Supplementary Text

S1 Text: Selection of Emotion-Related Scales

Prior to conducting the main experiment, a pilot study was conducted with 28 different participants to select the emotion-related scales we would use in the color rating task (A2) and the music rating task (A3). We first compiled a set of 40 emotion-related scales (see Table S3 below) by choosing any term we found in the emotion literature that seemed potentially relevant to music and/or color in the experimenters’ collective judgment (e.g., Rentfrow et al., 2012; Scherer, 2005; Zentner, Grandjean, & Scherer, 2008) and by adding scales that we did not find in the literature but thought might be relevant. One group of 14 pilot participants sorted 40 cards, each containing the name of an emotion-related scale (e.g., happy/sad, full/thin, spicy/bland), into 12 or fewer categories based on their similarity with respect to color. Then they rated the relevance of each of the 40 scales with respect to color on a continuous line-mark scale labeled “Not Relevant” (-200) on the left-end and “Very Relevant” (+200) on the right-end. A separate group of 14 participants completed the same card-sorting and relevance-rating tasks, but with respect to music instead of color. To arrive at the final list of emotion-related scales for the main experiment, we first eliminated any scales whose average relevance rating was less than zero with respect to either music or color. We also eliminated any remaining scale that was too closely related to any other scale, as measured by an occurrence frequency greater than 9 (of 14) in either of the card sorting tasks. Ten emotion-related scales were thus identified
as being relevant to both color and music without being judged as too similar via the card-sorting task (see Table 2(b)).

**S2 Text: Parafac of the 10 Emotion-Related Scales**

To find the latent dimensions of the ratings in $z_{ijk}$, we could have applied classic factor analysis (FA) in two different ways: (i) separately to each subject’s data $I$ stimuli by $J$ emotion scales data matrix, or (ii) to the $I$ stimuli by $J$ emotion scales data matrix obtained by averaging the ratings across all subjects. However, neither of these options is ideal. The first approach is flexible, i.e., provides a unique decomposition of each subject’s data, but lacks a coherent way of comparing the latent dimensions of different subjects. The second approach is simpler to interpret but lacks the flexibility to explore individual differences in the latent dimensions. Furthermore, both approaches have a rotational indeterminacy, which implies that the latent dimensions could be rotated without changing the model fit.

The Parafac model extends the classic FA model by leveraging the individual differences in the data to solve the rotational indeterminacy problem inherent to classic FA models. The Parafac model assumes that the standardized ratings have the form

$$z_{ijk} = \sum_{r=1}^{R} a_{ir} b_{jr} c_{kr} + e_{ijk} \tag{10}$$

where $a_{ir}$ gives the weight of the $i$-th stimulus on the $r$-th factor, $b_{jr}$ gives the weight of the $j$-th emotional scale on the $r$-th factor, $c_{kr}$ gives the weight of the $k$-th subject on the $r$-th factor, and $e_{ijk}$ is the error term (i.e., the portion of $z_{ijk}$ that cannot be explained by the Parafac model structure). Note that the Parafac model assumes that the same latent dimensions explain each subject’s ratings, but each subject has a unique set of scores on the latent dimensions (captured by the $c_{kr}$ weights). Furthermore, note that if we had a single subject ($K = 1$), then we can
assume that $c_{kr} = 1$ and the Parafac model would reduce to the classic PCA / FA model.

S3 Text. Parafac Analysis of the 15 Music-Perceptual Features

Parafac was performed to reduce the 15 music perceptual features to a smaller number of interpretable factors. Let $x_{mjk}^{A3}$ denote the data from Task A3, i.e., $x_{mjk}^{A3}$ is the rating of the $m$-th music selection on the $j$-th music-perceptual feature as judged by the $k$-th subject. To preprocess the data for the Parafac model, we removed the mean rating of each subject on each feature across the 34 musical excerpts

$$
\tilde{x}_{mjk}^{A3} = x_{mjk}^{A3} - \frac{1}{34} \sum_{m=1}^{34} x_{mjk}^{A3}
$$

and then standardized each music-perceptual feature to have equal influence

$$
z_{mjk}^{A3} = \frac{\tilde{x}_{mjk}^{A3}}{s_j} \quad \text{where} \quad s_j^2 = \frac{1}{(34)(15)} \sum_{m=1}^{34} \sum_{k=1}^{15} [\tilde{x}_{mjk}^{A3}]^2
$$

Next, we combined the standardized ratings to form $z_{ijk}$, which represents the $k$-th subject’s rating of the $i$-th stimulus on the $j$-th music-perceptual feature.

