	0.03	0.06	0.05	0.04	0.04	0.06
Contempt	0.16	0.06	0.12	0.05	0.10	0.06	0.04	0.06	0.08	0.04	0.04	0.08
Hate	0.27	0.04	0.07	0.04	0.08	0.06	0.03	0.09	0.15	0.04	0.04	0.08
Anger	0.23	0.04	0.06	0.05	0.06	0.08	0.04	0.09	0.34	0.04	0.05	0.07

70-87	black	blue	brown	green	grey	orange	pink	purple	red	turquoise	white	yellow
Interest	0.08	0.30	0.12	0.41	0.11	0.26	0.26	0.26	0.27	0.31	0.21	0.27
Amusement	0.02	0.25	0.09	0.28	0.08	0.35	0.38	0.20	0.36	0.23	0.12	0.28
Pride	0.09	0.21	0.09	0.18	0.08	0.20	0.12	0.16	0.23	0.10	0.15	0.13
Joy	0.02	0.26	0.06	0.32	0.06	0.33	0.44	0.22	0.50	0.23	0.22	0.31
Pleasure	0.02	0.26	0.08	0.42	0.06	0.34	0.35	0.17	0.41	0.24	0.20	0.27
Contentment	0.02	0.33	0.11	0.39	0.08	0.27	0.30	0.26	0.26	0.18	0.25	0.25
Admiration	0.06	0.28	0.08	0.31	0.06	0.34	0.22	0.26	0.33	0.22	0.20	0.30
Love	0.02	0.14	0.07	0.22	0.04	0.15	0.40	0.15	0.64	0.17	0.18	0.15
Relief	0.04	0.28	0.07	0.24	0.07	0.08	0.11	0.07	0.05	0.15	0.29	0.12
Compassion	0.12	0.12	0.13	0.09	0.15	0.14	0.08	0.12	0.05	0.07	0.13	0.10
Sadness	0.60	0.08	0.18	0.07	0.40	0.02	0.05	0.19	0.03	0.14	0.16	0.07
Guilt	0.17	0.06	0.13	0.06	0.15	0.06	0.05	0.09	0.05	0.07	0.07	0.07
Regret	0.19	0.08	0.16	0.06	0.20	0.06	0.08	0.12	0.05	0.09	0.07	0.09
Shame	0.15	0.04	0.08	0.06	0.17	0.07	0.05	0.09	0.08	0.08	0.05	0.09
Disappointment	0.25	0.12	0.19	0.06	0.33	0.07	0.07	0.13	0.02	0.11	0.16	0.11
Fear	0.48	0.02	0.10	0.05	0.18	0.06	0.03	0.08	0.07	0.06	0.08	0.03
Disgust	0.16	0.03	0.22	0.05	0.19	0.06	0.03	0.10	0.03	0.09	0.07	0.06
Contempt	0.18	0.06	0.12	0.05	0.25	0.07	0.08	0.06	0.03	0.09	0.06	0.12
Hate	0.26	0.02	0.06	0.03	0.17	0.05	0.03	0.06	0.07	0.08	0.06	0.07
Anger	0.24	0.05	0.06	0.05	0.10	0.05	0.03	0.07	0.15	0.06	0.03	0.06

Category	PSIage
All, <20	0.958
All, 20-30	0.982
All, 30-40	0.99
All, 40-50	0.99
All, 50-60	0.983
All, 60-70	0.975
All, >70	0.901

Table S10. Average color-emotion association pattern similarities (r) for each of the 12 color terms across all nations

Color term	Similarity	Variance	Range		CI 95%	
			Minimum	Maximum	Lower	Upper
black	0.905	0.004	0.645	0.981	0.882	0.929
blue	0.862	0.008	0.612	0.966	0.830	0.893
brown	0.865	0.020	0.340	0.968	0.814	0.916
green	0.900	0.002	0.784	0.969	0.885	0.915
grey	0.914	0.019	0.225	0.981	0.865	0.963
orange	0.916	0.013	0.375	0.981	0.876	0.957
pink	0.925	0.002	0.843	0.991	0.910	0.940
purple	0.659	0.095	-0.179	0.912	0.548	0.769
red	0.892	0.008	0.595	0.988	0.861	0.923
turquoise	0.911	0.003	0.725	0.971	0.891	0.930
white	0.862	0.015	0.297	0.953	0.818	0.905
yellow	0.849	0.057	-0.203	0.988	0.764	0.934

Table S11. Emotion intensity pattern similarities by nation and color term.

