**Color, Music, and Emotion in Mexican and US Populations**

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**1. Introduction**

Color and music are both fundamental aspects of daily life that influence our emotions and moods. Prior results have shown, for example, that brighter colors are generally associated with positive emotions, and darker colors with negative ones (Wright & Rainwater, 1962; D’Andrade & Egan, 1974; Boyatzis and Vargas, 1994; Hemphill, 1996). In a similar vein, music in a major key is ge­nerally associated with happiness, and that in a minor key with sadness (Webster & Weir, 2005). In this chapter we investigate possible cross-modal relations between music and color in a cross-cultural study of Mexican and US participants.

Schloss, Lawler, and Palmer (2008) studied the relation between classical music and colors in 48 non-synesthetic US participants. Eighteen one-minute samples of orchestral music were chosen, including six by each of three composers (Bach, Mozart, and Brahms) at slow, medium, and fast tempi in both the major and minor modes. While listening to these selections participants then picked the five colors that “went best” and the five that “went worst” with the music. The results showed several highly reliable patterns of association between the musical features that were manipulated (slow/medium/fast tempi and major/minor modes) and the primary dimensions of color appearance (light/dark, saturated/desaturated, blue/yellow, and red/green). In particular, they found that faster music in the major mode was systematically associated with more saturated, lighter, yellower colors, and slower music in the minor mode was associated with less saturated (grayer), darker, bluer colors.

Schloss, Lawler, and Palmer also studied the possibility that these music-to-color associations might be mediated by common underlying emotions, as had been suggested by others (e.g., Arnheim, 1986; Barbiere, Vidal, & Zellner, 2007; Bresin, 2005; Cutietta, 1987; Marks, 1975; Odbert, Karwoski, & Eckerson, 1942; Sebba, 1991; Simpson, Quinn, & Ausubel, 1956) but not extensively tested. Schloss, Lawler, and Palmer did so by having the same set of participants later rate each of the 18 musical samples and each of the 37 colors on their degree of association with each of eight emotional terms: *happy*, *sad*, *lively*, *dreary*, *angry*, *calm*, *strong*, and *weak*. They then computed the correlation coefficients between the emotional ratings of the 18 musical selections and an index of the emotional ratings of the colors chosen to go best/worst with the each musical selection for four bipolar emotional dimensions (*happy-sad*, *lively-dreary*, *angry-calm*, and *strong-weak*). The extremely high correlations for each emotional dimension (+.97, +.99, +.89, and +.96, respectively) provided powerful evidence that these music-to-color associations are mediated by common emotional content. That is, people appear to have emotional associations while listening to the music and then to pick the colors that were most closely associated with those same emotions as the colors that “went best” with the music, and the colors that were least closely associated with those emotions as the ones that “went worst” with the music.

In the present chapter we report the results of repeating this expe­riment with 49 Mexican participants to in­vestigate whether cultural differences might influence such music-to-color associations, and, if so, how.

**2. Methods**

2.1 *Participants*

The participants were 49 Mexican adults (25 women and 24 men) aged 18-50. All had normal color vision as indicated by their performance on pseudo-isochromatic plates. After giving informed consent, they completed the three tasks described below, and were paid for their participation.

2.2 *Materials and equipment*

Participants were tested in an aluminum-framed booth with heavy black curtains that provided conditions of near-total darkness. The booth contained a chair, computer table, and computer (an 18” iMac with a 1680 x 1050 pixel monitor). The positions of the 37 colors in CIELAB space are represented in Fig 1, and their coordinates are specified in Table 1. The 18 musical selections are listed in Table 2. Participants viewed the calibrated computer display from approximately 70 cm. The background was always neutral gray (CIE x=0.312, y=0.318, Y=19.26). Participants listened to the musical selections through speakers connected to the iMac computer.