The Parafac model assumes that the standardized ratings have the form

$$
z_{ijk} = \sum_{r=1}^{R} a_{ir} b_{jr} c_{kr} + e_{ijk}
$$

where $a_{ir}$ gives the weight of the $i$-th musical stimulus on the $r$-th factor, $b_{jr}$ gives the weight of the $j$-th music-perceptual feature on the $r$-th factor, $c_{kr}$ gives the weight of the $k$-th subject on the $r$-th factor, and $e_{ijk}$ is the error term (i.e., the portion of $z_{ijk}$ that cannot be explained by the Parafac model structure).

We fit the model using the multiway R package (Helwig, 2018) using 1000 random starts of the alternating least squares algorithm with $R = 2$ to 15 factors. The convergence tolerance was set to $1 \times 10^{-12}$ We chose the 2 factor solution because of (a) its interpretability, (b) the shape
of the scree plot, and (c) the results of the core consistency diagnostic. The two-factor Parafac model explained 39.98% of the variation in the data tensor $z_{ijk}$ and resulted in a moderately interpretable solution. All other factor solutions were complex and difficult to interpret in terms of the underlying structure. The music-perceptual weights for the two-factor solution are plotted in Figure S3(b). They reveal that the two latent factors underlying the music-perceptual data can perhaps best be interpreted as **electronic/acoustic** (factor 1) and **fast/slow** (factor 2).