Panel A represents the global matrix averaged across the 30-nations (top line), followed by the global matrices, leaving-out one nation at a time. Each cell represents the global emotion intensity given to each color term. Panel B represents nation-specific emotion intensities per color. Each cell represents the average emotion intensity given to each color term within each nation. Redder cells indicate higher emotion intensities; greener cells indicate lower emotion intensities.

	RED	ORANGE	YELLOW	GREEN	TURQUOISE	BLUE	PURPLE	PINK	BROWN	GREY	WHITE	BLACK
GLOBAL	4.12	3.74	3.82	3.88	3.82	3.81	3.67	3.73	3.41	3.58	4.01	4.01
Global - Azerbaijan	4.11	3.72	3.83	3.85	3.78	3.80	3.61	3.72	3.38	3.57	3.97	4.01
Global - Belgium	4.12	3.74	3.82	3.88	3.82	3.82	3.67	3.74	3.41	3.58	4.01	4.01
Global - China	4.12	3.74	3.82	3.88	3.83	3.82	3.67	3.73	3.41	3.58	4.01	4.01
Global - Colombia	4.12	3.74	3.82	3.89	3.82	3.81	3.67	3.73	3.41	3.58	4.00	4.01
Global - Egypt	4.13	3.75	3.84	3.89	3.81	3.82	3.67	3.73	3.41	3.58	3.99	4.00
Global - Estonia	4.12	3.74	3.81	3.88	3.81	3.81	3.67	3.74	3.41	3.58	4.00	4.01
Global - Finland	4.14	3.76	3.83	3.90	3.83	3.83	3.69	3.75	3.43	3.59	4.02	4.02
Global - France	4.12	3.75	3.82	3.89	3.82	3.82	3.67	3.73	3.41	3.58	4.01	4.01
Global - Georgia	4.12	3.73	3.82	3.87	3.81	3.81	3.66	3.73	3.40	3.57	4.00	4.01
Global - Germany	4.13	3.75	3.83	3.89	3.83	3.83	3.69	3.76	3.42	3.60	4.02	4.02
Global - Greece	4.12	3.74	3.82	3.88	3.81	3.80	3.67	3.73	3.40	3.57	3.99	4.01
Global - Iran	4.12	3.73	3.82	3.87	3.81	3.80	3.66	3.72	3.40	3.58	4.00	4.01
Global - Israel	4.13	3.74	3.82	3.89	3.82	3.81	3.67	3.73	3.41	3.58	4.01	4.01
Global - Italy	4.12	3.73	3.82	3.88	3.82	3.81	3.67	3.74	3.40	3.58	4.01	4.01
Global - Lithuania	4.13	3.74	3.82	3.89	3.81	3.81	3.67	3.73	3.42	3.58	4.01	4.01
Global - Mexico	4.12	3.74	3.81	3.88	3.81	3.80	3.67	3.73	3.40	3.57	4.00	4.01
Global - Netherlands	4.13	3.74	3.82	3.89	3.82	3.82	3.67	3.74	3.41	3.59	4.01	4.02
Global - New Zealand	4.13	3.76	3.83	3.90	3.83	3.82	3.67	3.74	3.42	3.59	4.02	4.02
Global - Nigeria	4.12	3.74	3.82	3.88	3.81	3.80	3.65	3.72	3.40	3.57	3.99	4.01
Global - Norway	4.14	3.75	3.82	3.89	3.83	3.82	3.68	3.74	3.42	3.58	4.02	4.02
Global - Poland	4.13	3.74	3.82	3.89	3.82	3.82	3.67	3.74	3.41	3.58	4.01	4.01
Global - Russia	4.12	3.73	3.82	3.87	3.82	3.81	3.66	3.73	3.41	3.58	4.00	4.01
Global - Saudi Arabia	4.12	3.74	3.81	3.87	3.81	3.81	3.65	3.72	3.39	3.57	3.99	4.00
Global - Serbia	4.13	3.74	3.82	3.88	3.82	3.82	3.67	3.74	3.41	3.58	4.01	4.01
Global - Spain	4.12	3.73	3.82	3.88	3.81	3.81	3.66	3.73	3.40	3.57	4.00	4.01
Global - Sweden	4.13	3.75	3.84	3.89	3.83	3.82	3.68	3.75	3.42	3.59	4.03	4.02
Global - Switzerland	4.13	3.75	3.83	3.90	3.83	3.82	3.68	3.74	3.42	3.58	4.02	4.02
Global - UK	4.13	3.75	3.82	3.89	3.83	3.82	3.67	3.74	3.42	3.58	4.02	4.02
Global - Ukraine	4.12	3.74	3.82	3.88	3.82	3.82	3.67	3.73	3.42	3.58	4.01	4.02
Global - USA	4.13	3.75	3.83	3.89	3.83	3.81	3.66	3.74	3.42	3.59	4.01	4.02

