

## Color Preferences Are Not Universal

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Claims of universality pervade color preference research. It has been argued that there are universal preferences for some colors over others (e.g., Eysenck, 1941), universal sex differences (e.g., Hurlbert & Ling, 2007), and universal mechanisms or dimensions that govern these preferences (e.g., Palmer & Schloss, 2010). However, there have been surprisingly few cross-cultural investigations of color preference and none from nonindustrialized societies that are relatively free from the common influence of global consumer culture. Here, we compare the color preferences of British adults to those of Himba adults who belong to a nonindustrialized culture in rural Namibia. British and Himba color preferences are found to share few characteristics, and Himba color preferences display none of the so-called “universal” patterns or sex differences. Several significant predictors of color preference are identified, such as cone-contrast between stimulus and background (Hurlbert & Ling, 2007), the valence of color-associated objects (Palmer & Schloss, 2010), and the colorfulness of the color. However, the relationship of these predictors to color preference was strikingly different for the two cultures. No one model of color preference is able to account for both British and Himba color preferences. We suggest that not only do patterns of color preference vary across individuals and groups but the underlying mechanisms and dimensions of color preference vary as well. The findings have implications for broader debate on the extent to which our perception and experience of color is culturally relative or universally constrained.

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Ever since Fechner’s (1801–1887) demonstration that abstract forms are pleasing to the human senses (e.g., see Fancer, 1996), scientists have strived to establish the extent to which human preferences for basic sensory stimuli are systematic and universal. The first scientific study of color preferences came soon after Fechner’s discovery (Cohn, 1894; cited in Ball, 1965), and a number of large scale investigations of color preference were conducted over the next century (e.g., Eysenck, 1941; Guilford & Smith, 1959; Hogg, 1969). These studies claimed to reveal systematic patterns of color preference, and a universal order of color preference (blue, red, green, purple, orange, and yellow) was proposed (Eysenck, 1941). Recent studies of color preference have

provided general support for the idea that some colors (e.g., blue) are more likely to be liked than others (e.g., yellow). Although some cultural variation has been acknowledged on the basis of studies that compare the color preferences of two or more cultures (Choungourian, 1968, 1969; Hurlbert & Ling, 2007; Ou, Luo, Sun, Hu, Chen, Guan, et al., 2012; Ou, Luo, Woodcock, & Wright, 2004; Saito, 1994, 1996), the general consensus is that there are universal tendencies in patterns of color preference. As a result of this, attempts have been made to identify the underlying mechanisms and dimensions that govern these preferences (Hurlbert & Ling, 2007; Palmer & Schloss, 2010), and mathematical models that aim to predict preference on the basis of co-ordinates in color space have even been formulated (Ou et al., 2004).

The systematic nature of color preference has also led some to postulate that color preferences are biologically fixed. One recent theory argues that color preference is largely governed by the two neural subsystems that underlie human color vision—the “red-green” L-M and “blue-yellow” S-(L+M) cone-opponent processes<sup>1</sup> (Hurlbert & Ling, 2007). Hurlbert and Ling measured British and Chinese adults’ color preferences for a set of hues. The

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<sup>1</sup> There are retinal cone photoreceptors sensitive to short (bluish), medium (greenish), and long (reddish) wavelengths. The comparison of long- (L) and medium- (M) wavelength sensitive cone signals gives a “red-green” opponent process (L-M). The comparison of short- (S) wavelength cone signals with the combined L- and M-cone signals gives a “blue-yellow” opponent process: S-(L+M) (e.g., DeValois & DeValois, 1975). The actual appearance of the endpoints of the opponent processes is best characterized as “cherry-teal” and “violet-chartreuse” (Jameson & D’Andrade, 1997).



L-M and S-(L+M) cone-contrast between stimulus and background for each hue was calculated, and regression analyses were conducted with L-M and S-(L+M) cone-contrast entered as predictors of color preference. The two cone-contrast components accounted for 70% of the variance in preference across colors, leading Hurlbert and Ling (2007) to argue that an individual's weighting of L-M and S-(L+M) cone-contrast could be used to predict their color preference throughout color space. Furthermore, analysis of each individual's regression weights revealed a sex difference in how the color preferences of both British and Chinese adults weighted the "red-green" cone-contrast, and it was suggested that females preferred "reddish," and males preferred "greenish" contrast against the background. It was proposed that this sex difference is "universal" and that it evolved in line with sex differences in the behavioral use of color vision. More specifically, these researchers argued that the female "gatherer" role of identifying ripe fruit or edible red leaves amongst green foliage, which relies on the "red-green" cone-opponent process (Dominy & Lucas, 2001; Osorio & Vorobyev, 1996; Sumner & Mollon, 2000), underlies the female preference for "reddish" contrasts. Hurlbert and Ling suggested that this "universal" sex difference in color preference evolved on top of "natural, universal preferences" for some colors such as blue, although they did also acknowledge potential cultural influences (e.g., red symbolizes good luck in China).

Another recent theory of color preference, the *ecological valence theory* (EVT; Palmer & Schloss, 2010), proposes a very different account of color preference from Hurlbert and Ling's (2007) and suggests that color preferences result from affective responses to color-associated objects. In other words, the EVT proposes that people like/dislike colors to the degree that they are associated with liked/disliked objects of those particular colors. This association is suggested to have an ecological and adaptive function. For example, preference for blue draws one toward objects that are good for survival (e.g., clear sky and clean water), and a dislike of green-yellow draws one away from objects that are bad for survival (e.g., feces and rotten food). In this sense, Palmer and Schloss argued that there could be universal "genetically based preferences" and/or "innate learning mechanisms" that favor "evolutionary advantageous colors over evolutionary disadvantageous ones" (Palmer & Schloss, 2011, p. 363). However, EVT also attempts to account for "nonuniversal" and idiosyncratic aspects of color preference, including cross-cultural differences, by proposing that color preferences can be modified within an individual's lifetime by their affective experiences of colored objects.

Palmer and Schloss (2010) provided striking evidence to support EVT. In their study, different samples of American participants rated their preference for a set of colors, listed objects associated with those colors, rated how much they liked the associated objects, or rated how well the object matched the associated color. Palmer and Schloss then calculated an estimate of the average valence of objects associated with each color (WAVE) using the object ratings. The WAVE weights the valence ratings of the objects associated with each color with the appropriateness of the color-object association and then averages the weighted object valence for each color (by dividing the sum of the weighted valences for a color by the number of associated objects). The resulting WAVEs for the set of colors was highly similar to the

pattern of color preference and 80% of the variance in color preference and the WAVEs were shared.

A replication and extension of Palmer and Schloss's (2010) investigation with British participants has lent some support for the theory that color preferences are related to the valence of color-object associations and also suggests that EVT can partially account for sex differences in color preference (Taylor & Franklin, 2012). However, Taylor and Franklin also found that color-object associations were better able to account for British male than female color preferences. In addition, their investigation revealed a strong negative relationship, which was unrelated to object valence, between color preference and the number of objects associated with a color. The EVT therefore has its constraints. One advantage of the theory is its potential to be able explain both the universal patterns and the variation in color preference across cultures. For example, Palmer and Schloss (2011) predicted that cross-cultural variation in color preference "should covary with corresponding differences in color-object associations and/or object valences" (p. 365; see also Schloss, Poggessi, & Palmer, 2011) but also that color preferences for "diverse samples of people across the world should generally reflect universal trends in object valences: for example, nearly everyone presumably likes clear sky and dislikes rotten food" (Palmer & Schloss, 2011, p. 365). They report a preliminary investigation of this issue, relating color preferences and the WAVE in a Japanese sample (Palmer & Schloss, 2010). The WAVEs for Japanese and American samples were more strongly associated with intraculture color preferences, although the Japanese WAVE only accounted for 44% of the variation in Japanese color preferences. Nevertheless, a peak at blue and dip at dark yellow for color-object associations and preference could be identified in the Japanese data (Fushikida, Schloss, Yokosawa, & Palmer, 2009).

Although claims of universality pervade color preference research, the surprisingly thin literature of cross-cultural research on color preference has been limited to the industrialized world (Choungourian, 1968, 1969; Hurlbert & Ling, 2007; Ou, Luo, Sun, Hu, Chen, Guan, et al., 2012; Saito, 1994, 1996). Therefore, similarity in color preference, or the underlying mechanisms of color preference across cultures (such as the sex difference in the weighting of "red-green" cone-contrast) could arise from shared cultural influences in industrialized societies (e.g., global consumer culture), rather than biological, evolutionary, or ecological drivers. Here, we put ideas of "universality" of color preference to a more stringent test by comparing the color preferences of a group of British adults to those of adults from a nonindustrialized culture. We measure the color preferences of the Himba, a seminomadic group of people from Northern Namibia who have their own distinctive culture and generally live in remote rural villages with no electricity or running water. In the majority of Himba villages (apart from those close to the nearest town), there are few artifacts or objects that are not handmade from natural materials. This means that the chromatic environment of a Himba village is more natural than the chromatic environment of industrialized cultures that are dominated by manufactured objects produced in a vast range of artificial highly saturated colors (e.g., cars, clothes, electronics, furniture, accessories etc.). Himba color preferences are compared to British color preference data from Taylor and Franklin (2012), which were collected in the same manner for identical stimuli. We conduct new analyses on both British and Himba color



preferences to identify the predictors of preference for the two groups, and we also conduct new analyses that make direct comparisons between the two groups.