Figure S3(a) plots the Parafac stimulus weights for 34 musical excerpts (i.e., $a_{ir}$), which are useful for visualizing the perceptual interrelations among the stimuli; Figure S3(b) plots the music-perceptual weights (i.e., $b_{jr}$), which are useful for assigning meaning to the factors; and Figure S3(c) plots the subject weights (i.e., $c_{kr}$), which are useful for understanding individual differences in the saliences each subject assigned to each factor. We note that although we have named these composite, latent factors with the same labels as two of the originally rated features (**electronic/acoustic** and **fast/slow**), we use bold italics to indicate that they are not actually the same because the latent factors include weightings from the entire dataset from task B1, including other rated features. The musical selections represented in Figure S3(a) show a slightly negative bias for the music that is rated as electronic tends to be rated as slower (e.g., House and Dubstep), whereas the music that is rated as acoustic tends to be rated as faster (e.g., Dixieland, Mozart, and Jazz). This negative correlation is presumably inherent in the musical sample of 34 selections we studied. Third, the more extreme individuals represented in Figure S3(c) showed a negative correlation in their weighting structure, tending to emphasize **electronic/acoustic** over **fast/slow** or **fast/slow** over **electronic/acoustic**.
| Color     | x   | y   | Y   | Hue | Value/Chroma |
|-----------|-----|-----|-----|-----|--------------|
| Red Saturated | 0.549 | 0.313 | 22.93 | 5 R | 5/15         |
| Light     | 0.407 | 0.326 | 49.95 | 5 R | 7/8          |
| Muted     | 0.441 | 0.324 | 22.93 | 5 R | 5/8          |
| Dark      | 0.506 | 0.311 | 7.60  | 5 R | 3/8          |
| Orange Saturated | 0.513 | 0.412 | 49.95 | 5 YR | 7/13       |
| Light     | 0.399 | 0.366 | 68.56 | 5 YR | 8/6         |
| Muted     | 0.423 | 0.375 | 34.86 | 5 YR | 6/6         |
| Dark      | 0.481 | 0.388 | 10.76 | 5 YR | 3.5/6       |
| Yellow Saturated | 0.446 | 0.472 | 91.25 | 5 Y | 9/12        |
| Light     | 0.391 | 0.413 | 91.25 | 5 Y | 9/6.5       |
| Muted     | 0.407 | 0.426 | 49.95 | 5 Y | 7/6.5       |
| Dark      | 0.437 | 0.450 | 18.43 | 5 Y | 5/6.5       |
| Chartreuse Saturated | 0.387 | 0.504 | 68.56 | 5 GY | 8/11      |
| Light     | 0.357 | 0.420 | 79.90 | 5 GY | 8.5/6      |
| Muted     | 0.360 | 0.436 | 42.40 | 5 GY | 6.5/6      |
| Dark      | 0.369 | 0.473 | 18.43 | 5 GY | 4.5/6      |
| Green Saturated | 0.254 | 0.449 | 42.40 | 3.75 G | 6.5/11.5 |
| Light     | 0.288 | 0.381 | 63.90 | 3.75 G | 7.75/6.25 |
| Color      | Muted  | Dark   | Saturated | Light | Muted | Dark   |
|------------|--------|--------|-----------|-------|-------|--------|
| Cyan       | 0.281  | 0.261  | 0.226     | 0.267 | 0.254 | 0.233  |
|            | 0.392  | 0.419  | 0.335     | 0.330 | 0.328 | 0.324  |
|            | 34.86  | 12.34  | 49.95     | 68.56 | 34.86 | 13.92  |
|            | 3.75 G | 3.75 G | 5 BG      | 5 BG  | 5 BG  | 5 BG   |
|            | 6/6.25 | 3.75/6.25 | 7/9     | 8/5   | 6/5   | 4/5    |
| Blue       | 0.200  | 0.255  | 0.200     | 0.255 | 0.241 | 0.212  |
|            | 0.230  | 0.278  | 0.230     | 0.278 | 0.265 | 0.236  |
|            | 34.86  | 59.25  | 34.86     | 59.25 | 28.90 | 10.76  |
|            | 10 B   | 10 B   | 10 B      | 10 B  | 10 B  | 10 B   |
|            | 6/10   | 7.5/5.5 | 6/10    | 7.5/5.5 | 5.5/5.5 | 3.5/5.5 |
| Purple     | 0.272  | 0.290  | 0.272     | 0.290 | 0.287 | 0.280  |
|            | 0.156  | 0.242  | 0.156     | 0.242 | 0.222 | 0.181  |
|            | 18.43  | 49.95  | 18.43     | 49.95 | 22.93 | 7.60   |
|            | 5 P    | 5 P    | 5 P       | 5 P   | 5 P   | 5 P    |
|            | 4.5/17 | 7/9    | 4.5/17    | 7/9   | 5/9   | 3/9    |
| Achromatic | Black  | Dark gray | Med Gray | Light Gray | White |        |
|            | 0.310  | 0.310  | 0.310     | 0.310 | 0.310 | 0.310  |
|            | 0.316  | 0.316  | 0.316     | 0.316 | 0.316 | 0.316  |
|            | 0.30   | 12.34  | 31.88     | 63.90 | 116.00 |        |
Table S2. Details of musical excerpts. Start and stop times are embedded in YouTube links, where possible, but otherwise must be manually stopped after 15 s.