	RED	ORANGE	YELLOW	GREEN	TURQUOISE	BLUE	PURPLE	PINK	BROWN	GREY	WHITE	BLACK
Azerbaijan	4.25	3.95	3.72	4.15	4.17	3.93	4.16	3.87	3.65	3.70	4.31	4.08
Belgium	4.18	3.68	4.02	3.82	3.70	3.77	3.49	3.62	3.42	3.38	3.80	3.94
China	4.34	3.86	3.78	4.02	3.50	3.77	3.51	3.95	3.37	3.68	3.83	3.96
Colombia	4.38	3.89	4.04	3.72	3.80	3.89	3.68	3.77	3.37	3.68	4.17	4.09
Egypt	3.99	3.51	3.51	3.77	4.00	3.58	3.53	3.93	3.36	3.62	4.34	4.26
Estonia	4.12	3.89	4.14	3.95	4.00	3.95	3.63	3.64	3.39	3.61	4.13	4.03
Finland	3.62	3.26	3.59	3.39	3.33	3.32	3.08	3.30	2.89	3.16	3.47	3.79
France	4.25	3.49	3.71	3.69	3.69	3.76	3.61	3.86	3.41	3.62	3.89	4.01
Georgia	4.25	4.01	4.03	4.26	4.00	3.96	3.76	3.85	3.81	3.89	4.25	4.16
Germany	3.98	3.61	3.68	3.78	3.52	3.57	3.31	3.25	3.31	3.25	3.65	3.93
Greece	4.24	3.76	3.81	3.93	3.97	3.98	3.64	3.82	3.59	3.69	4.28	4.13
Iran	4.27	4.00	3.92	4.45	4.27	4.22	4.08	4.12	3.69	3.71	4.41	4.15
Israel	4.01	3.72	3.70	3.67	3.66	3.84	3.80	3.76	3.24	3.33	3.69	4.01
Italy	4.24	4.03	4.09	3.95	3.92	3.94	3.76	3.54	3.74	3.66	4.01	4.08
Lithuania	4.00	3.86	4.02	3.82	3.95	3.81	3.62	3.78	3.16	3.57	4.02	3.95
Mexico	4.42	3.96	4.09	4.12	3.98	4.15	3.63	3.89	3.64	3.83	4.41	4.14
Netherlands	3.97	3.74	3.76	3.59	3.62	3.57	3.40	3.57	3.21	3.12	3.63	3.81
New Zealand	3.87	3.33	3.74	3.42	3.42	3.57	3.51	3.62	3.11	3.40	3.60	3.72
Nigeria	4.19	3.95	3.95	4.08	4.02	4.14	4.13	4.23	3.75	3.92	4.38	4.19
Norway	3.84	3.56	3.80	3.76	3.67	3.75	3.48	3.59	3.24	3.59	3.81	3.87
Poland	4.11	3.69	3.76	3.80	3.70	3.73	3.49	3.56	3.34	3.66	3.84	3.99
Russia	4.26	4.03	4.06	4.20	3.82	4.05	3.82	3.91	3.49	3.72	4.10	4.14
Saudia Arabia	4.41	3.94	4.20	4.32	4.23	4.09	4.06	4.14	3.98	3.86	4.56	4.48
Serbia	4.02	3.62	3.77	3.82	3.80	3.78	3.70	3.67	3.26	3.41	3.96	4.01
Spain	4.35	3.99	3.94	4.03	3.96	4.01	3.84	3.84	3.61	3.79	4.07	4.13
Sweden	3.94	3.47	3.54	3.72	3.46	3.62	3.38	3.37	3.11	3.29	3.54	3.77
Switzerland	4.00	3.55	3.62	3.61	3.65	3.58	3.31	3.63	3.20	3.51	3.64	3.84
UK	4.06	3.58	3.84	3.59	3.61	3.69	3.56	3.64	3.21	3.48	3.62	3.85
Ukraine	4.24	3.84	4.02	3.92	3.90	3.59	3.78	3.77	2.93	3.28	4.04	3.87
USA	4.00	3.44	3.55	3.60	3.51	3.85	3.94	3.60	2.99	3.22	3.71	3.75