If there are elements of similarity between Himba and British color preference or previously reported color preferences from other cultures, this would indeed strongly suggest that color preferences are likely to be universally constrained. Of particular interest is whether (a) the Himba color preferences share the previously claimed "innate" or "natural" preference of blue and aversion to yellow/yellow-green and (b) the so called "universal" sex difference in the weighting of "red-green" cone-contrast is present in both Himba and British color preference. The study provides an excellent opportunity to test the limits of both Hurlbert and Ling's (2007) and Palmer and Schloss's (2010) recent theories of color preference. British and Himba color preferences are analyzed through the lens of Hurlbert and Ling's (2007) cone-contrast theory to establish the extent to which patterns of preference are governed by the underlying subsystems of color vision. This provides new data on whether Hurlbert and Ling's findings replicate with a British sample and identifies whether there are cross-cultural differences in how well their cone-contrast model can explain color preference. Color-object associations and ratings of object valences are also taken from separate samples of Himba adults (as in Taylor & Franklin, 2012, for British participants) to establish the extent to which the color-object associations made by the Himba are related to their color preference. Comparisons are made between the Himba and British data to determine whether the relationship between color-object associations and color preference is culturally variable and also to establish the degree of cultural specificity in any identified relationship.

## Method

### Participants

Himba participants were adults from Himba villages in rural northern Namibia, and they had lived in those villages all of their lives. Adults were recruited from these villages with the assistance of a Himba translator who first sought permission from the head of each village. There were separate groups of Himba participants for each task: 38 for color preference (21 male), 35 for object description (17 male), 22 for object valence (13 male). The Himba do not traditionally keep record of birth dates, but all participants were estimated to be between 20 and 30 years old. As reported in Taylor and Franklin (2012), British participants were students at the University of Surrey in England, were British citizens and had a mean age of 20 years ( $SD = 1.61$ ). There were separate groups of British participants for each task: 42 for color preference (22 male), 55 for object description (26 male), 40 for object valence (20 male). All participants were screened for color vision deficiencies using the City Colour Vision Test (Fletcher, 1981).

### Stimuli and Set-Up

Colors were presented on a calibrated 21-in. (53.34-cm) CRT monitor (Sony Trinitron GDM-F520), as rectangular patches

(11.6° horizontal, 12.1° vertical) in the center of the screen and on a gray background ( $Y = 17.75 \text{ cd/m}^2$ ,  $x = 0.312$ ,  $y = 0.318$ ). Colors were close approximations of the "saturated" (S), "light" (L), and "dark" (D) stimulus sets from Palmer and Schloss (2010). The "saturated" set were eight hues that were good examples of red (R), orange (O), yellow (Y), chartreuse (H), green (G), cyan (C), blue (B), and purple (P). Palmer and Schloss termed this the "saturated set," as the stimuli had the highest rendered Munsell Chroma,<sup>2</sup> compared to corresponding hues in the other stimulus sets. For the "light" set, stimuli were light versions of the eight hues at reduced Munsell Chroma: Lightness and chroma was approximately halfway between that of the corresponding color in the saturated set and Munsell Value 9 (light), Munsell Chroma 1 (reduced chroma). For the "dark" set, stimuli were dark versions of the eight hues at reduced chroma: Lightness and saturation was approximately halfway between that of the corresponding color in the "saturated" set and Munsell Value 1 (dark), Munsell Chroma 1 (reduced chroma). The "muted" set from Palmer and Schloss (eight hues at mid-luminance and reduced chroma) was not included. This set was excluded because the preference curves and WAVES were highly similar for "muted" and "light" sets in Palmer and Schloss, and excluding the set had the needed benefit of reducing the testing time for the Himba who are unused to formal testing sessions.

Table 1 gives the CIE (1931)  $x, y, Y$  stimulus coordinates as verified by a colorimeter (Cambridge Research Systems ColorCal, Rochester, England). The chromaticity coordinates of these stimuli give approximately the same Munsell Hue and Chroma, as in Palmer and Schloss (2010). The luminance ( $Y \text{ cd/m}^2$ ) of the stimuli also converts to approximately the same Munsell Value (lightness) as the stimuli from Palmer and Schloss, when the white point of the monitor is used for the conversions. Table 1 also gives the stimulus coordinates in CIELUV<sup>3</sup> color space, for Hue (radians calculated anticlockwise from horizontal), Lightness ( $L^*$ ), and CIELUV Chroma (colorfulness relative to the gray background). In order to test Hurlbert and Ling's biological component model of color preference, the L-M and S-(L+M) cone-contrast between each stimulus and the background was also calculated, as in Hurlbert and Ling (2007).<sup>4</sup> The stimulus-background cone-contrast for each stimulus is given in Table 1.

Participants were sat at eye-level to the center of the CRT monitor, at a distance of 59 cm. British participants were tested in a dark room, and Himba participants were tested in a large tent

<sup>2</sup> The Munsell color system describes color using three axes: Hue, Value, and Chroma. Hue is divided into 100 equal divisions around a color circle. Value denotes the lightness of the color and ranges from value 0 (black) to value 10 (white). Chroma is the purity or saturation of a color and has a minimum value of 0.

<sup>3</sup> CIE LUV is a perceptually uniform color space used by the International Commission on Illumination (CIE).  $L^*$  describes the lightness of a color, while  $u^*$  and  $v^*$  correspond to a color's chromaticity coordinates within the color space. CIE LUV is most commonly used with radiant colors.

<sup>4</sup> The L-M and S cone-contrast between stimulus and background was calculated using the method of Hurlbert and Ling (2007). As in Hurlbert and Ling, the calculations were made on the basis of the  $x, y, Y$  (CIE, 1931) chromaticity co-ordinates of the stimuli, and the Smith-Pokorny cone fundamentals were used to calculate the L, M, and S cone excitations (Smith & Pokorny, 1975). Cone-contrast was calculated for L ( $\Delta L = [L_s - L_b]/L_b$ ), M ( $\Delta M = [M_s - M_b]/M_b$ ), and S ( $\Delta S = [S_s - S_b]/S_b$ ; the subscript "s" indicates the stimulus and "b" the background color). The L-M (LM) and S-cone



Table 1  
Characteristics of the Stimuli

Stimulus	x	y	Y	Hue radians	L*	Chroma	L-M	S-(L+M)
SR	0.53	0.32	21.35	0.21	51.57	117.83	0.4881	0.5778
LR	0.41	0.33	46.14	0.32	71.37	63.19	0.4185	0.6287
DR	0.51	0.31	7.00	0.17	30.59	61.49	0.1447	0.1605
SO	0.51	0.41	46.07	0.66	71.32	111.57	0.5581	1.7703
LO	0.40	0.37	63.21	0.78	81.03	58.02	0.3527	1.2893
DO	0.48	0.39	9.91	0.62	36.31	49.33	0.1113	0.3210
SY	0.41	0.44	84.38	1.31	90.84	82.53	0.1868	2.6181
LY	0.39	0.41	84.20	1.27	90.76	68.81	0.2045	2.2537
DY	0.44	0.45	21.18	1.17	51.39	54.72	0.0884	0.7502
SH	0.39	0.50	63.31	1.71	80.98	91.94	0.0794	2.3162
LH	0.36	0.42	73.55	1.66	86.06	60.61	0.0376	1.8024
DH	0.37	0.47	16.99	1.76	46.62	45.66	0.0245	0.5431
SG	0.25	0.45	39.22	2.55	66.76	76.79	0.3523	0.7469
LG	0.29	0.38	59.04	2.48	78.05	47.43	0.2807	0.6636
DG	0.26	0.42	11.37	2.57	38.77	37.46	0.0903	0.1718
SC	0.23	0.34	46.18	3.14	71.39	60.00	0.4274	0.2826
LC	0.27	0.33	63.18	3.13	81.02	37.23	0.3173	0.1529
DC	0.23	0.32	12.84	3.33	41.04	30.41	0.1052	0.1045
SB	0.20	0.28	32.24	3.67	61.53	60.82	0.3357	0.8794
LB	0.26	0.28	54.82	4.06	76.53	41.90	0.2338	1.1023
DB	0.21	0.24	9.94	4.09	36.37	39.07	0.0793	0.4541
SP	0.29	0.23	16.99	5.06	46.62	39.99	0.0521	0.6044
LP	0.29	0.24	46.09	5.02	71.33	51.53	0.1035	1.3717
DP	0.28	0.18	7.03	5.08	30.66	46.42	0.0477	0.4908

Note. Stimuli are characterized using Palmer and Schloss's (2010) nomenclature: "Saturated" (S), "light" (L), or "dark" (D) versions of red (R), orange (O), yellow (Y), chartreuse (H), green (G), cyan (C), blue (B), and purple (P) hues. Stimulus values for Y(cd/m<sup>2</sup>), X, Y (CIE, 1931), hue (radians CIELUV calculated anticlockwise from horizontal), lightness (L\*), and CIELUV chroma, L-M and S-(L+M) stimulus-background cone-contrast. L\* is calculated using the white point of the monitor Y(cd/m<sup>2</sup>) = 108 as the reference white, which had the same chromaticity coordinates as the gray background x = 0.312, y = 0.318. L-M = red-green cone-opponent processes; S-(L+M) = blue-yellow cone-opponent processes.

lined with blackout material, with the computer and monitor powered by a generator.

## Task Design and Procedure

For Himba participants, two translators who spoke fluent Herero (the language of the Himba) and English explained the tasks to the participants using a carefully scripted and translated set of instructions. In all tasks, participants were tested individually, and trials commenced following adaptation to the darkness of the testing environment and the gray background.

