Journal of the Optical Society of America A
OPTICS, IMAGE SCIENCE, AND VISION

Color preferences of Western females with art education

Patrícia M. H. Oliveira,[1] João M. M. Linhares,[1] Claudia Feitosa-Santana,[2] and Sérgio M. C. Nascimento[1,*]

[1]Physics Center of Minho and Porto Universities (CF-UM-UP), Gualtar Campus, University of Minho, 4710-057 Braga, Portugal
[2]Neuroscience for Human Development, São Paulo, Brazil
*smcn@fisica.uminho.pt

Received 22 December 2024; revised 13 March 2025; accepted 17 March 2025; posted 18 March 2025; published 16 April 2025

The goal of this study was to investigate whether Western females with art education have different color preferences compared to those without such education. Forty-six physical samples from the Natural Color System were used in the experiments. Fifty participants without art education, half females, and 45 females with university-level art education carried out the experiment. They viewed each colored sample isolated, in random order, and rated how much they liked or disliked the color using a scale from −10 to +10. For participants without art education, the results followed the typical preference pattern: a higher preference for blue and a lower preference for dark yellow, with expected variations based on sex. Compared to females without art education, those with art education rated the samples much more evenly across hues and lightness levels, with less tendency to overrate samples in the red–purple hue range. Overall, these findings imply that, at least for Western females, art education is associated with distinct and more uniform color preferences.

https://doi.org/10.1364/JOSAA.553844

1. INTRODUCTION

Humans can abstract color from objects, enabling the evaluation of how much a color is liked or disliked. Although the quantitative study of color preference has a long history [1–3], the idea that preference is determined by the physical properties of the light reaching the eye is relatively recent [4,5]. Modern psychophysics has shown that color preferences can be quantified, are partially predictable, and can be quantitatively modeled (for reviews, see Refs. [3] and [6]).

For normal trichromats, there is a universal tendency to like blues and dislike dark yellows [6–8]. For dichromats, however, the strong preference is for yellow and the weaker preference is for blue [9]. There are marked cross-cultural differences in color preferences [10–13] as well as sex differences [10,12,14,15]. In Western adults, males tend to prefer more saturated colors [14] and females tend to prefer more pinks and reds [10,12]. Color preferences also change with age [16–20], evolve over time within the same society [21], and are influenced by the seasons [22]. A preference for specific colors is not limited to humans, and it has also been observed in monkeys [23–25].

Preferences can be associated with ecological experience [8,26] and, at a physiological level, with cone contrast weights [12], although none of these models fully explain the variations observed in color preference. Brain activity is known to be modulated by color preferences [27] but the degree to which they are hard wired or acquired is still unclear [3].

One underexplored aspect of color preference is whether individuals with art education exhibit a different pattern of preferences compared to those without such education. Using the ordering of colors by preference, no effect of art education was found among 500 college students [28]. There is, however, evidence of significant relationships between educational background and color preferences in general and in practical situations, e.g., selecting colors for the living room or buildings [29–31]. With regard to education level, one study suggests that university-educated subjects tend to prefer blue more frequently than vocational-level subjects, who show a higher preference for light green and pink [30]. Another study suggests that architects tend to select yellow as the most liked color for buildings, while nonarchitects tend to select blue [31]. Color preferences also seem to partly depend on personality [32,33].

Research using comprehensive and accurate techniques to evaluate the influence of art education on single-color preferences is lacking. We hypothesized that individuals with art education have different color preferences due to the influence of their training or inherent artistic personality traits. For complex color compositions, artists understand which chromatic compositions appeal to viewers' preferences [34,35], but it remains unclear whether their personal color preferences for individual colors align with those of the general public.

The aim of this study was to explore whether art education influences color preferences among females. We compared the preferences of females with art education to a sample of females and males without such education. We found that females with art education exhibit less variability in color preferences compared to those without this background.