Table S 12. Linguistics distances for each nation-nation pair of the current study. Distances were derived from Jäger (2018) and raised to the fourth power. Linguistic distances below .240 indicate related languages. We used the following languages from Jäger (2018) for our nations: AZERBAIJANI_NORTH_2 (AZ), DUTCH (NL & BE), ENGLISH (GB, NG, NZ & US), ESTONIAN (EE), FINNISH (FI), FRENCH (FR & CH), GEORGIAN (GE), GREEK (GR), HEBREW (IL), ITALIAN (IT), LITHUANIAN (LT), MANDARIN (CN), NORWEGIAN_BOKMAAL (NO), PERSIAN (IR), POLISH (PL), RUSSIAN (RU), SERBOCROATIAN (RS), SPANISH (CO, ES & MX), STANDARD_ARABIC (EG & SA), STANDARD_GERMAN (DE), SWEDISH (SE), and UKRAINIAN (UA). Nation codes are available in Table S1.

	AZ	BE	CH	CN	CO	DE	EE	EG	ES	FI	FR	GB	GE	GR	IL	IR	IT	LT	MX	NG	NL	NO	NZ	PL	RS	RU	SA	SE	UA	US
AZ	0	0.6	0.547	0.588	0.541	0.55	0.539	0.488	0.541	0.469	0.547	0.587	0.434	0.499	0.541	0.426	0.479	0.536	0.541	0.587	0.6	0.652	0.587	0.56	0.609	0.552	0.488	0.652	0.6	0.587
BE	0.6	0	0.398	0.558	0.319	0.012	0.475	0.525	0.319	0.487	0.398	0.031	0.583	0.433	0.533	0.382	0.258	0.353	0.319	0.031	0	0.039	0.031	0.392	0.305	0.346	0.525	0.047	0.409	0.031
CH	0.547	0.398	0	0.559	0.112	0.426	0.564	0.481	0.112	0.531	0	0.374	0.596	0.353	0.431	0.349	0.065	0.351	0.112	0.374	0.398	0.391	0.374	0.347	0.346	0.317	0.481	0.434	0.319	0.374
CN	0.588	0.558	0.559	0	0.561	0.554	0.474	0.59	0.561	0.493	0.559	0.585	0.542	0.558	0.61	0.553	0.545	0.558	0.561	0.585	0.558	0.62	0.585	0.57	0.5	0.527	0.59	0.635	0.513	0.585
CO	0.541	0.319	0.112	0.561	0	0.396	0.534	0.528	0	0.517	0.112	0.314	0.549	0.376	0.46	0.419	0.007	0.381	0	0.314	0.319	0.407	0.314	0.338	0.358	0.334	0.528	0.386	0.295	0.314
DE	0.55	0.012	0.426	0.554	0.396	0	0.433	0.529	0.396	0.393	0.426	0.064	0.591	0.37	0.545	0.375	0.275	0.363	0.396	0.064	0.012	0.031	0.064	0.377	0.292	0.283	0.529	0.044	0.373	0.064
EE	0.539	0.475	0.564	0.474	0.534	0.433	0	0.569	0.534	0.006	0.564	0.524	0.533	0.552	0.583	0.539	0.545	0.554	0.534	0.524	0.475	0.534	0.524	0.424	0.399	0.406	0.569	0.506	0.499	0.524
EG	0.488	0.525	0.481	0.59	0.528	0.529	0.569	0	0.528	0.508	0.481	0.523	0.553	0.483	0.079	0.409	0.485	0.515	0.528	0.523	0.525	0.512	0.523	0.544	0.525	0.472	0	0.483	0.464	0.523
ES	0.541	0.319	0.112	0.561	0	0.396	0.534	0.528	0	0.517	0.112	0.314	0.549	0.376	0.46	0.419	0.007	0.381	0	0.314	0.319	0.407	0.314	0.338	0.358	0.334	0.528	0.386	0.295	0.314
FI	0.469	0.487	0.531	0.493	0.517	0.393	0.006	0.508	0.517	0	0.531	0.571	0.549	0.538	0.546	0.49	0.577	0.534	0.517	0.571	0.487	0.51	0.571	0.466	0.415	0.45	0.508	0.445	0.482	0.571
FR	0.547	0.398	0	0.559	0.112	0.426	0.564	0.481	0.112	0.531	0	0.374	0.596	0.353	0.431	0.349	0.065	0.351	0.112	0.374	0.398	0.391	0.374	0.347	0.346	0.317	0.481	0.434	0.319	0.374
GB	0.587	0.031	0.374	0.585	0.314	0.064	0.524	0.523	0.314	0.571	0.374	0	0.489	0.421	0.549	0.311	0.257	0.381	0.314	0	0.031	0.05	0	0.409	0.298	0.366	0.523	0.032	0.406	0
GE	0.434	0.583	0.596	0.542	0.549	0.591	0.533	0.553	0.549	0.549	0.596	0.489	0	0.58	0.516	0.576	0.564	0.537	0.549	0.489	0.583	0.616	0.489	0.568	0.541	0.547	0.553	0.607	0.649	0.489