**Color preference.** Numerate British and Himba participants were asked to rate their preference from 0 (*not at all*) to 10 (*very much*). Non-numerate Himba participants were asked to rate their preference using a set of 10 white sticks: no sticks (*not at all*); all the sticks (*very much*). As a quick check that Himba participants

had understood the rating task, participants were asked to rate how much they liked animals the Himba consider to be good (e.g., cow) and bad (e.g., scorpion). All participants gave appropriate ratings when asked how much they liked the animals. For the color preference task, participants were told to look at the color presented and rate how much they liked the color.<sup>5</sup> Stimuli were presented individually in the center of the gray background. The stimulus remained until the participant had made their response, and a gray background was then presented until the experimenter started the next trial. All stimuli were shown twice giving 48 trials, and trials were presented in a randomized order.

**Object description task.** The stimuli and set up were identical to the color preference task, but instead of rating preference for each color, participants were asked to verbally report objects that they associated with the color. As in Palmer and Schloss (2010), participants were asked to only list objects that were specific to the presented color and not unique to themselves (e.g., my favorite pot) and not to list objects that could be a variety of colors (e.g., cars), or to list abstract concepts such as "happiness." Participants were given as long as they needed to think of objects associated

contrast ( $S_c$ ) were calculated using formulae from Eskew, McLellan, and Giulianini (1999):  $LM_c = 0.7 \cdot \Delta L - 0.72 \Delta M + 0.02 \Delta S$ ;  $S_c = 0.8 \cdot \Delta S - 0.55 \Delta L - 0.25 \Delta M$ . It should be noted that using CIE x,y,Y chromaticity coordinates to estimate cone-contrast is known to underestimate response for very short wavelengths (below 460 nm) and that measuring colors with a spectroradiometer provides a more precise estimation of wavelengths in that region (e.g., Stockman & Sharpe, 1999). This issue is important for studies that require very precise estimates of cone excitation, such as low-level psychophysical investigations of cone response. However, it was felt that Hurlbert and Ling's approach of using CIE x,y,Y values provided sufficient accuracy to test their model, and especially to address the issue of whether there are sex differences in the weighting of L-M cone-contrast.

<sup>5</sup> We treat the preference ratings as having a ratio level of measurement for analysis as the variable has a meaningful 0 (0 = no preference), and the assumption is that participants make their ratings in a ratio manner (e.g., a color with a preference score of 4 is liked twice as much as a color with a preference score of 2). Even if this assumption does not hold, it is common practice in psychological studies to analyze scales or ratings using correlational or regression analyses as we do here.



with the color, were told to list as many objects as they could and were told to say if they couldn't think of anything. Unlike in Palmer and Schloss, participants were tested individually rather than in groups. Each stimulus was presented once, and the order of stimulus presentation was randomized.

**Object valence task.** An object list was compiled following Palmer and Schloss's (2010) criteria: objects were removed from the object list if they could be any color (e.g., cars), described a concept (e.g., "love") instead of an object, or did not match the color on the screen at all (e.g., "pumpkin" for saturated blue). Few associations needed to be removed, as participants generally followed task instructions. The removed object-associations for the British were "sweets," "fondant fancies" (a type of multicolored cake), and "TV," as all of these could be any color, and "royalty," "horizon," and "angry person," as these were deemed to be abstract or the color not easily identifiable. For the Himba, the removed object-associations were "clothes," "blanket," "mirror," "car," and "plate," as all of these can be any color. After exclusions, there was a list of 282 objects for the British participants and 47 objects for the Himba. The relatively small number of objects for the Himba relative to the British is to be expected as in nonindustrialized nonconsumer cultures objects are more greatly restricted to those occurring in the natural environment, and therefore objects are more scarce. The experimenter (or translator for the Himba) read out each of the objects one at a time and asked participants to rate how much they liked each of the objects using the preference rating scale.

## Results

The preference ratings for the first and second time colors were rated were highly significantly correlated for British ( $r = .95, p < .001$ ) and for Himba ( $r = .92, p < .001$ ), indicating a high degree of reliability in the ratings for both groups. Each participant's preference for each color was averaged across the two stimulus presentations. Figure 1 gives the average preference ratings for the hues in each set, for Himba participants and British participants (British figure from Taylor & Franklin, 2012). As can be seen in Figure 1, the average pattern of color preference is strikingly different for Himba and British participants. Himba participants have a clear preference for the "saturated" versions of red, orange, yellow, chartreuse, and green hues but have low preference for the light and dark versions of these hues and low preference for all bluish colors. There is no evidence from the Himba color preferences for the so called "universal" preference for bluish hues or aversion to yellow-green, which can be clearly seen in the British data. The British color preferences also appear to vary with hue more than the Himba color preferences, with less of a distinction between "saturated," "dark," and "light" colors (see the online supplemental materials for an analysis of the individual differences in these key characteristics of British and Himba color preference).

Analyses were conducted on both the Himba and British data to establish whether weighted biological components of color vision (Hurlbert & Ling, 2007) could account for the patterns of color preference, to see whether the model works in a similar way for both cultures, and to establish whether a sex difference in L-M cone-contrast weighting is stable both within and across cultures. Himba data were also analyzed to establish whether the valence of Himba color-object associations (EVT; Palmer & Schloss, 2010) could ac-

count for the pattern of Himba color preference. The relationship between color-object associations and color preference for the Himba was then compared to previous identical analyses that revealed such a relationship for the British data (Taylor & Franklin, 2012). In addition, new analyses were conducted on both the Himba and British data to determine the cultural specificity of the relationship between color preference and color-object associations.

## Cone-Contrast Analysis

Hurlbert and Ling's (2007) preference model states that

$$\text{preference}_{\text{predict}} = w_1 * S_c + w_2 * LM_c + a,$$

where  $S_c$  and  $LM_c$  are the cone-contrast values,  $w_1$  and  $w_2$  are the weights for the corresponding cone-contrast values, and  $a$  is the offset. In order to test this model, least squares multiple regressions were conducted with the values of L-M and S-(L+M) cone-contrast for each of the colors as predictors of preference ratings for each of the colors. As colors also varied in lightness and chroma, separate least squares multiple regressions were also conducted with CIELUV lightness and CIELUV chroma as predictors of preference ratings.<sup>6</sup> Regressions were conducted on the average preference ratings for British and Himba male and female samples. The percentage of shared variance between average color preference ratings and the model gives an indication of how well the model captures the average pattern of color preference for male or female participants.

The cone-contrast model accounted for just under a quarter of the variance in the average pattern of color preference for British males (23%) and British females (22%). However, only L-M cone-contrast was a significant predictor for British males (21%,  $t = -2.45, p < .05$ ), and only S-(L+M) cone-contrast was a significant predictor for British females (22%,  $t = 2.45, p < .05$ ). The cone-contrast model captured a similar amount of variance in the Himba male color preference curve as for the British color preferences (22%) yet only explained 10% of the variance for Himba female color preference (no significant predictors). For Himba males, only S-(L+M) cone-contrast was a significant predictor of color preference (22%,  $t = -2.51, p < .05$ ).

Chroma and lightness did not account for British color preference (0% variance for British males, 2% variance for British females). However, the chroma-lightness model did capture a large proportion of the variance in Himba color preferences (57% males, 47% females), which was largely due to the amount of variance explained by chroma (Himba males, 55%,  $t = 5.14, p < .001$ ; Himba females, 45%,  $t = 4.20, p < .001$ ). This strong relationship of chroma and preference for the Himba can be clearly seen in

<sup>6</sup> Ling and Hurlbert (2009) also tested their model with a stimulus set that varied in lightness and chroma and proposed an extended version of their cone-contrast model, where CIELUV lightness and chroma or saturation are included as predictors: for example,  $\text{preference}_{\text{predict}} = w_1 * S_c + w_2 * LM_c + w_3 * \text{chroma} + w_4 * \text{lightness} + a$ . However, as chroma is not independent of L-M and S-(L+M) cone-contrast this model is not technically appropriate. Therefore, we choose not to adopt the extended model here, and we instead have separate cone-contrast and lightness/chroma models. We add chroma, rather than saturation, to the second model, as chroma is independent of lightness (and can therefore be added as a separate predictor), whereas saturation is calculated relative to the lightness of the color and so is not independent.



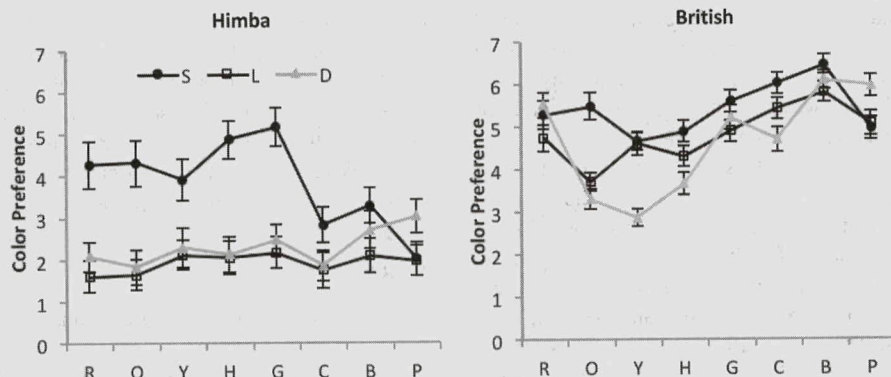


Figure 1. Mean color preference ratings ( $\pm 1$  SE) and WAVes (weighted affective valence estimates) for “saturated” (S), “light” (L), and “dark” (D) versions of eight hues (x axis: Red, Orange, Yellow, cHartreuse, Green, Cyan Blue and Purple), for Himba participants from the current investigation (left panel) and for British participants from Taylor and Franklin (2012; right panel).