*Table 1.* CIE 1931 values and Munsell values for the 32 chromatic colors and five achromatic colors.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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 |
| Muted | 0.281 | 0.392 | 34.86 |  | 3.75 G | 6/6.25 |
| Dark | 0.261 | 0.419 | 12.34 |  | 3.75 G | 3.75/6.25 |
|  |  |  |  |  |  |  |  |
| Cyan | Saturated | 0.226 | 0.335 | 49.95 |  | 5 BG | 7/9 |
| Light | 0.267 | 0.330 | 68.56 |  | 5 BG | 8/5 |
| Muted | 0.254 | 0.328 | 34.86 |  | 5 BG | 6/5 |
| Dark | 0.233 | 0.324 | 13.92 |  | 5 BG | 4/5 |
|  |  |  |  |  |  |  |  |
| Blue | Saturated | 0.200 | 0.230 | 34.86 |  | 10 B | 6/10 |
| Light | 0.255 | 0.278 | 59.25 |  | 10 B | 7.5/5.5 |
| Muted | 0.241 | 0.265 | 28.90 |  | 10 B | 5.5/5.5 |
| Dark | 0.212 | 0.236 | 10.76 |  | 10 B | 3.5/5.5 |
|  |  |  |  |  |  |  |  |
| Purple | Saturated | 0.272 | 0.156 | 18.43 |  | 5 P | 4.5/17 |
| Light | 0.290 | 0.242 | 49.95 |  | 5 P | 7/9 |
| Muted | 0.287 | 0.222 | 22.93 |  | 5 P | 5/9 |
| Dark | 0.280 | 0.181 | 7.60 |  | 5 P | 3/9 |
|  |  |  |  |  |  |  |  |
| Achromatic | Black | 0.310 | 0.316 | 0.30 |  |  |  |
| Dark gray | 0.310 | 0.316 | 12.34 |  |  |  |
| Med Gray | 0.310 | 0.316 | 31.88 |  |  |  |
| Light Gray | 0.310 | 0.316 | 63.90 |  |  |  |
|  | White | 0.310 | 0.316 | 116.00 |   |  |  |

*Table 2.* The 18 musical selections.

|  |  |
| --- | --- |
| Composer/Mode/Tempo | Selection |
| Bach Major Fast | Brandenburg Concerto no. 2 in F Major, BWV 1047, Allegro assai |
| Bach Major Med. | Brandenburg Concerto no. 3 in G Major, BWV 1048, Ohne Satzbezeichnung |
| Bach Major Slow | Brandenburg Concerto no. 6 in B flat Major, BWV 1051, Adagio ma non tanto |
|  |  |
| Bach Minor Fast | Orchestral Suite no. 2 in B minor, BWV 1067, Badinerie |
| Bach Minor Med. | Orchestral Suite no. 2 in B minor, BWV 1067, Rondeau |
| Bach Minor Slow | Brandenburg Concerto no. 2 in F Major, BWV 1047, Andante |
|  |  |
| Brahms Major Fast | Symphony no. 4 in E minor, Opus 98, Allegro giocoso |
| Brahms Major Med. | Symphony no. 3 in F Major, Opus 90, Allegro con brio |
| Brahms Major Slow | Symphony no. 2 in D Major, Opus 73, Allegro non troppo |
|  |  |
| Brahms Minor Fast | Symphony no. 3 in F Major, Opus 90, Allegro |
| Brahms Minor Med. | Symphony no. 3 in F Major, Opus 90, poco allegretto |
| Brahms Minor Slow | Symphony no. 1 in C minor, Opus 68, Adagio |
|  |  |
| Mozart Major Fast | Symphony no. 39 in E flat Major, K 543, Finale allegro |
| Mozart Major Med. | Symphony no. 39 in E flat Major, K 543, Menuetto allegro |
| Mozart Major Slow | Symphony no. 39 in E flat Major, K 543, Andante |
|  |  |
| Mozart Minor Fast | Symphony no. 40 in G minor, KV 550, Allegro assai |
| Mozart Minor Med. | Symphony no. 40 in G minor, KV 550, Menuetto Allegro |
| Mozart Minor Slow | Sinfonia Concertante in E flat Major, K364, Andante |

2.3 *Procedure*

All participants completed the following three tasks in this order:

2.3.1 *Color-music associations*

Participants saw all 37 colors (Fig 1) while listening to each of the 18 musical selections (see Table 2). They initially heard each clip for 30 s, while they considered which colors were most consistent (“went best”) and most inconsistent (“went worst”) with the music. They were then prompted to click on the five most consistent (“best”) colors, in order, with each color disappearing when clicked. All 37 squares then reappeared, and participants clicked on the five least consistent (“worst”) colors, in order. Each musical selection looped continually during the music-color association task, with fade-in/fade-out transitions at the start and end of each pass through the loop.