2. METHODS

Although color preference experiments often use monitor screens [8,9], we used colored physical samples to overcome the constraints imposed by displaying colors on a monitor screen.

A. Colored Samples

Forty-six colored samples were selected from the Natural Color System (NCS) [36]. The samples are listed in Table S1 of Supplement 1. They represent 10 hues spanning the entire hue circle, two colorfulness levels, and three lightness levels. In this study, the hue perceptual dimension is represented categorically rather than numerically to maintain consistency with previous research on color preference. Colorfulness and lightness are used as defined in the CAM02-UCS color space (see below). There were four approximate unique hues (Red, Green, Yellow, and Blue) and six intermediate hues (Orange, Chartreuse, Cyan, Violet, Purple, and Pink). The underlined letters are used to denote the hues throughout the paper. Three samples were achromatic: white, mid-gray, and black, represented by W, G, and B, respectively. The selection is similar to the Berkeley Color Project (BCP) 37 [22] used in other reference studies on color preference [8,9,11,22,37], whose samples were also selected according to the dimensional structure of the NCS. The main differences include the two additional hues, pink and violet, three additional samples with high colorfulness and high lightness, and the exclusion of two achromatic samples. Additionally, this set exhibits less lightness variation across each set of hues.

The samples were created as solid square patches of 3 cm × 3 cm, making them easy to manipulate. The spectral reflectance functions of the samples were measured with a Konica Minolta CM-2600d spectrophotometer [38], and their representation in the color space CAM02-UCS [39] was computed assuming the illumination from the light measured from the Solux lamps used in the experiments (see below). These computations followed the guidelines outlined in the Technical Report CIE 015:2018 [39], using parameters tailored to the evaluation of small surface colors in a controlled light booth environment. The parameters included the CIE 1931 standard colorimetric observer, a white standard at the center of the observation board with a luminance of 276 cd/m^2 as the white reference, a gray board with a luminance of 138 cd/m^2 as the background, an "average" surround condition, and full adaptation ($D = 1$). Figure 1 shows the sRGB colors of the samples, and Fig. 2 shows their representation in the CAM02-UCS color space. Table S1 lists the coordinates J', a'_M, and b'_M of the colors in that color space. The sRGB values were computed from the tristimulus values obtained by combining the spectral