Figure 1, where preference for the saturated set appears generally stronger than that of the light and dark set.

A second analysis was conducted to establish whether there were significant sex differences in how Himba and British color preference weighted L-M stimulus-background cone-contrast. This analysis repeated the above regressions but this time used each individual’s preference ratings, rather than the average preference rating for each group (essentially, one regression per participant). Figure 2 gives the mean L-M individual regression weights for Himba and British males and females. As can be seen in the figure, British and Himba females do not, on average, weight L-M stimulus-background cone-contrast positively, contrary to Hurlbert and Ling’s (2007) predictions. British males do appear to weight L-M more negatively than British females, although this sex difference appears to be reversed for the Himba. An analysis of variance was conducted on these weights, with sex (male/female) and culture (British/Himba) as factors to establish whether there was a sex difference in the L-M regression weights and whether such a difference is present for both British and Himba color preference. This revealed a significant interaction of sex and culture,  $F(1, 44) = 6.00$ ,  $p < .05$ , and neither main effect was significant (largest  $F = 0.011$ , smallest  $p = .74$ ). Follow-up post hoc  $t$  tests revealed a significant sex difference in L-M weights for

the British,  $t(40) = 2.27$ ,  $p < .05$ , but not for the Himba,  $t(37) = 1.32$ ,  $p = .20$ .

### Color-Object Association Analysis

The large number of British color-object associations ranged from naturally occurring objects, such as “blood,” “clouds,” and “lavender,” to man-made objects, such as “toothpaste,” “astroturf,” and “beer” (for a full breakdown of British color-object associations, see the supplemental section of Taylor & Franklin, 2012). The Himba color-object associations and their valence ratings of the objects are given in Table 2. All Himba object associations in the final list were for naturally occurring things, with the exception of “tarred road” and “orange Fanta drink” that was mentioned by only one participant from one of the villages closest to the nearest town. The most common things to be associated with colors were soil, mopane leaves, grass, cow, fire, and sky, as well as ochre, which is a natural reddish paste that Himba women apply to their bodies. Some colors elicited more object associations than others, and the Himba found it particularly difficult to think of objects for purple hues, especially light purple. We were surprised by this and by the low number of objects overall. However, we could not find any other objects of purple or any of the other colors in the Himba environment other than those that the Himba provided. Color-object associations were inspected to check that objects were appropriately matched to the color. All appeared appropriate, with the exception of associations made by one individual, who associated cows with inappropriate colors such as blue and cyan. As cows are not these colors, the inappropriate cow-color associations offered by one person were removed. Inspection of the object ratings also revealed them to be appropriate: Highly beneficial things (e.g., grass, clouds, fresh water, leaf shoots, cow) were rated positively, and negative things (e.g., tick blood, bad water, poisonous wild onion leaves, ashes) were rated negatively.

The WAVE was calculated as in Palmer and Schloss (2010) and Taylor and Franklin (2012), with one exception. For the Himba, as in earlier versions of the WAVE (Fushikida et al., 2009), we use the number of times an object was associated with the color as a measure of the appropriateness of the color-object association,

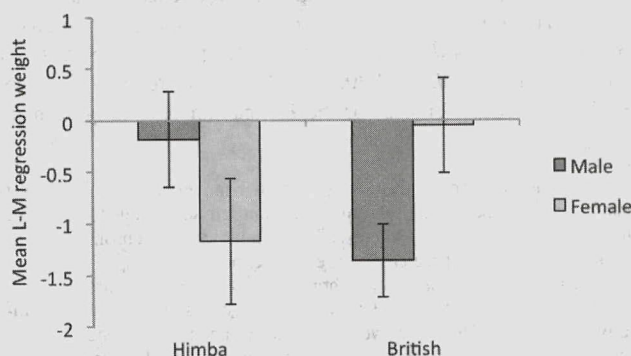


Figure 2. The mean ( $\pm 1$  SE) individual regression weights for L-M cone-contrast for Himba and British males and females. L-M = red-green cone-opponent processes.



Table 2

*The Object Associations Provided by the Himba for Each Color, the Frequency of These Associations, the Average Object Valence Rating (Converted -5 to 5 Scale), and Average Color Preference Rating*

Color	Object association	Frequency of association	Object valence rating	Color preference rating
SR	Blood	8; 6; 2	-2.1; -1.4; -2.5	4.35; 3.62; 5.09
SR	Cow	1; X; 1	3.2; X; 2.3	4.35; 3.62; 5.09
SR	Fire	2; 2; X	1.0; 1.4; X	4.35; 3.62; 5.09
SR	Ochre	8; 2; 6	0.5; -1.0; 1.5	4.35; 3.62; 5.09
SR	Phobia Tree	1; 1; X	-0.5; 0.0; X	4.35; 3.62; 5.09
SR	Soil	1; 1; X	1.4; 1.8; X	4.35; 3.62; 5.09
LR	Autumn Leaves	1; 1; X	-2.3; -1.8; X	1.65; 1.24; 2.06
LR	Clouds	1; 1; X	2.9; 4.0; X	1.65; 1.24; 2.06
LR	Fire	2; 1; 1	1.0; 1.4; 0.6	1.65; 1.24; 2.06
LR	Ochre	4; 3; 1	0.5; -1.0; 1.5	1.65; 1.24; 2.06
LR	Sand	1; 1; X	0.5; 0.7; X	1.65; 1.24; 2.06
LR	Soil	2; 2; X	1.4; 1.8; X	1.65; 1.24; 2.06
LR	Sun	1; X; 1	1.4; X; 0.9	1.65; 1.24; 2.06
LR	Sunset	1; X; 1	-0.4; X; -0.5	1.65; 1.24; 2.06
DR	Blood	4; 3; 1	-2.0; -1.4; -2.5	2.07; 2.14; 2.00
DR	Cow	2; 1; 1	3.2; 4.6; 2.3	2.07; 2.14; 2.00
DR	Fire	1; 1; X	1.0; 1.4; X	2.07; 2.14; 2.00
DR	Ochre	4; 1; 3	0.5; -1.0; 1.5	2.07; 2.14; 2.00
DR	Palm Tree Fruit	1; 1; X	-0.5; 0.0; X	2.07; 2.14; 2.00
DR	Soil	1; 1; X	1.4; 1.8; X	2.07; 2.14; 2.00
SO	Dry Leaves	1; 1; X	-3.0; -3.6; X	4.26; 4.79; 3.74
SO	Fire	2; 1; 1	1.0; 1.4; 0.6	4.26; 4.79; 3.74
SO	Omahoho Tree	1; 1; X	-2.2; -2.6; X	4.26; 4.79; 3.74
SO	Omukangai Tree	1; 1; X	-2.3; -3.1; X	4.26; 4.79; 3.74
SO	Orange Fanta	1; X; 1	0.5; X; 0.4	4.26; 4.79; 3.74
SO	Oranges	1; X; 1	-2.0; X; -2.2	4.26; 4.79; 3.74
SO	Pumpkin	2; 1; 1	0.0; -0.2; 0.2	4.26; 4.79; 3.74
SO	Sunset	2; 1; 1	-0.4; -0.2; -0.5	4.26; 4.79; 3.74
LO	Cow	2; X; 2	3.2; X; 2.3	1.69; 1.29; 2.09
LO	Dry Grass	1; 1; X	-1.1; -0.8; X	1.69; 1.29; 2.09
LO	Fire	1; 1; X	1.0; 1.4; X	1.69; 1.29; 2.09
LO	Hut	1; 1; X	1.1; 1.0; X	1.69; 1.29; 2.09
LO	Moon	1; X; 1	0.8; X; 0.5	1.69; 1.29; 2.09
LO	River	1; X; 1	-1.4; X; -1.2	1.69; 1.29; 2.09
LO	Soil	7; 4; 3	1.4; 1.8; 1.1	1.69; 1.29; 2.09
LO	Sunset	2; 2; X	-0.4; -0.2; X	1.69; 1.29; 2.09
DO	Cow	5; 4; 1	3.2; 4.6; 2.3	1.81; 1.98; 1.65
DO	Dunes	1; X; 1	-1.8; X; -1.8	1.81; 1.98; 1.65
DO	Elephant	1; 1; X	-1.3; 0.6; X	1.81; 1.98; 1.65
DO	Palm Tree Fruit	1; 1; X	-0.5; 0.0; X	1.81; 1.98; 1.65
DO	Soil	3; 2; 1	1.4; 1.8; 1.1	1.81; 1.98; 1.65
SY	Autumn Leaves	5; 5; X	-2.3; -1.8; X	3.84; 4.62; 3.06
SY	Cow	2; X; 2	3.2; X; 2.3	3.84; 4.62; 3.06
SY	Dry Grass	1; X; 1	-1.1; X; -1.3	3.84; 4.62; 3.06
SY	Dry Leaves	2; 2; X	-3.0; -3.6; X	3.84; 4.62; 3.06
SY	Fire	1; 1; X	1.0; 1.4; X	3.84; 4.62; 3.06
SY	Leaf Shoots	1; X; 1	2.2; X; 2.1	3.84; 4.62; 3.06
SY	Moon	1; 1; X	0.8; 1.3; X	3.84; 4.62; 3.06
SY	Sunset	1; 1; X	-0.4; -0.2; X	3.84; 4.62; 3.06
LY	Autumn Leaves	1; 1; X	-2.3; -1.8; X	2.14; 1.95; 2.32
LY	Cow	8; 1; 7	3.2; 4.6; 2.3	2.14; 1.95; 2.32
LY	Grass	1; 1; X	2.5; 2.9; X	2.14; 1.95; 2.32
LY	Omuthzu Tree	1; 1; X	0.4; 0.6; X	2.14; 1.95; 2.32
LY	Soil	1; X; 1	1.4; X; 1.1	2.14; 1.95; 2.32
LY	Sunrise	2; 1; 1	1.1; 0.4; 1.5	2.14; 1.95; 2.32
DY	Copper	1; X; 1	-1.2; X; -0.8	2.26; 2.55; 1.97
DY	Cow	3; X; 3	3.2; X; 2.3	2.26; 2.55; 1.97
DY	Grass	1; 1; X	2.5; 2.9; X	2.26; 2.55; 1.97
DY	Soil	1; X; 1	1.4; X; 1.1	2.26; 2.55; 1.97
SH	Autumn Leaves	1; 1; X	-2.3; -1.8; X	4.87; 4.98; 4.77
SH	Bad Water	2; 2; X	-4.6; -4.4; X	4.87; 4.98; 4.77
SH	Dry Grass	1; 1; X	-1.1; -0.8; X	4.87; 4.98; 4.77
SH	Fire	1; 1; X	1.0; 1.4; X	4.87; 4.98; 4.77
SH	Grass	1; 1; X	2.5; 2.9; X	4.87; 4.98; 4.77
SH	Mopane Leaves	3; 1; 2	-0.3; 0.7; -0.9	4.87; 4.98; 4.77