| Genre-Excerpt | Artist | Album | Title | Start Time | Album | YouTube |
|---------------|--------|-------|-------|------------|-------|---------|
| Alternative   | Metric | Black Sheep - Single Turath | Black Sheep | 3:39 | 3:40 |
| Arabic        | Simon Shaheen | Turath | Bashraf Farahfaza | 4:36 | 4:36 |
| Bach          | Johann Sebastian Bach | Bach: Brandenburg Concertos Nos 1-6 | Brandenburg Concerto No. 5, Ia | 0:00 | 0:00 |
| Balkan Folk   | Beirut | Gulag Orkestar | Canals of Our City | 0:44 | 0:44 |
| Big Band      | Glenn Miller | The Essential Glenn Miller | String of Pearls | 0:08 | 0:08 |
| Bluegrass     | Doc Watson | The Essential Doc Watson | Beaumont Rag | 0:01 | 0:03 |
| Blues         | Albert King | The Definitive Albert King On Stax | Blues Power | 2:36 | 2:36 |
| Classic Rock  | BBM | Around the Next Dream Cold Hard Truth | City of Gold | 1:56 | 1:56 |
| Country       | George Jones | Cold Hard Truth | Choices | 0:00 | 0:00 |
| Western Dixieland | Firehouse Five Plus Two Bar 9 | Firehouse Five Plus Two Story UKF Dubstep 2010 | Everybody Loves My Baby Piano Tune | 0:04 | 0:04 |
| Dubstep       | Madonna | This Is Happening | I Can Change | 0:00 | 0:00 |
| Eighties Pop  | LCD Sound System | Tea for the Tillerman | Where Do The Children Play | 2:23 | 2:23 |
| Electronic    | Cat Stevens | Mothership Connection Listen, 6th Edition | Night of the Thumpasorus Bopong | 0:11 | 0:11 |
| Folk          | Parliament | Raga Bairagi Todi | Psychosocial | 0:04 | 0:04 |
| Gamelon       | I Lotring | All Hope Is Gone Spirit of India | Raga Bairagi Todi | 10:28 | 10:28 |
| Heavy Metal   | Slipknot | Nothing Lasts Forever Loro | Nothing Lasts Forever | 4:20 | 4:20 |
| Hindustani Sitar | Ravi Shankar | Nothing Lasts Forever | 4:20 | 4:20 |
| Hip Hop       | J. Cole | Pinback | Loro | 0:00 | 0:00 |
| Indie         | Pinback | Pinback | Loro | 0:00 | 0:00 |
| Genre | Artist/Group | Album/Work | Duration | Notes |
|-------|--------------|------------|----------|-------|
| Irish | The Rogues  | Live in Canada, Eh? More Reels | 2:06 | 2:06 |
| Jazz | Dizzy Gillespie | An Electrifying Evening with the Dizzy Gillespie Quintet Salt Peanuts | 3:47 | 3:47 |
| Mozart | Mozart (Philharmonia Orchestra; Vladimir Ashkenazy) | Piano Concerto in A, K. 488, I a | 0:32 | 0:35 |
| Piano | Hagood Hardy | Alone If I had Nothing But a Dream | 0:07 | NA |
| Progressive House | Deadmau5 | Ghosts N Stuff – Single | 1:14 | 0:45 |
| Progressive Rock | Pink Floyd | The Dark Side of the Moon | Any Colour You Like | 0:27 | 0:27 |
| Psychobilly | Tiger Army | Music From Regions Beyond Pain | 2:19 | 2:19 |
| Reggae | Bob Marley & The Wailers | Legend (Remastered) Satisfy My Soul | 0:00 | 0:05 |
| Salsa | Sonora Carruseles | Al Son de los Cueros - Hits de la Salsa, Cumbia & Boogaloo Al son de los Cueros | 2:11 | 2:11 |
| Ska | Streetlight Manifesto | Everything Goes Numb Here's to Life | 0:05 | 0:05 |
| Smooth Jazz | Kenny G | Kenny G: Greatest Hits | Sentimental | 1:50 | 1:50 |
| Soundtrack | Yann Tiersen | Amélie (Original Soundtrack) La Valse D'Amelie (Version orchestre) | 0:29 | 0:30 |
| Stravinsky | Stravinsky (Atlanta Symphony Orchestra; Yoel Levi) | The Rite of Spring Pulcinella Suite Rite of Spring; Part 1: Dances of the Adolescent Girls (Track 2) | 0:32 | NA |
| Trance | Darude | Before the Storm Feel the Beat | 3:14 | 3:05 |
Table S3. The 40 emotion-related scales from the pilot study from which the 10 emotion-related scales were selected for the main experiment.