GR	0.499	0.433	0.353	0.558	0.376	0.37	0.552	0.483	0.376	0.538	0.353	0.421	0.58	0	0.564	0.387	0.268	0.407	0.376	0.421	0.433	0.441	0.421	0.435	0.394	0.412	0.483	0.469	0.382	0.421
IL	0.541	0.533	0.431	0.61	0.46	0.545	0.583	0.079	0.46	0.546	0.431	0.549	0.516	0.564	0	0.497	0.51	0.555	0.46	0.549	0.533	0.499	0.549	0.506	0.538	0.509	0.079	0.489	0.468	0.549
IR	0.426	0.382	0.349	0.553	0.419	0.375	0.539	0.409	0.419	0.49	0.349	0.311	0.576	0.387	0.497	0	0.276	0.382	0.419	0.311	0.382	0.367	0.311	0.344	0.358	0.331	0.409	0.397	0.38	0.311
IT	0.479	0.258	0.065	0.545	0.007	0.275	0.545	0.485	0.007	0.577	0.065	0.257	0.564	0.268	0.51	0.276	0	0.292	0.007	0.257	0.258	0.321	0.257	0.265	0.306	0.304	0.485	0.346	0.331	0.257
LT	0.536	0.353	0.351	0.558	0.381	0.363	0.554	0.515	0.381	0.534	0.351	0.381	0.537	0.407	0.555	0.382	0.292	0	0.381	0.381	0.353	0.381	0.381	0.257	0.211	0.201	0.515	0.388	0.243	0.381
MX	0.541	0.319	0.112	0.561	0	0.396	0.534	0.528	0	0.517	0.112	0.314	0.549	0.376	0.46	0.419	0.007	0.381	0	0.314	0.319	0.407	0.314	0.338	0.358	0.334	0.528	0.386	0.295	0.314
NG	0.587	0.031	0.374	0.585	0.314	0.064	0.524	0.523	0.314	0.571	0.374	0	0.489	0.421	0.549	0.311	0.257	0.381	0.314	0	0.031	0.05	0	0.409	0.298	0.366	0.523	0.032	0.406	0
NL	0.6	0	0.398	0.558	0.319	0.012	0.475	0.525	0.319	0.487	0.398	0.031	0.583	0.433	0.533	0.382	0.258	0.353	0.319	0.031	0	0.039	0.031	0.392	0.305	0.346	0.525	0.047	0.409	0.031
NO	0.652	0.039	0.391	0.62	0.407	0.031	0.534	0.512	0.407	0.51	0.391	0.05	0.616	0.441	0.499	0.367	0.321	0.381	0.407	0.05	0.039	0	0.05	0.375	0.336	0.377	0.512	0.004	0.41	0.05
NZ	0.587	0.031	0.374	0.585	0.314	0.064	0.524	0.523	0.314	0.571	0.374	0	0.489	0.421	0.549	0.311	0.257	0.381	0.314	0	0.031	0.05	0	0.409	0.298	0.366	0.523	0.032	0.406	0
PL	0.56	0.392	0.347	0.57	0.338	0.377	0.424	0.544	0.338	0.466	0.347	0.409	0.568	0.435	0.506	0.344	0.265	0.257	0.338	0.409	0.392	0.375	0.409	0	0.004	0.004	0.544	0.402	0.014	0.409
RS	0.609	0.305	0.346	0.5	0.358	0.292	0.399	0.525	0.358	0.415	0.346	0.298	0.541	0.394	0.538	0.358	0.306	0.211	0.358	0.298	0.305	0.336	0.298	0.004	0	0.001	0.525	0.312	0.016	0.298
RU	0.552	0.346	0.317	0.527	0.334	0.283	0.406	0.472	0.334	0.45	0.317	0.366	0.547	0.412	0.509	0.331	0.304	0.201	0.334	0.366	0.346	0.377	0.366	0.004	0.001	0	0.472	0.399	0.007	0.366
SA	0.488	0.525	0.481	0.59	0.528	0.529	0.569	0	0.528	0.508	0.481	0.523	0.553	0.483	0.079	0.409	0.485	0.515	0.528	0.523	0.525	0.512	0.523	0.544	0.525	0.472	0	0.483	0.464	0.523
SE	0.652	0.047	0.434	0.635	0.386	0.044	0.506	0.483	0.386	0.445	0.434	0.032	0.607	0.469	0.489	0.397	0.346	0.388	0.386	0.032	0.047	0.004	0.032	0.402	0.312	0.399	0.483	0	0.384	0.032
UA	0.6	0.409	0.319	0.513	0.295	0.373	0.499	0.464	0.295	0.482	0.319	0.406	0.649	0.382	0.468	0.38	0.331	0.243	0.295	0.406	0.409	0.41	0.406	0.014	0.016	0.007	0.464	0.384	0	0.406
US	0.587	0.031	0.374	0.585	0.314	0.064	0.524	0.523	0.314	0.571	0.374	0	0.489	0.421	0.549	0.311	0.257	0.381	0.314	0	0.031	0.05	0	0.409	0.298	0.366	0.523	0.032	0.406	0