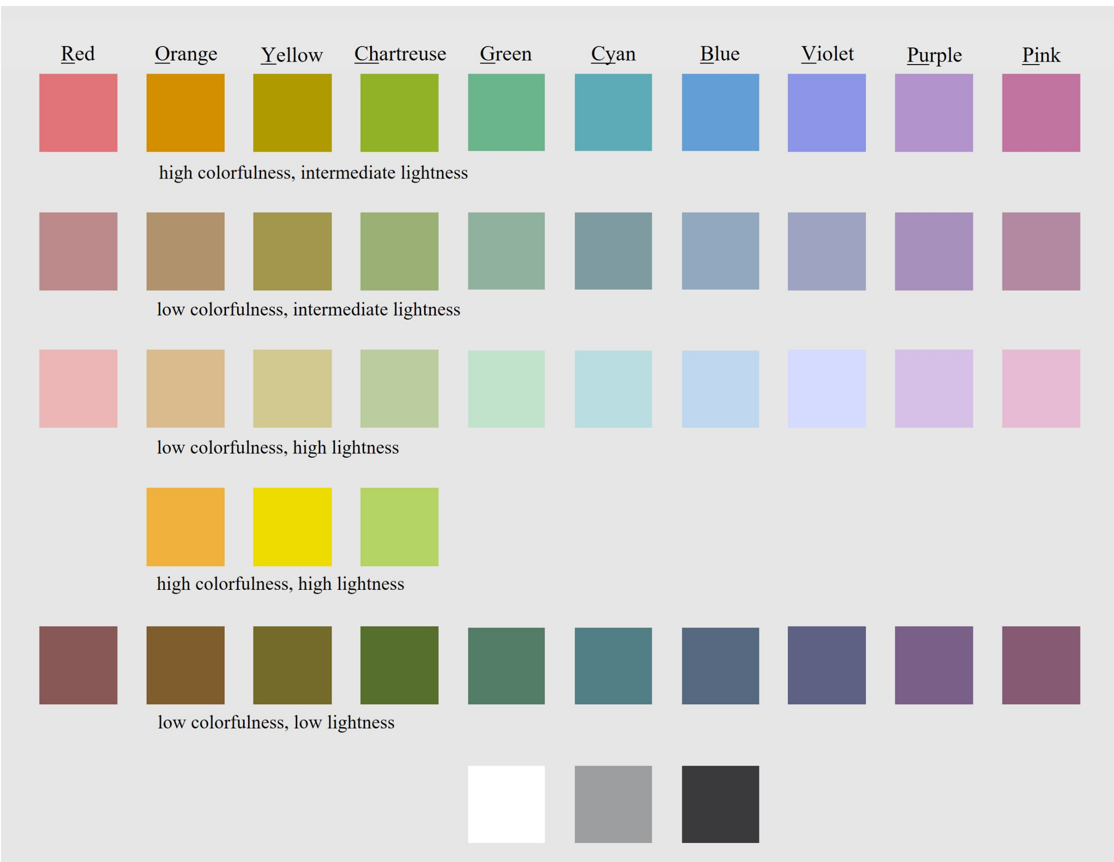

Fig. 1. sRGB representation of the 46 NCS samples used in the experiment. The colors were computed assuming the spectrum of the light source of the experimental setup.