(table continues)



Table 2 (continued)

Color	Object association	Frequency of association	Object valence rating	Color preference rating
SH	Pumpkin	1; 1; X	0.0; -0.2; X	4.87; 4.98; 4.77
LH	Autumn Leaves	2; 1; 1	-2.3; -1.8; -2.7	2.06; 1.98; 2.15
LH	Cow	4; 1; 3	3.2; 4.6; 2.3	2.06; 1.98; 2.15
LH	Dry Grass	2; 2; X	-1.1; -0.8; X	2.06; 1.98; 2.15
LH	Fresh Water	2; 1; 1	1.9; 2.4; 1.5	2.06; 1.98; 2.15
LH	Grass	1; 1; X	2.5; 2.9; X	2.06; 1.98; 2.15
LH	Moon	1; 1; X	0.8; 1.3; X	2.06; 1.98; 2.15
LH	Soil	1; X; 1	1.4; X; 1.1	2.06; 1.98; 2.15
LH	Sun	1; 1; X	1.4; 2.0; X	2.06; 1.98; 2.15
LH	Sunrise	1; 1; X	1.1; 0.4; X	2.06; 1.98; 2.15
LH	Sunset	1; X; 1	-0.4; X; -0.5	2.06; 1.98; 2.15
DH	Animal Pancreas	1; X; 1	-3.3; X; -3.2	2.08; 2.55; 1.62
DH	Grass	1; 1; X	2.5; 2.9; X	2.08; 2.55; 1.62
DH	Leaf Shoots	3; 2; 1	2.2; 2.3; 2.1	2.08; 2.55; 1.62
DH	Mopane Leaves	1; X; 1	-0.3; X; -0.9	2.08; 2.55; 1.62
DH	Nature	1; X; 1	3.4; X; 3.3	2.08; 2.55; 1.62
DH	Ochre	1; X; 1	0.5; X; 1.5	2.08; 2.55; 1.62
SG	Grass	4; 1; 3	2.5; 2.9; 2.2	5.26; 4.38; 6.15
SG	Mopane Leaves	15; 7; 8	-0.3; 0.7; -0.9	5.26; 4.38; 6.15
LG	Clouds	1; 1; X	2.9; 4.0; X	2.21; 1.88; 2.53
LG	Fresh Water	1; 1; X	1.9; 2.4; X	2.21; 1.88; 2.53
LG	Grass	1; X; 1	2.5; X; 2.2	2.21; 1.88; 2.53
LG	Mopane Leaves	3; 2; 1	0.9; 0.7; -0.9	2.21; 1.88; 2.53
LG	Nature	1; 1; X	3.4; 3.6; X	2.21; 1.88; 2.53
LG	Sky	2; 1; 1	1.9; 2.9; 1.2	2.21; 1.88; 2.53
LG	Wild Onion Leaves	1; 1; X	-4.3; -4.6; X	2.21; 1.88; 2.53
DG	Grass	5; 3; 2	2.5; 2.9; 2.2	2.48; 2.43; 2.53
DG	Leaf Shoots	1; X; 1	2.2; X; 2.1	2.48; 2.43; 2.53
DG	Mopane Leaves	11; 7; 4	-0.3; 0.7; -0.9	2.48; 2.43; 2.53
DG	Nature	2; 1; 1	3.4; 3.6; 3.3	2.48; 2.43; 2.53
SC	Clouds	2; 1; X	2.9; 4.0; X	2.92; 2.07; 3.77
SC	Mopane Leaves	4; 4; X	-0.3; 0.7; X	2.92; 2.07; 3.77
SC	Nature	1; 1; X	3.4; 3.6; X	2.92; 2.07; 3.77
SC	Sky	6; 3; 3	1.9; 2.9; 1.2	2.92; 2.07; 3.77
LC	Clouds	3; 2; 1	2.9; 4.0; 2.1	1.77; 1.43; 2.12
LC	Fresh Water	3; 1; 2	1.9; 2.4; 1.5	1.77; 1.43; 2.12
LC	Mountain	1; X; 1	0.9; X; -0.9	1.77; 1.43; 2.12
LC	Sky	6; 5; 1	1.9; 2.9; 1.2	1.77; 1.43; 2.12
LC	Soil	2; 1; 1	1.4; 1.8; 1.1	1.77; 1.43; 2.12
DC	Fresh Water	1; X; 1	1.9; X; 1.5	1.84; 1.91; 1.77
DC	Mopane Leaves	4; 3; 1	-0.3; 0.7; -0.9	1.84; 1.91; 1.77
DC	Mountain	3; 2; 1	0.9; 3.1; -0.6	1.84; 1.91; 1.77
DC	Nature	1; X; 1	0.7; 3.6; 3.3	1.84; 1.91; 1.77
DC	Ochre	1; X; 1	0.5; X; 1.5	1.84; 1.91; 1.77
DC	Sky	5; 4; 1	1.9; 2.9; 1.2	1.84; 1.91; 1.77
DC	Soil	1; 1; X	1.4; 1.8; X	1.84; 1.91; 1.77
SB	Acacia Tree	1; 1; X	-2.1; -1.7; X	3.37; 2.62; 4.12
SB	Sky	12; 6; 6	1.9; 2.9; 1.2	3.37; 2.62; 4.12
LB	Ashes	1; 1; X	-4.0; -4.3; X	2.11; 1.91; 1.77
LB	Clouds	4; 4; X	2.9; 4.0; X	2.11; 1.91; 1.77
LB	Fresh Water	3; 1; 2	1.9; 2.4; 1.5	2.11; 1.91; 1.77
LB	Mountain	1; X; 1	0.9; X; -0.6	2.11; 1.91; 1.77
LB	Sky	9; 5; 4	1.9; 2.9; 1.2	2.11; 1.91; 1.77
LB	Smoke	1; 1; X	-3.7; -3.8; X	2.11; 1.91; 1.77
LB	Tarred Road	1; X; 1	1.5; X; -0.1	2.11; 1.91; 1.77
DB	Ashes	1; X; 1	-4.0; X; -3.8	2.73; 2.52; 2.94
DB	Mountain	3; 1; 2	0.9; 3.1; -0.6	2.73; 2.52; 2.94
DB	Night Sky	1; 1; X	0.7; 1.0; X	2.73; 2.52; 2.94
DB	Sky	8; 5; 3	1.9; 2.9; 1.2	2.73; 2.52; 2.94
SP	Maizemeal	1; X; 1	1.5; X; 0.8	1.99; 1.96; 3.03
SP	Mountain	1; 1; X	0.9; 3.1; X	1.99; 1.96; 3.03
SP	Sky	1; X; 1	1.9; X; 1.2	1.99; 1.96; 3.03
LP	Sunrise	2; 1; 1	1.1; 0.4; 1.5	5.08; 4.68; 5.53
DP	Sky	1; X; 1	1.9; X; 1.2	3.03; 2.98; 3.09
DP	Tick Blood	1; 1; X	-4.4; -4.7; X	3.03; 2.98; 3.09
DP	Wild Onion	1; 1; X	-4.4; -4.3; X	3.03; 2.98; 3.09

Note. Himba male, female, and overall averages are separated with a semicolon (e.g., Overall; Male; Female), with X denoting an object not listed by that sex. S = saturated; L = light; D = dark; R = red; O = orange; Y = yellow; H = chartreuse; G = green; C = cyan; B = blue; P = purple.



rather than ratings of the match between the color and the object. Importantly, this has minimal effect on the relationship between the WAVE and preference, as there is only 4% difference in shared variance between two versions of the WAVE for Palmer and Schloss's color preference data (76% in Fushikida et al., 2009; 80% in Palmer & Schloss, 2010). The log of the number of times the object was associated with the colors was taken and was used to weight the object valence ratings:

$$W_c = \frac{1}{R_c} \sum_{o=1}^{\eta_c} (1 + \log w_{co}) v_o,$$

where  $w_{co}$  is the number of times each object ( $o$ ) was mentioned for the color ( $c$ ),  $v_o$  is the average valence rating for each object  $o$ , and  $R_c$  is the number of objects associated with each color  $c$  (see Table 2 for a breakdown of these data). The average WAVE for the 24 colors was then correlated with the average preference ratings for the 24 colors. In order to investigate possible sex differences, the WAVEs were calculated separately for males and females. The new WAVEs were then correlated with the same-sex color preference ratings. Figure 3a shows the average color preferences and WAVEs for Himba participants and male and female Himba participants separately. Figure 3b gives the equivalent figures for the British (taken from Taylor & Franklin, 2012).