Table S 13. Geographic distances for each nation-nation pair of the current study. Distances were calculated by taking population-weighted mean of each country, or the most populated city when the former data was unavailable (see Table S 14). Distances are presented in kilometers (km).

	AZ	BE	CH	CN	CO	DE	EE	EG	ES	FI	FR	GB	GE	GR	IL	IR	IT	LT	MX	NG	NL	NO	NZ	PL	RS	RU	SA	SE	UA	US
AZ	0	3653	3405	5653	12425	3285	2673	2041	4455	2899	3802	4072	447	2273	1626	541	3122	2519	12628	5951	3599	3539	15290	2645	2419	1514	1770	3155	1706	10551
BE	3653	0	496	8431	8796	368	1613	3205	1379	1742	433	470	3220	2005	3292	4074	1060	1383	9252	4929	148	1188	18280	1037	1460	3320	4616	1139	1960	7312
CH	3405	496	0	8461	9020	444	1764	2749	1220	1962	399	937	2961	1557	2868	3783	566	1433	9660	4524	593	1569	18448	972	1064	3291	4215	1412	1776	7754
CN	5653	8431	8461	0	15735	8124	6830	7635	9678	6767	8779	8638	6028	7846	7209	5658	8437	7059	13203	11498	8304	7537	10000	7490	7786	5178	6515	7368	6788	11721
CO	12425	8796	9020	15735	0	9163	10107	11204	8034	10024	8623	8412	11981	10321	11529	12781	9342	10079	3171	8565	8868	9226	12199	9829	10032	11934	12829	9537	10754	4085
DE	3285	368	444	8124	9163	0	1351	2923	1599	1529	657	808	2853	1725	2979	3709	905	1065	9587	4963	334	1139	18060	676	1150	2985	4284	969	1591	7625
EE	2673	1613	1764	6830	10107	1351	0	3243	2950	310	2000	1820	2336	2261	3108	3195	2012	426	9956	6129	1480	899	16708	896	1728	1833	4150	575	1197	7881
EG	2041	3205	2749	7635	11204	2923	3243	0	3303	3552	3096	3672	1780	1201	425	1980	2217	2860	12369	3913	3241	3791	16570	2602	1778	3210	1634	3421	2087	10502
ES	4455	1379	1220	9678	8034	1599	2950	3303	0	3111	958	1457	4009	2290	3556	4757	1334	2647	9123	3746	1527	2547	19658	2192	2037	4502	4917	2516	2938	7410
FI	2899	1742	1962	6767	10024	1529	310	3552	3111	0	2153	1874	2586	2567	3411	3430	2263	726	9740	6393	1599	806	16547	1166	2025	1916	4426	611	1496	7655
FR	3802	433	399	8779	8623	657	2000	3096	958	2153	0	697	3359	1920	3239	4182	879	1721	9290	4515	581	1621	18700	1303	1457	3629	4594	1560	2158	7410
GB	4072	470	937	8638	8412	808	1820	3672	1457	1874	697	0	3646	2473	3762	4510	1500	1685	8785	5159	478	1162	18227	1429	1930	3614	5083	1269	2367	6842
GE	447	3220	2961	6028	11981	2853	2336	1780	4009	2586	3359	3646	0	1850	1397	879	2675	2138	12271	5653	3170	3174	15733	2224	1973	1500	1898	2783	1290	10210
GR	2273	2005	1557	7846	10321	1725	2261	1201	2290	2567	1920	2473	1850	0	1321	2496	1053	1841	11210	4099	2041	2660	17504	1484	600	2860	2685	2316	1311	9309