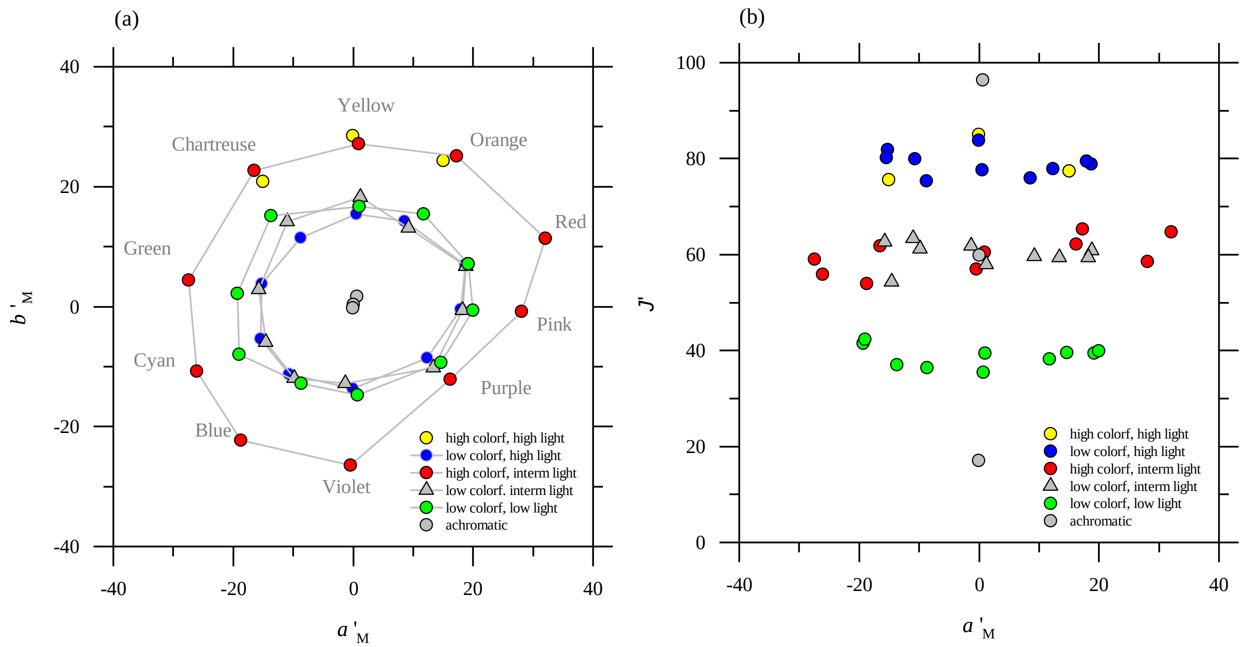

Fig. 2. Colors of the 46 samples represented in the color space CAM02-UCS. The colors were computed assuming the spectrum of the light source of the experimental setup.

reflectance functions with the effective illumination on the samples, using this spectrum as the white point.

B. Experimental Setup

The experimental setup is illustrated schematically in Fig. 3. Experiments were conducted in a dark room, with the only illumination provided by the light sources directed at the samples. The samples were displayed on a gray board (28 cm × 40 cm) horizontally positioned on a table. The board was painted with gray paint corresponding to the Munsell N7 spectrum (VeriVide Limited, Leicester LE19 4SG UK) and illuminated by two Solux lamps (Tailored Lighting, Inc., Rochester, NY) with nominal correlated color temperature (CCT) of 4700 K. To improve light uniformity on the board, two diffusers (Lamp Sock Soft Diffuser 18 cm from Honoson) were used, one in each lamp. The spectra of the lamps with and without the diffuser are shown in Fig. 4. The actual spectrum of the lamps with diffusers mounted was measured using a telespectroradiometer (SpectraRadiometer, PR-650, Photo Research Inc., Chatsworth, California), and all colorimetric computations were based on this spectrum. The lights with diffuser delivered daylight with a CCT of 3240 K. Using daylight with a higher color temperature would result in only minimal color differences, barely distinguishable from those produced under the current illumination. For instance, daylight with a CCT of 5000 K (D50) would yield colors with an average Euclidean difference of just 2 in the CAM02-UCS color space. The Solux lamps were placed at 40 cm from the board. In this condition, illuminance was 840 lux at the center and varied less than 10% over the area where the samples were viewed during the experiment. Observers sat at the table such that the viewing distance was about 50 cm.

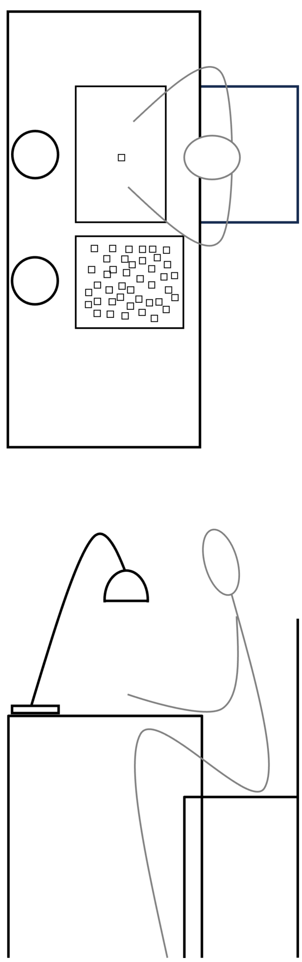

Fig. 3. Diagram of the experimental setup.

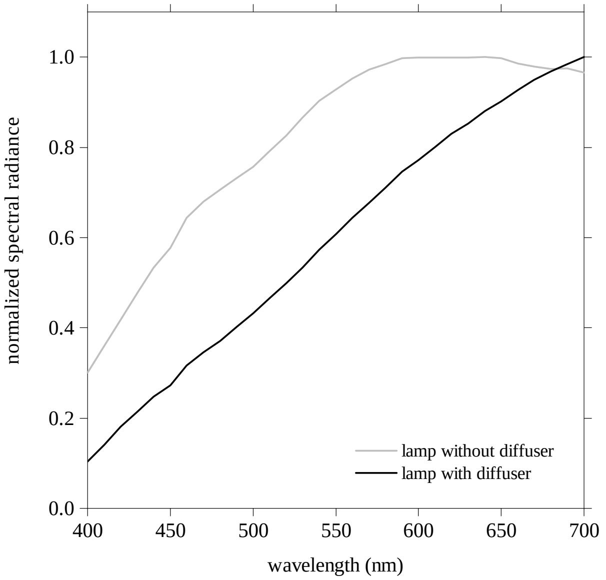

Fig. 4. Spectra of the lamps with and without the diffuser.