Previous analyses of the British data (Taylor & Franklin, 2012) established that there was a significant positive relationship between the British WAVEs and British color preference for the sample overall ( $r = .81, p < .001, 66\%$ ) and for males ( $r = .86, p < .001, 74\%$ ) and females ( $r = .67, p < .001, 45\%$ ) separately. Generally, liked colors (e.g., blue) were associated with liked objects (e.g., sky, water), and disliked colors (e.g., dark chartreuse) were associated with disliked objects (e.g., mucus, sewage, mold). This strong positive relationship was not found in an analysis of Himba color preferences and WAVEs. For the Himba, the Himba WAVE only explained 23% of the variance in their color preference for the sample overall, and the WAVE was significantly negatively correlated ( $r = -.48, p < .05$ ). There was a stronger negative correlation when male WAVE and male preference data were correlated ( $r = -.49, p < .05, 24\%$  of variance explained), but the female WAVE and female color preference were not correlated ( $r = -.20, p = .36$ ). The negative relationship between the WAVE and color preference for the Himba males can be seen from Figure 3a: for some colors, high preference is accompanied by low WAVE. For example, preference is highest for the "saturated" versions of red, orange, yellow, chartreuse, and green hues, while there is a clear dip in the WAVE for four of these colors. This dip in the WAVE for red, orange, yellow and chartreuse is

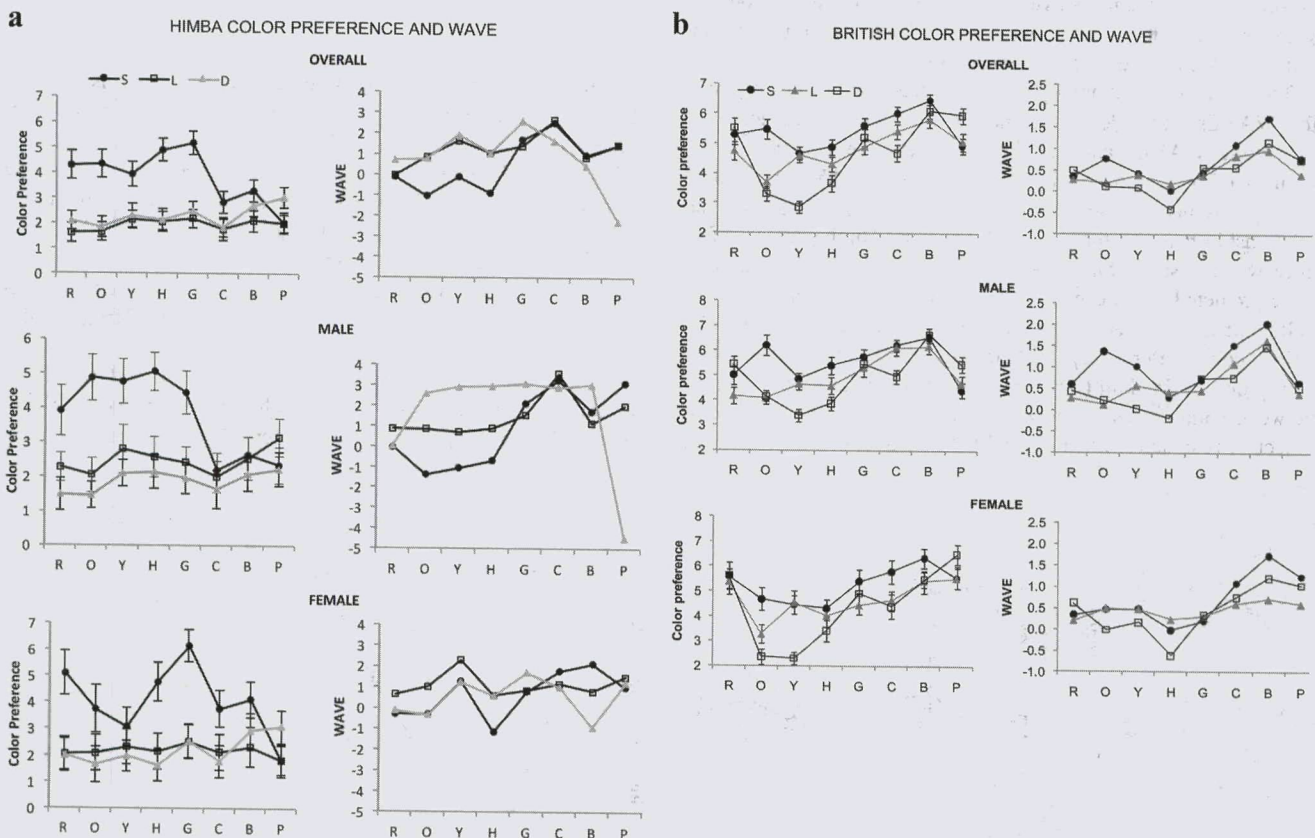


Figure 3. The average color preference rating ( $\pm 1$  SE; left panel), and WAVE (right panel), for "saturated" (S), "light" (L), and "dark" (D) versions of eight hues (x axis: Red, Orange, Yellow, cHartreuse, Green, Cyan Blue and Purple), for all participants (top), males (middle), and females (bottom), for the Himba (a), and for the British (b). WAVE = an estimate of the average valence of objects associated with each color.



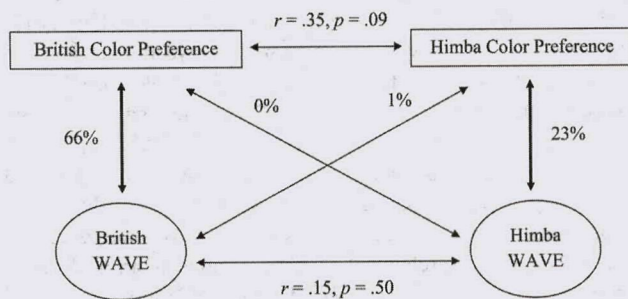


Figure 4. The percentage of variance in color preference explained by British and Himba WAVEs for intraculture color preference and for intercultural color preference. The correlation coefficients between the two WAVEs and between British and Himba color preference are also shown. WAVE = an estimate of the average valence of objects associated with each color.

due to associations with highly disliked objects such as “blood,” “omukangai tree,” “dry leaves,” and “bad water,” respectively. For other colors, low preference is accompanied by a high WAVE. For example, preference is low for light cyan, while this is the highest point in the male WAVE as light cyan was associated with highly liked objects such as “fresh water” and “sky.” As can be seen in Figure 3a, there is a dramatic dip in the male WAVE for “dark” purple; this was due to its association with highly disliked objects such as “tick blood” and “wild onion,” yet this dip was not reflected in the male color preference ratings.

To establish the cultural-specificity of the relationships between the WAVEs and color preference, intercultural correlations between the WAVEs and color preference were conducted (see Figure 4). The relationship between the Himba WAVE and British color preference was not significant ( $r = -.056, p = .79$ ), and the relationship between the British WAVE and Himba color preference was not significant ( $r = .087, p = .69$ ). Color preferences were predicted significantly better by the WAVEs from the same culture than the WAVEs of the other culture ( $p = <.001$  for British color preference,  $p = <.005$  for Himba color preference).

Taylor and Franklin (2012) also found significant relationships between components of the British WAVE (e.g., the number of objects associated with a color was negatively correlated with

British color preference). Therefore, additional correlational analyses were conducted to investigate whether there were also significant relationships between the components of the WAVE and preference for the Himba. The only significant relationship was between color preference and the summed object valence for Himba males ( $r = -.70, p < .001$ ), but the relationship is negative rather than positive. The summed object valence is simply the object valence summed for all objects associated with a color, rather than being weighted by the logarithm of the number of times each object was said as in the WAVE. Figure 5 gives the summed object valence for Himba males, which explains significantly more variance in Himba male color preference (49%) than does the Himba male WAVE (24%,  $p < .05$ ).

The amount of variance in Himba male color preference explained by Himba male summed object valence is remarkably similar to the amount explained by the chroma of the stimuli (51%), and summed object valence and chroma are negatively related ( $r = -.55, p < .005$ ). To explore the possible relationship between these two predictors, a hierarchical regression was conducted with Himba male color preference as the criterion variable. The first block included only chroma as a predictor, while the second block included both chroma and Himba male summed object valence. The results showed that when the variance explained by chroma is controlled for, the amount of variance explained by summed object valence drops to 11%.