IL	1626	3292	2868	7209	11529	2979	3108	425	3556	3411	3239	3762	1397	1321	0	1556	2374	2756	12527	4334	3308	3741	16285	2568	1832	2866	1368	3357	1917	10602
IR	541	4074	3783	5658	12781	3709	3195	1980	4757	3430	4182	4510	879	2496	1556	0	3439	3015	13144	5859	4032	4047	15014	3095	2750	2016	1301	3658	2167	11075
IT	3122	1060	566	8437	9342	905	2012	2217	1334	2263	879	1500	2675	1053	2374	3439	0	1614	10162	4133	1143	2030	18392	1120	703	3270	3738	1796	1649	8288
LT	2519	1383	1433	7059	10079	1065	426	2860	2647	726	1721	1685	2138	1841	2756	3015	1614	0	10134	5714	1271	1044	17017	494	1302	1940	3870	648	892	8082
MX	12628	9252	9660	13203	3171	9587	9956	12369	9123	9740	9290	8785	12271	11210	12527	13144	10162	10134	0	11065	9254	9097	10955	10117	10709	11484	13868	9488	11005	2099
NG	5951	4929	4524	11498	8565	4963	6129	3913	3746	6393	4515	5159	5653	4099	4334	5859	4133	5714	11065	0	5067	6092	16532	5234	4467	6932	5028	5915	5404	10079
NL	3599	148	593	8304	8868	334	1480	3241	1527	1599	581	478	3170	2041	3308	4032	1143	1271	9254	5067	0	1042	18132	962	1477	3211	4617	994	1897	7294
NO	3539	1188	1569	7537	9226	1139	899	3791	2547	806	1621	1162	3174	2660	3741	4047	2030	1044	9097	6092	1042	0	17118	1189	2063	2708	4906	397	1933	7040
NZ	15290	18280	18448	10000	12199	18060	16708	16570	19658	16547	18700	18227	15733	17504	16285	15014	18392	17017	10955	16532	18132	17118	0	17478	17694	15177	14940	17142	16761	12595
PL	2645	1037	972	7490	9829	676	896	2602	2192	1166	1303	1429	2224	1484	2568	3095	1120	494	10117	5234	962	1189	17478	0	898	2327	3792	832	939	8106
RS	2419	1460	1064	7786	10032	1150	1728	1778	2037	2025	1457	1930	1973	600	1832	2750	703	1302	10709	4467	1477	2063	17694	898	0	2654	3160	1727	1017	8769
RU	1514	3320	3291	5178	11934	2985	1833	3210	4502	1916	3629	3614	1500	2860	2866	2016	3270	1940	11484	6932	3211	2708	15177	2327	2654	0	3284	2407	1638	9385
SA	1770	4616	4215	6515	12829	4284	4150	1634	4917	4426	4594	5083	1898	2685	1368	1301	3738	3870	13868	5028	4617	4906	14940	3792	3160	3284	0	4510	2979	11895
SE	3155	1139	1412	7368	9537	969	575	3421	2516	611	1560	1269	2783	2316	3357	3658	1796	648	9488	5915	994	397	17142	832	1727	2407	4510	0	1537	7434
UA	1706	1960	1776	6788	10754	1591	1197	2087	2938	1496	2158	2367	1290	1311	1917	2167	1649	892	11005	5404	1897	1933	16761	939	1017	1638	2979	1537	0	8965
US	10551	7312	7754	11721	4085	7625	7881	10502	7410	7655	7410	6842	10210	9309	10602	11075	8288	8082	2099	10079	7294	7040	12595	8106	8769	9385	11895	7434	8965	0