2.3.2 *Color-emotion associations*

Participants rated each of the 37 colored squares (100 x 100 px) singly in random order for consistency with each of 8 emotional terms (*happy*, *sad*, *angry*, *calm*, *lively*, *dreary*, *strong*, and *weak*) by sliding a cursor along a continuous scale and clicking to record their its final position. The to-be-rated emotional term was centered above the square, and the 400-pixel response scale was centered 250 pixels below the square, with the left, right, and center points labeled “inconsistent,” “consistent,” and “neutral,” respectively. Responses were scaled from -100 to +100. Trials were blocked by the emotional term being rated, with block-order randomized. Before each block, participants anchored the end points for the particular emotional term by viewing all colors simultaneously and considering which color was most/least consistent with that term and being told that the most consistent color should be rated at or near the positive/negative end of the scale. Trials were separated by 500ms inter-trial intervals.

2.3.3 *Music-emotion associations*

Participants heard each musical selection in random order and rated its consistency with each of the same 8 emotional terms using the same procedure as for color-emotion associations.



**Figure 1.** The 37 colors projected onto a plane of equal luminance in CIELAB color space.

**3. Results**

3.1 *Music-to-color cross-modal matching*

The results of primary interest are the nature of the colors people chose to be the best/worst cross-modal matches for the musical selections. The color data were analyzed to determine how the variations in the musical dimensions in our music samples (i.e., tempo and mode) might be related to the dimensional structure of color by computing a color-music association (*MCA*) score for each of the 18 musical selections along each of four color appearance dimensions (*R/G, Y/B, L/D, and S/U)* as rated by the same participants. Conceptually, the *MCA* score for a given musical selection on a given dimension (say, saturation) is a linearly weighted average of the saturation ratings of the five colors chosen as most consistent with that music minus an analogous weighted average of the saturation ratings of the five colors chosen to be least consistent with that music. In particular, we computed the consistency (*Cd,m*) and inconsistency (*Id,m*) of a musical selection *m* for color dimension *d* as follows:

 (1) *Cd,m=(5c1,d,m + 4c2,d,m + 3c3,d,m + 2c4,d,m + 1c5,d,m)/15,*

 (2) *Id,m=(5i1,d,m + 4i2,d,m + 3i3,d,m + 2i4,d,m + 1i5,d,m)/15,*

where *cj,d,m* represents the value along dimension *d* of the *jth* color picked as most consistent with musical selection *m*, where *j* ranges from 1 to 5, and *ij,d,m* represents the corresponding value of the *jth* color picked as most inconsistent with musical selection *m*. The *MCA* score for a given musical selection *m* on dimension *d* is then,

 (3) *MCAd,m=Cd,m - Id,m*.



**Figure 2.** The music-color association (MCA) scores for the musical selections in terms of the (A) saturated-unsaturated, (B) light-dark, (C) yellow-blue, and (D) red-green color appearance dimensions. Error bars represent standard errors of the mean (SEMs)

*MCA* values were computed for each of the 18 musical selections for each subject in Mexico separately for each of the 4 colorimetric dimensions. Fig. 2 shows average *MCA* values for Mexican participants as a function of tempo and mode (averaged over composers) for each color dimension. Separate ANOVAs were conducted for each color dimension. They showed that, averaged over composers, faster tempi were generally associated with more saturated, lighter, and yellower colors (*F*(2,96) = 97.13, 14.61, 62.12, *p <* .001, respectively). The same was true for major (vs. minor) mode (*F*(1,48) = 65.87, 18.30, 36.97, *p <* .001, respectively). By the same token, slower tempi and music in the minor mode were associated with less saturated, darker, bluer colors. For major (but not minor) music, slow tempi were associated with greener colors than Med. or faster tempi (*F*(2,96) = 28.08, 2.50, *p <* .001, p < .05, respectively). Main effects of composer were also present, with Brahms’s music being associated with less saturated, darker, bluer colors than Bach’s and Mozart’s music (*F*(2,96) = 33.14, 18.09, 25.00, *p <* .001, respectively).