C. Procedure

Observers rated how much they liked or disliked each color. The rating was carried out by pointing to a ruler located at the bottom of the board with a scale from −10 to +10. Prior to the experiment, observers did an anchoring procedure (see Ref. [6]): they saw all the colors in a tray and were instructed to pick the one they liked the most and the one they liked the least. This procedure, along with the preliminary testing using Ishihara plates, was conducted under the experimental light source and took approximately 5 min, allowing participants to adapt to the illumination. They were then informed that the extremes of the rating scale corresponded to the two samples selected. The experimenter then placed each color sample one by one in random order at the center of the board, and observers were instructed to rate how much they liked or disliked each color sample by pointing to the corresponding position on the ruler.

D. Observers

One hundred participants, all of Western origin, took part in the experiment. For the group without art education, there were 50 participants—half of whom were female—primarily students from the University of Minho, Portugal. The average age of females and males in this group was 22 ± 3 years (ranging from 18 to 30) and 22 ± 4 years (ranging from 18 to 33), respectively. There was no statistically significant difference in age between females and males. The inclusion criterion was no formal education in arts. They did the experiment at the Color Science Laboratory of the University of Minho.

For the group with art education, there were 50 participants, 45 of whom were females, each having received some form of art education at the university level. The average age of females and males in this group was 23 ± 5 years (ranging from 18 to 42) and 36 ± 13 years (ranging from 21 to 52), respectively. There was no statistically significant difference in age between females with and without art education. They were enrolled in bachelor's, master's, or PhD programs in painting, drawing, design, or other related art fields. They were mainly students from the Faculty of Fine Arts at the University of Lisbon, where they did the experiment. Students typically receive a maximum of one semester of instruction on color, covering a diverse range of topics. These include the historical and cultural uses of color and pigments and occasional introductions to human color vision. Examples are color theories (e.g., Goethe's, Newton's, Da Vinci's, Hering's, and Helmholtz's), color systems (e.g., CIE's, Chevreul's, and Munsell's), color vision from light to perception, color mixing for light and pigment, color harmony (e.g., Chevreul's laws and Albers's principles), and historical perspectives on color in art and its evolution.

Given the imbalance in sex and age within the group, the results for participants with art education focus exclusively on the 45 female participants. This imbalance aligns with the observation that the majority of students in art-related fields are females. Data for males with art education are presented in S3 and S4 of Supplement 1 and are briefly addressed in Section 4.

All participants had normal or corrected-to-normal visual acuity and normal color vision as assessed by Ishihara plates (38 plates edition, Kanehara & Co., Ltd., Tokyo, Japan). The experiment protocol respects the Declaration of Helsinki (1964, World Medical Association) and was approved by the Comissão de Ética para a Investigação em Ciências da Vida e da Saúde (CEICVS 052/2021) of the University of Minho. All participants signed the informed consent prior to the experiment.

3. RESULTS

Figure 5 shows the average ratings across the 50 observers without art education. Error bars represent the confidence intervals obtained with bootstrapping, with 1000 iterations [40]. The duration of the experiment was on average 9 ± 2 min across observers, with no significant sex differences. The general pattern of results is typical for Western populations [8,9,11,22,37]. Blue is the preferred color for all lightness and colorfulness levels, while yellows with low and intermediate lightness are the least liked. White and black are rated highly and are preferred over gray.