## Discussion

Himba color preferences share very few characteristics with British color preferences or the common pattern of color preference of people from industrialized cultures. Relative to British color preferences, Himba color preferences appear to make a starker distinction between colorful and less colorful hues, have a greater indifference to the actual hue of the color, and lack the so called “universal and natural” peak in preference at blue and dip in preference for yellow. Analyses revealed striking differences in the predictors of British and Himba color preferences. For the Himba, chroma was a strong predictor of both male and female Himba color preference and explained around half of the variance: Colors that were most colorful and most different from gray were preferred. For Himba females,

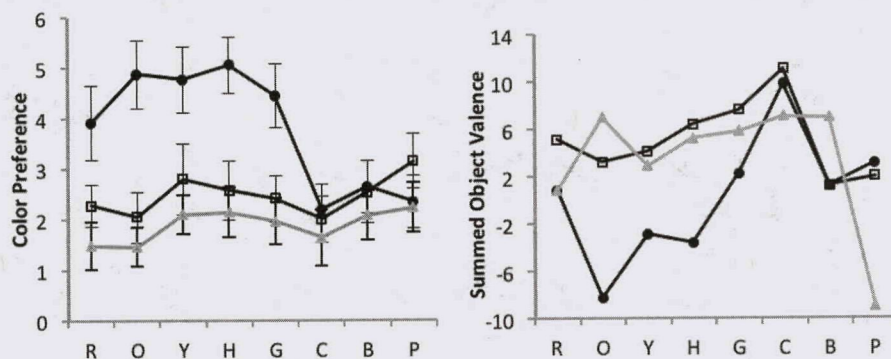


Figure 5. The mean color preference ratings ( $\pm 1$  SE) and summed object valences (unweighted) for “saturated” (S), “light” (L), and “dark” (D) versions of eight hues (x axis: Red, Orange, Yellow, Green, Cyan, Blue, and Purple), for male participants.



chroma was the only significant predictor of color preference across all regression analyses. However, for Himba males, there was also a negative relationship between the summed valence of objects associated with a color and color preference, which explained around half of the variance: Himba males preferred colors that were associated with disliked objects. In addition, S-(L+M) stimulus-background cone-contrast was also a significant predictor of Himba male color preference, which explained just under a quarter of the variance: Himba males preferred colors with "yellowish" contrast to the background.

The significant predictors of color preference for the British were highly different to those of the Himba. For the British, the weighted valences of color-object associations accounted for around three quarters of the variance in male color preference and around half of the variance in female color preference: Both British males and females preferred colors that were associated with liked objects. For British males, L-M stimulus-background cone-contrast was also a significant predictor: They preferred colors with "greenish" contrast to the background. For British females, S-(L+M) stimulus-background cone-contrast was also a significant predictor: They preferred colors with "bluish" contrast to the background. We discuss the implications of these findings for the theory that biological components govern color preference (Hurlbert & Ling, 2007) and for the EVT (Palmer & Schloss, 2010) in the following.

### Biological Components of Color Preference

The findings are not consistent with Hurlbert and Ling's (2007) theory that color preferences are largely governed by cone-contrast. Whereas Hurlbert and Ling found that 70% of the variance in British color preference was accounted for by cone-contrast, here less than a quarter of the variance in British color preference was explained. Hurlbert and Ling's theory has also been challenged by Palmer and Schloss's (2010) investigation, which found only a very weak relationship between American participant's color preference and cone-contrast: L-M = 4%; S-(L+M) = 19%. We suggest that this is because colors only varied in hue in Hurlbert and Ling's study but along all three perceptual dimensions of color in Palmer and Schloss's study and the current investigation. One possibility is that cone-contrast is less important to color preferences when all three perceptual dimensions of color vary. In addition, British and U.S. patterns of hue preference clearly interact with lightness and saturation, yet a cone-contrast model has no way of capturing this interaction. As color in the real world varies perceptually along the three dimensions of hue, lightness and saturation, it is important that a model of color preference is able to account for variation in preference when colors vary in this way. Hurlbert and Ling's cone-contrast model fails to do this.

In addition to this issue, the cross-cultural comparison in the current investigation also establishes that the extent to which cone-contrast governs color preference varies greatly with the people whose color preferences are tested. For example, the cone-contrast model did not significantly predict the color preferences of Himba females. We therefore suggest that Hurlbert and Ling's (2007) cone-contrast model is severely constrained as a universal explanation of color preference.

Hurlbert and Ling (2007) also proposed that there is a "universal" sex difference in how color preferences weight L-M stimulus-background cone-contrast, with females biased toward weighting L-M cone-contrast positively. However, the current study finds no evidence for such a sex difference in Himba color preferences. In fact, for the Himba, the means are in the opposite direction to that predicted by Hurlbert and Ling's theory. The sex differences predicted by Hurlbert and Ling may well be found in the color preferences of other cultures. However, the lack of the difference in Himba color preference suggests that if there is a biological driver for this sex difference, then it would also need to be highly malleable or easily overridden. The lack of a sex difference in how infant color preference weights L-M stimulus-background cone-contrast (Franklin, Bevis, Ling, & Hurlbert, 2010) also undermines the notion that such a sex difference may be "inborn."

In addition, although the current investigation finds a sex difference in how British color preferences weight L-M cone-contrast, British females did not actually weight L-M positively or significantly. Therefore, Hurlbert and Ling's (2007) proposal for a female preference for hues with a "reddish" contrast to the background is not supported by the British color preferences of the current study either. In fact, this preference is not even found in Hurlbert and Ling's own data as, for their British females, the L-M regression weights were slightly positive but not significantly so (see Figure 2C in Hurlbert & Ling, 2007; mean weights are not significantly different to 0). Therefore, we strongly challenge the theory that there is an evolved "universal" sex difference where females but not males prefer "reddish" contrasts. Although Hurlbert and Ling's (2007) cone-contrast model did not predict much variance for either British or Himba color preference, chroma did account for a relatively large amount of the variance in Himba color preference. This relationship between chroma and preference could be because Himba prefer colors that are high in chromatic contrast to the gray background: They like colors that are maximally chromatically different from the context in which they are presented. Alternatively, it could be that they prefer maximally colorful and intense colors irrespective of the context: Color is desirable, and they just want more of it. Either way, the finding suggests that under some circumstances, color preferences are more strongly predicted by perceptual dimensions such as chroma, rather than cone-contrast.

### Color-Object Associations and Color Preference

As established by Taylor and Franklin (2012), the weighted valence of color-object associations positively predicts British color preferences, in line with the predictions of EVT. Also in support of the EVT, the current investigation establishes that the relationship between the WAVE and color preference is culturally specific: Both British and Himba color preferences are most successfully accounted for by the color-object associations from their own culture. However, the current investigation also challenges the EVT, as the relationship between color-object associations and color preference for the Himba was not in line with the EVT's predictions. The relationship between Himba color preference and Himba object valences (weighted or summed) was only significant for males, and the relationship was actually negative. For example, "saturated" chartreuse was associated with several bad things, such as "bad water," "dry grass," and "autumn leaves" (autumn leaves



are not liked as it signals the onset of the barren winter), yet was actually one of the most liked colors. Therefore, contrary to the predictions of EVT, Himba males actually tended to like colors associated with disliked objects, and to dislike colors associated with liked objects. This finding clearly indicates that the EVT does not provide a universal account of color preferences. One possibility is that the EVT can only account for color preferences of consumer-driven object-rich industrialized cultures.<sup>7</sup>

What can explain the negative relationship between object valence and color preference for Himba males? Why would Himba males tend to like colors that are associated with disliked objects? We suggest that the most likely explanation is that this relationship is indirect and is actually due to independent relationships of each of these variables with chroma (chroma and color preference are positively related, and chroma and object valence are negatively related). When chroma is controlled for, little of the relationship between object valence and color preference is left. The Himba may prefer colors of high chroma because they like the extra stimulation, or they may especially value colors of such intensity due to their scarcity in natural chromatic environments. However, it is not clear why the Himba males associated less liked objects with high chroma. What is clear is that these findings indicate that the relationship between color preference and object valence, at least for some groups, is not as simple as the EVT suggests.

### Color Preferences and Universality

As outlined in the introduction, claims of universality pervade color preference research, yet these are based on data from surprisingly few cultures. Here, comparison of British color preferences to the color preferences of people from a nonindustrialized highly distinctive culture, provide no evidence for the "universal" order or pattern of color preference or that certain colors (such as blue) are "universally" or "naturally" liked or disliked. There is also no evidence for "universal" biologically driven sex differences in color preference, such as a sex difference in the weighting of "red-green" cone-contrast. Of course, one could just argue that the different pattern of color preference for the Himba relative to British and other cultures tested previously could simply be because Himba color preferences are an exception to the rule. However, the absence of "universal" color preference patterns in the Himba does suggest that if universal constraints on patterns of color preference do exist, then they would also need to be completely malleable by social, cultural or environmental forces.

Of course, color preferences and their underlying mechanisms may well be universal at some stage in development, and patterns and predictors of color preference could diverge with cultural influence throughout development. Converging evidence suggests that infants prefer to look longer at some colors than others (e.g., Adams, 1987; Bornstein, 1975; Franklin et al., 2008, 2010; Teller, Civan, Bronson-Castain, 2004; Zemach, Chang, & Teller, 2007), and some (e.g., Palmer & Schloss, 2010) have argued that infants' color preferences display some of the so called "universal" characteristics of adult color preferences (such as a preference for blue over yellow). However, the pattern of infant color preference does vary across studies, and it is also not clear that infants' looking preferences are actually a measure of "liking" as opposed to salience (see Franklin, Gibbons, Chittenden, Alvarez, & Taylor, in press, for further discussion). Unfortunately, there have only been

few studies of how color preferences change across development (e.g., Child, Hansen, & Hornbeck, 1968; Dorcus, 1926; Ou, Luo, Sun, Hu, & Chen, 2012; Zentner, 2001), yet these do suggest an influence of culture and socialization. For example, within industrialized cultures, the female preference for pink does appear to emerge at the time that children's behavior becomes sex-stereotyped (e.g., LoBue & DeLoache, 2011). However, there have been no cross-cultural developmental studies of color preference. Such studies may be particularly useful in shedding light on the diversity of patterns and predictors of color preferences in adulthood.