| Emotion-Related Scales from Pilot Study |
|----------------------------------------|
| Aggressive/Gentle | Dirty/Clean | Painful/Soothing | Slow/Fast |
| Agitated/Calm | Disgusting/Appealing | Quiet/Loud | Small/Large |
| Angry/Peaceful | Dissonant/Harmonious | Random/Orderly | Solid/Fluid |
| Angular/Curved | Dreary/Lively | Relaxing/Exciting | Stale/Fresh |
| Artificial/Natural | Dull/Inspirational | Rough/Smooth | Static/Movement |
| Bland/Spicy | Evil/Good | Sad/Happy | Strong/Weak |
| Blurry/Clear | Expected/Surprising | Scary/Comforting | Tense/Relaxed |
| Closed/Open | Hard/Soft | Serious/Whimsical | Thin/Full |
| Constrained/Free | Heavy/Light | Sharp/Blunt | Ugly/Beautiful |
| Cool/Warm | Jarring/Hypnotic | Simple/Complex | Unrefined/Refined |
Table S4. Across-subject agreement for the musicians who rated the music-perceptual features (a) and each of the subjects who rated the emotion-related scales (b). Values correspond to Cronbach’s α.

| (a) Music-Perceptual Features | α        |
|-------------------------------|----------|
| Electric/Acoustic             | 0.931    |
| Distorted/Clear               | 0.939    |
| Many/Few instruments          | 0.923    |
| Loud/Soft                     | 0.910    |
| Heavy/Light                   | 0.964    |
| High/Low pitch                | 0.915    |
| Wide/Narrow pitch variation   | 0.887    |
| Punchy/Smooth                 | 0.985    |
| Harmonious/Disharmonious      | 0.959    |
| Clear/No melody               | 0.939    |
| Repetitive/Not-repetitive     | 0.959    |
| Complex/Simple rhythm         | 0.967    |
| Fast/Slow tempo               | 0.922    |
| Dense/Sparse                  | 0.844    |
| Strong/Weak beat              | 0.957    |

| (b) Emotion-Related Scales    | α (Music Ratings) | α (Color-Ratings) |
|-------------------------------|-------------------|-------------------|
| Calm/Agitated                 | 0.978             | 0.945             |
| Spicy/Bland                   | 0.946             | 0.963             |
| Warm/Cool                     | 0.816             | 0.967             |
| Appealing/Disgusting          | 0.902             | 0.892             |
| Harmonious/Dissonant          | 0.954             | 0.864             |
| Loud/Quiet                    | 0.982             | 0.956             |
| Happy/Sad                     | 0.947             | 0.949             |
| Whimsical/Serious             | 0.872             | 0.945             |
| Complex/Simple                | 0.912             | 0.896             |
| Like/Dislike                  | 0.879             | 0.845             |
Figure S1. The best-fitting color chosen by each of the 30 participants in the music-to-color association task (A1) for each of the 34 musical selections.
Figure S2. Correlations between the 15 music-perceptual features and the weighted average color-appearance values of the colors picked to go with the music (PMCAs) after accounting for variance due to the EMCAs (a) or after accounting for the variance due to the 2 Parafac latent
affective factors – *arousal* and *valence* of the music (b). Consistent with the emotional mediation hypothesis, any significant correlations between lower-level perceptual features (in Figure 3(a) of the main text) were no longer significant after accounting for emotion-related content in both cases. Family-wise error rate was controlled using Holm’s method.
Figure S3. Two-factor music-perceptual Parafac solutions. Panel A plots the weights for the 34 musical excerpts, panel B plots the weights for the 15 music-perceptual features (b<sub>p</sub>), and panel C plots the weights for the 30 individual participants (c<sub>kr</sub>). Because the perceptual features are bi-polar, both the actual perceptual weights (black circles) and the implied, inverse of the perceptual weights (grey circles) are shown. Factor 1 was interpreted as \textit{electronic}/\textit{acoustic} and Factor 2 as \textit{fast}/\textit{slow}. 
References

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