Figure 6 shows the data from Fig. 5, segmented by sex for the 25 males and 25 females. For the chromatic samples, each panel represents the data for a specific level of colorfulness and lightness, as indicated. Error bars represent the confidence intervals obtained with bootstrapping, with 1000 iterations [40]. Significant differences between males and females obtained by the two-sided Wilcoxon test are signaled with an asterisk. There are systematic differences for the red [Fig. 6(a), $p = 0.0440$, Fig. 6(b), $p = 0.0001$, and Fig. 6(c), $p = 0.0307$], purple [Fig. 6(b), $p = 0.0003$, Fig. 6(c), $p = 0.0027$, and Fig. 6(e), $p = 0.0401$], and pink samples [Fig. 6(b), $p = 0.0000$, Fig. 6(c), $p = 0.0003$, and Fig. 6(e), $p = 0.0110$], these being rated higher by females. Dark yellows [Figs. 6(a), 6(b), and 6(e)] are the least liked by both groups. Blue is the most liked by males [Figs. 6(a), 6(b), 6(c), and 6(e)], whereas red [Figs. 6(a) and 6(b)], purple, and pink [Fig. 6(e)] tend to be the most liked by females. Males tend to prefer more saturated colors than females, particularly, for yellow ($p = 0.0052$) and blue ($p = 0.0263$), but not for purple ($p = 0.0401$) and pink

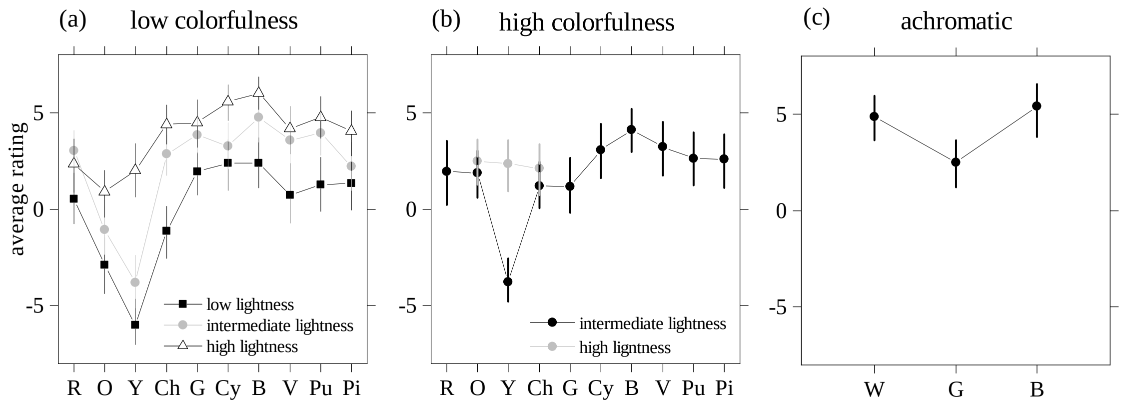

Fig. 5. Average rating for the 50 observers without art education. Error bars represent the confidence intervals obtained with bootstrapping, with 1000 iterations.