The corresponding results for US participants were very similar, as indicated by very high correlations between cultures for each colorimetric dimension: +.88 for R/G, +.96 for Y/B, +.97 for L/D, and +.95 for S/U. ANOVAs including both cultural data sets were also performed for each of these dimensions, with culture (Mexico/US) as a between-subjects factor and composers, tempi, and modes as within-subject factors. (A Bonferroni-corrected critical alpha of .01 to adjust for multiple comparisons for the four color appearance dimensions.) The results revealed no interactions between culture and tempo for R/G, Y/B, L/D, and S/U (*F*(2,190) = .20, .95, 1.89, 2.33, *p* > .01, respectively), culture and mode (*F*(1,95) = 1.36, .00, 5.60, .00, *p* > .01, respectively), or culture, tempo, and mode (*F*s < 1.02). There were minor main effects of culture for the different color dimensions, because Mexican participants, on average, chose somewhat lighter, yellower, and greener colors than US participants did (*F*(1,95) = 5.44, 8.07, 7.78, *p <* .05, .01, .01, respectively). There were also minor interactions involving culture and composer for the R/G and S/U dimensions, but the qualitative patterns in terms of the ordering of conditions were the same in both countries.

3.2. *Color-emotion ratings*

We computed average ratings for each of the 37 colors for each of the eight emotional terms we investigated. We then correlated the pairs of emotional terms that we expected might form bipolar dimensions (happy-sad, lively-dreary, strong-weak, and angry-calm) to determine whether they have the expected high negative correlations. Clearly, they do for happy-sad (*r* = -.94, *p* < .01), lively-dreary (*r* = -.95, *p* < .01), and strong-weak (*r* = -.87, *p* < .01), but not for angry-calm (*r* = -.13, *p* > .05). The average data for each emotional term are plotted in Fig. 3. These graphs show that happier and livelier (less sad and dreary) colors are lighter (*r* = .64, *p* < .001; *r* = .56, *p* < .001, respectively) and more saturated (*r* = .57, *p* < .001, *r* = .63, *p* < .001, respectively). Angrier and stronger colors are redder (*r* = .60, *p* < .001; *r* =.34, *p* < .01, respectively) and darker (*r* = -.67, *p* < .001; *r* = -.46, *p* < .01), whereas calmer and weaker colors are less saturated (*r* = -.84, *p* < .001; *r* = -.78, *p* < .001, respectively). Calmer colors are also bluer (*r* = .39, *p* < .05) and weaker colors tend to be bluer, but not reliably so (*r* = .29, *p* > .05).

Note that some of the canonical notions in popular culture about the emotional associations of “colors” (meaning hues) are true only for certain combinations of lightness and saturation. For example, yellow is usually claimed to be the happiest hue, but dark yellow is among the saddest colors, even though saturated yellow is indeed the happiest. Similarly, blue is usually thought to be the saddest hue – no doubt influenced by linguistic uses such as “I’ve got the blues,” and “I’m feeling really blue today” – yet saturated blue is among the happiest colors, even though dark blue is indeed among the saddest. Note also that for happiness, sadness, liveliness, and dreariness ratings, lightness and saturation are generally more important than hue, whereas for angriness, hue dominates in terms of similarity to red. Finally, it is interesting to see how wide the variability is among achromatic colors (white, grays, ands black) for all 8 emotional terms, given that they differ only in lightness. This is presumably due to the more extreme levels of lightness that the achromatic series encompasses, with white being lighter than any other color and black being darker.



**Figure 3**. Color-emotion ratings as a function of hue (x-axis) for saturated (circles), light (triangles), muted (diamonds), and dark (squares) colors, plus white (downward triangles) and black (stars).

3.3 *Music-emotion ratings*

We also computed average ratings for each of the 18 musical selections for each of the eight emotional terms we investigated. We again correlated the pairs of emotional terms that were expected to form bipolar dimensions to determine whether they have the expected high negative correlations. Clearly, they do for happy-sad (*r* = -.96, *p* < .01), lively-dreary (*r* = -.98, *p* < .01), and strong-weak (*r* = -.97, *p* < .01), but, again, not for angry-calm (*r* = -.31, *p* > .05). The average data for the first three dimensions are plotted in Figure 4 as bipolar dimensions, whereas angry and calm are plotted as unipolar dimensions. These graphs show that happier, livelier, and stronger music is faster (*F*(2,96) = 147.34, 190.18, 158.75, *p* < .001, respectively), and in the major mode (*F*(1,48) = 80.40, 81.07, 78.78, *p* < .001, respectively) whereas slower music in the minor mode is rated as sadder, drearier, and weaker. Calmer music is also slower (*F*(2,96) = 184.83, p < .001) and in the minor mode (F(1,47) = 30.21, p < .001) mode. Angrier music had much weaker effects than the other emotions, but it was somewhat faster (*F*(2,96) = 15.07, p < .001) and minor (*F*(1,48) = 9.08, p < .01).