Table S 14. Coordinates of the population-weighted mean geographical centers of each nation or coordinates of the most populated cities. Column “source” indicates the source of the data.

Country code	Country	Source	Notes
AZ	Azerbaijan	http://worldpopulationreview.com/countries/azerbaijan-population/	coordinates of Baku
BE	Belgium	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
CN	China	http://sourcedb.igsrr.cas.cn/zw/lw/201007/P020100706529106697457.pdf	coordinates of Zhumadian
CO	Colombia	http://worldpopulationreview.com/countries/colombia-population/	coordinates of Bogota
EG	Egypt	http://worldpopulationreview.com/countries/egypt-population/	coordinates of Cairo
EE	Estonia	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
FI	Finland	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
FR	France	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
GE	Georgia	http://worldpopulationreview.com/countries/georgia-population/	coordinates of Tbilisi
DE	Germany	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
GR	Greece	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
IR	Iran	http://worldpopulationreview.com/countries/iran-population/	coordinates of Tehran
IL	Israel	http://worldpopulationreview.com/countries/israel-population/	coordinates of Jerusalem
IT	Italy	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
LT	Lithuania	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
MX	Mexico	http://worldpopulationreview.com/countries/mexico-population/	coordinates of Mexico city
NL	Netherlands	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
NZ	New Zealand	http://worldpopulationreview.com/countries/new-zealand-population/	coordinates of Auckland
NG	Nigeria	http://worldpopulationreview.com/countries/nigeria-population/	coordinates of Lagos
NO	Norway	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
PL	Poland	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
RU	Russia	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html	
SA	Saudi Arabia	http://worldpopulationreview.com/countries/saudi-arabia-population/	coordinates of Riyadh

RS	Serbia	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html
ES	Spain	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html
SE	Sweden	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html
CH	Switzerland	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html
GB	UK	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html
UA	Ukraine	https://cs.baylor.edu/~hamerly/software/europe_population_weighted_centers.html
US	USA	https://en.wikipedia.org/wiki/Mean_center_of_the_United_States_population