In recent years there has been a quest for finding a model that can provide a universal account for why adults like some colors more than others. In fact, some have even attempted to specify mathematical models of color preference that predict preference on the basis of coordinates in color space (Ou et al., 2004). The strength of both Hurlbert and Ling's (2007) and Palmer and Schloss's (2010) theories is that both allow for individual differences in patterns of color preference. For example, individuals can vary in how they weight cone-contrast, or they can vary in their color-object associations and emotional response to objects. This is important as individuals, groups, and cultures clearly vary in their patterns of color preference. However, the current investigation suggests that not only do patterns of color preference vary, but the underlying mechanisms and dimensions of color preference vary considerably as well. Elements of both Hurlbert and Ling's (2007) and Palmer and Schloss's (2010) models govern Himba color preference, yet not in the ways predicted by their models, and the predictors are different for British and Himba males and females.

We suggest here that there is not one universal explanation for why some colors are liked more than others: The reasons for color preference are fluid and diverse. Some peoples' preferences may be governed by object associations, others by basic psychophysical dimensions, others by biological components of color vision. It will be a challenge for further research to clarify the conditions under which different mechanisms or dimensions govern color preferences, yet there are clear applications of such research to industries such as marketing or product design. Further research on color preference could also provide a greater understanding of both the diversity and the constraint in human's response to color.

<sup>7</sup> The relationship between color-object associations and color preference for the Himba may have been stronger if there were more color-object associations. However, note that even if this were the case, the relationship was still in the opposite direction to that predicted by EVT.

### References

- Adams, R. J. (1987). An evaluation of color preference in early infancy. *Infant Behavior & Development*, 10, 143-150. doi:10.1016/0163-6383(87)90029-4
- Ball, V. K. (1965). The aesthetics of color: A review of fifty years of experimentation. *Journal of Aesthetics & Art Criticism*, 23, 441-452. doi:10.2307/427666
- Bornstein, M. H. (1975). Qualities of color vision in infancy. *Journal of Experimental Child Psychology*, 19, 401-419. doi:10.1016/0022-0965(75)90070-3



- Child, I. L., Hansen, J. A., & Hornbeck, F. W. (1968). Age and sex differences in children's color preferences. *Child Development*, 39, 237–247. doi:10.2307/1127374
- Choungourian, A. (1968). Color preferences and cultural variation. *Perceptual and Motor Skills*, 26, 1203–1206. doi:10.2466/pms.1968.26.3c.1203
- Choungourian, A. (1969). Color preferences: A cross-cultural and cross-sectional study. *Perceptual and Motor Skills*, 28, 801–802.
- DeValois, R. L., & DeValois, K. (1975). Neural coding of color. In E. Carterette, & M. Friedman (Eds.), *Handbook of perception* (Vol. 5, pp. 117–166). New York, NY: Academic Press.
- Dominy, N. J., & Lucas, P. W. (2001). Ecological importance of trichromatic vision to primates. *Nature*, 410, 363–366. doi:10.1038/35066567
- Dorcus, R. M. (1926). Color preferences and color associations. *The Pedagogical Seminary and Journal of Genetic Psychology*, 33, 399–434.
- Eskew, R. T., McLellan, J. S., & Giulianini, F. (1999). Chromatic detection and discrimination. In K. R. Gegenfurtner, & L. T. Sharpe (Eds.), *Color vision: From genes to perception* (pp. 345–368). Cambridge, England: Cambridge University Press.
- Eysenck, H. J. (1941). A critical and experimental study of color preferences. *The American Journal of Psychology*, 54, 385–394. doi:10.2307/1417683
- Fancher, R. E. (1996). *Pioneers of psychology*. New York, NY: Norton.
- Fletcher, R. (1981). *City Colour Vision Test*. Windsor, England: Keeler.
- Franklin, A., Bevis, L., Ling, Y., & Hurlbert, A. (2010). Biological components of colour preference in infancy. *Developmental Science*, 13, 346–354. doi:10.1111/j.1467-7687.2009.00884.x
- Franklin, A., Gibbons, E., Chittenden, K., Alvarez, J., & Taylor, C. (in press). Infant color preference for red is not selectively context specific. *Emotion*. doi:10.1037/a0025333
- Franklin, A., Pitchford, N. J. P., Mahony, L., Davies, I. R. L., Clausse, S., & Jennings, S. (2008). Salience of primary and secondary colours in infancy. *British Journal of Developmental Psychology*, 26, 471–483. doi:10.1348/026151007X256672
- Fushikida, W., Schloss, K., Yokosawa, K., & Palmer, S. (2009). Cross-cultural differences in color preference: Japan vs. the USA. *Journal of Vision*, 9, 336. doi:10.1167/9.8.336
- Guilford, J. P., & Smith, P. C. (1959). A system of color-preferences. *The American Journal of Psychology*, 72, 487–502. doi:10.2307/1419491
- Hogg, J. (1969). A principal components analysis of semantic differential judgments of single colors and color pairs. *Journal of General Psychology*, 80, 129–140. doi:10.1080/00221309.1969.9711279
- Hurlbert, A. C., & Ling, Y. (2007). Biological components of sex differences in color preference. *Current Biology*, 17, R623–R625. doi:10.1016/j.cub.2007.06.022
- Jameson, K. A., & D'Andrade, R. G. (1997). It's not really red, green, yellow, blue: An inquiry into perceptual color space. In C. L. Hardin, & L. Maffi (Eds.), *Color categories in thought and language* (pp. 295–319). Cambridge, England: Cambridge University Press.
- Ling, Y. L., & Hurlbert, A. C. (2009). A new model for color preference: Universality and individuality. In *15th Color Imaging Conference final program and proceedings* (pp. 8–11). Springfield, VA: Society for Imaging Science and Technology.
- LoBue, V., & DeLoache, J. S. (2011). Pretty in pink: The early development of gender-stereotyped colour preferences. *British Journal of Developmental Psychology*, 29, 656–667.
- Osorio, D., & Vorobyev, M. (1996). Color vision as an adaptation to frugivory in primates. *Proceedings of the Royal Society B*, 263, 593–599. doi:10.1098/rspb.1996.0089
- Ou, L.-C., Luo, M. R., Sun, P.-L., Hu, N.-C., & Chen, H.-S. (2012). Age effects on colour emotion, preference, and harmony. *Color Research & Application*, 37, 92–105. doi:10.1002/col.20672
- Ou, L.-C., Luo, M. R., Sun, P.-L., Hu, N.-C., Chen, H.-S., Guan, S.-S., . . . Richter, K. (2012). A cross-cultural comparison of colour emotion for two-colour combinations. *Color Research & Application*, 37, 23–43. doi:10.1002/col.20648
- Ou, L.-C., Luo, M. R., Woodcock, A., & Wright, A. (2004). A study of colour emotion and colour preference. Part III: Colour preference modelling. *Color Research and Application*, 29, 381–389. doi:10.1002/col.20047
- Palmer, S. E., & Schloss, K. B. (2010). An ecological valence theory of human color preference. *PNAS Proceedings of the National Academy of Sciences of the United States of America*, 107, 8877–8882. doi:10.1073/pnas.0906172107
- Palmer, S. E., & Schloss, K. B. (2011). Ecological valence and theories of human color preference. In C. P. Biggam, C. Hough, C. J. Kay, & D. R. Simmons (Eds.), *New directions in colour studies* (pp. 361–376). Amsterdam, the Netherlands: John Benjamins.
- Saito, M. (1994). A cross-cultural study on color preference in three Asian cities: Comparison between Tokyo, Taipei and Tianjin. *Japanese Psychological Research*, 36, 219–232.
- Saito, M. (1996). A comparative study of color preferences in Japan, China and Indonesia, with emphasis on the preference for white. *Perceptual and Motor Skills*, 83, 115–128. doi:10.2466/pms.1996.83.1.115
- Schloss, K. B., Poggesi, R. M., & Palmer, S. E. (2011). Effects of university affiliation and "school spirit" on color preferences: Berkeley vs. Stanford. *Psychonomic Bulletin & Review*, 18, 498–504.
- Smith, V. C., & Pokorny, J. (1975). Spectral sensitivity of the foveal cone photopigments between 400 and 500 nm. *Vision Research*, 15, 161–171.
- Stockman, A., & Sharpe, L. T. (1999). Cone spectral sensitivities and color matching. In K. R. Gegenfurtner, & L. T. Sharpe (Eds.), *Color vision: From genes to perception* (pp. 53–89). Cambridge, England: Cambridge University Press.
- Sumner, P., & Mollon, J. D. (2000). Chromaticity as a signal of ripeness in fruits taken by primates. *Journal of Experimental Biology*, 203, 1987–2000.
- Taylor, C., & Franklin, A. (2012). The relationship between color-object associations and color preference: Further investigation of ecological valence theory. *Psychonomic Bulletin & Review*. doi:10.3758/s13423-012-0222-1
- Teller, D. Y., Civan, A., & Bronson-Castain, K. (2004). Infants' spontaneous color preferences are not due to adult-like brightness variations. *Visual Neuroscience*, 21, 397–401. doi:10.1017/S0952523804213360
- Zemach, I., Chang, S., & Teller, D. Y. (2007). Infant color vision: Prediction of infants' spontaneous color preferences. *Vision Research*, 47, 1368–1381. doi:10.1016/j.visres.2006.09.024
- Zentner, M. R. (2001). Preferences for colours and colour-emotion combinations in early childhood. *Developmental Science*, 4, 389–398. doi:10.1111/1467-7687.00180

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