**Figure 4.** Music-emotion associations as a function of tempo (x-axis) for music in the major (filled symbols) and minor (open symbols) modes. Error bars indicate standard errors of the mean (SEMs).

3.4 *Correlations between emotion ratings of colors and music*

The emotional mediation hypothesis implies that the systematic relations we found between musical selections and the colors chosen as the best/worst cross-modal matches with them arise because the music and colors share common, underlying, emotional responses (Arnheim, 1986; Barbiere, Vidal, & Zellner, 2007; Bresin, 2005; Cutietta, 1987; Marks, 1975; Odbert, Karwoski, & Eckerson, 1942; Sebba, 1991; Simpson, Quinn, & Ausubel, 1956). Indeed, Schloss Lawler, and Palmer (2008) reported remarkably high correlations between the emotional ratings of the same 18 selections of music and the emotional ratings of the colors picked as going best/worst with the music for US participants in the California Bay Area. We therefore assessed the same correlations in the present study for Mexican participants. Although classical orchestral music is not very popular in Mexico, the present data showed similarly high correlations for Mexican and US participants (see Table 3): happy-sad (+.97, +.97), lively-dreary (+.96, +.99), strong-weak (+.96, +.96), and angry-calm (+.93, +.89), respectively. These results are clearly consistent with the emotional mediation hypothesis. Because the evidence is purely correlational, however, it does not establish the causal role of emotion in producing the present pattern of results. Although it is possible that there are redundant, direct associations between color and music that do not actually depend on emotional response, such a coincidence seems implausible.

The striking similarity of the results supporting emotional mediation in Mexican and US participants suggests the possibility that it may be culturally invariant to some degree. The hedge (“to some degree”) is warranted by the fact that the musical traditions in Mexico and the US are tonally similar in that they use the same Western, well-tempered scales in major and minor modes. There are both weak and strong forms of cultural invariance between which the present results do not discriminate. The weaker form would be that similar emotional mediation will be evident in any of the many Western (or Westernized) cultures (or subcultures) that share this musical heritage, possibly including subcultures in non-Western societies whose musical tastes have become strongly Westernized, such as urban youth in many international cities. The strong form of cultural invariance (i.e., universality) would require that the same patterns of emotional correlation will be evident for members of any society, regardless of the similarity of their musical heritages. Moreover, universality implies that the same will be true for people’s response to all musical forms: i.e., not only will different cultures pick similar colors for the same western, classical music, but also for non-western, traditional music from other cultures. Obviously, the present results have addressed only a small fraction of the relevant issues, which must be left for future research to decide.

**4. Discussion**

The present data show that brief selections of major music at fast tempos were judged as happy, li­vely, and strong, whereas selections of minor music at slow tempos were considered calm, sad, and weak. These findings support Webster and Weir’s (2005) claim that music in a major key is almost always associated with happy emotional responses, and those in a minor key with sadness.

The present findings also show that lighter, more saturated, yellower colors (e.g., yellow, orange, and red) are generally associated with happy feelings, whereas darker, desaturated, bluer colors (e.g., dark-gray, dark-blue, and black) are associated with feelings of sad­ness. This pattern is consistent with results reported in a study of the as­sociations between color and emotions (Hemphill, 1996). Putting the two patterns together implies that lighter, more saturated, yellower colors should be associated with (and thus be chosen to “go best with”) major music at faster tempos because both are happier, whereas darker, desaturated, bluer colors should be associated with minor music at slower tempos because both are sadder. This is precisely the pattern of results that we have found.

The remarkable similarities between Mexican and North American populations in all aspects of the present data suggest that such respon­ses may derive from culturally invariant mechanisms of emotional mediation rather than from purely sociocultural influences. The extent to which the present results reflect universal tendencies in cross-cultural associations remains to be seen, when cultures with non-western musical structures are studied in similar paradigms.

Barbiere, Vidal and Zellner (2007) have suggested that “weak synesthesia” may serve as a probable underlying explanatory concept in understanding the kinds of results we have found in non-synesthetic individuals. Although this is possible, it is not yet clear whether the same kinds of principles are involved. Synesthetic experiences of colors from hearing sounds may be quite different from the emotio­nally-mediated associations we have discovered in non-synesthetic people, because it is unclear whether synesthetic experiences are mediated by emotion or the product of direct sound-to-color correspondences. We are currently testing music-color synesthetes in similar experimental tasks to find out.

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