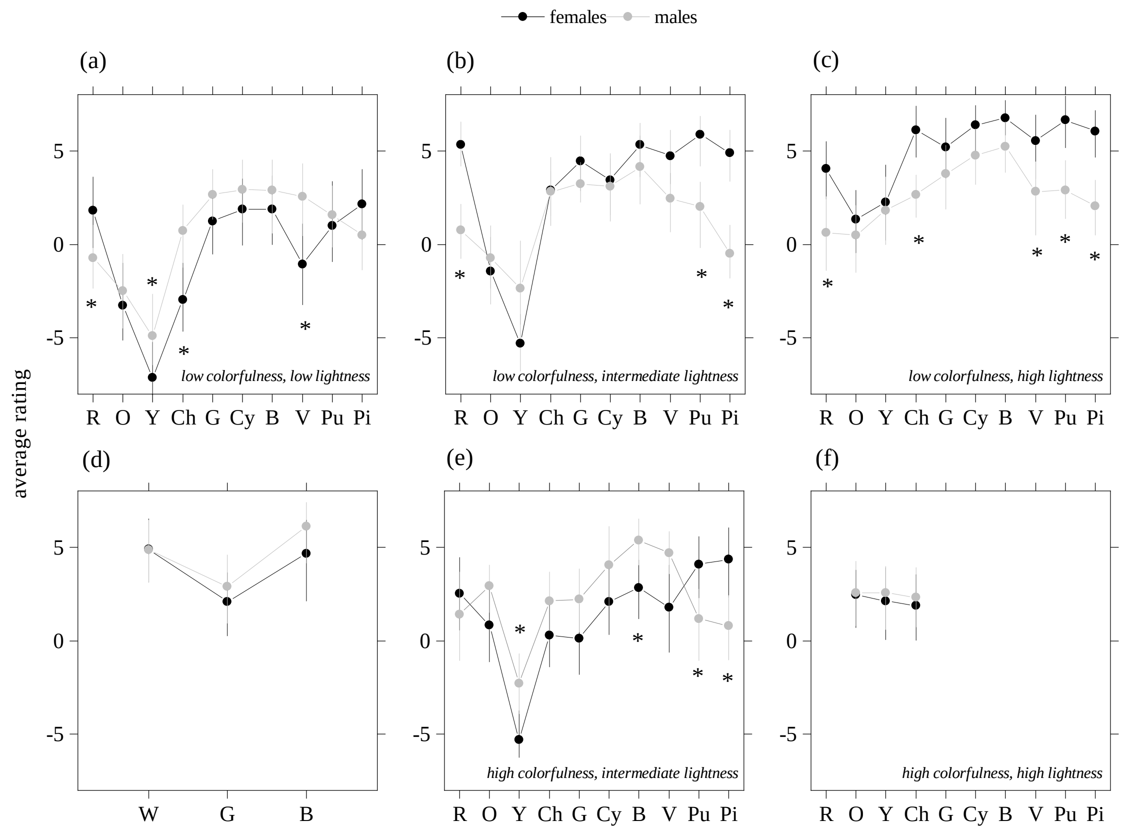

Fig. 6. Average rating for the 25 males and 25 females without art education. For the chromatic samples, each panel represents the data for a specific level of colorfulness and lightness, as indicated. Error bars represent the confidence intervals obtained with bootstrapping, with 1000 iterations. Significant differences between males and females are signaled with an asterisk.

($p = 0.0110$). The pattern of preferences for males is more uniform than that of females (see also Fig. 8). No significant differences between females and males were observed for the achromatic samples. More detailed statistical data are presented in S2 of Supplement 1. These results reveal significant sex differences that are largely consistent with those found in previous studies [12,41].

Figure 7 compares, in the same format as Fig. 6, the average ratings across the 45 females with art education to those of the 25 females represented in Fig. 6. Error bars represent the confidence intervals obtained with bootstrapping, with 1000 iterations [40]. No significant differences in the duration of the experiments were found between the two groups of females. Significant differences obtained by the two-sided Wilcoxon test are signaled with an asterisk. There are systematic differences for the red [Fig. 7(b), $p = 0.0175$, Fig. 7(c), $p = 0.0010$, and Fig. 7(e), $p = 0.0038$] and pink [Fig. 7(b), $p = 0.0243$, Fig. 7(c), $p = 0.0001$, and Fig. 7(e), $p = 0.0086$], which were rated lower by females with art education, and yellow samples [Fig. 7(a), $p = 0.0001$, Fig. 7(b), $p = 0.0235$, and Fig. 7(e), $p = 0.0199$], which were rated higher by females with art education. Females with art education rated low lightness samples

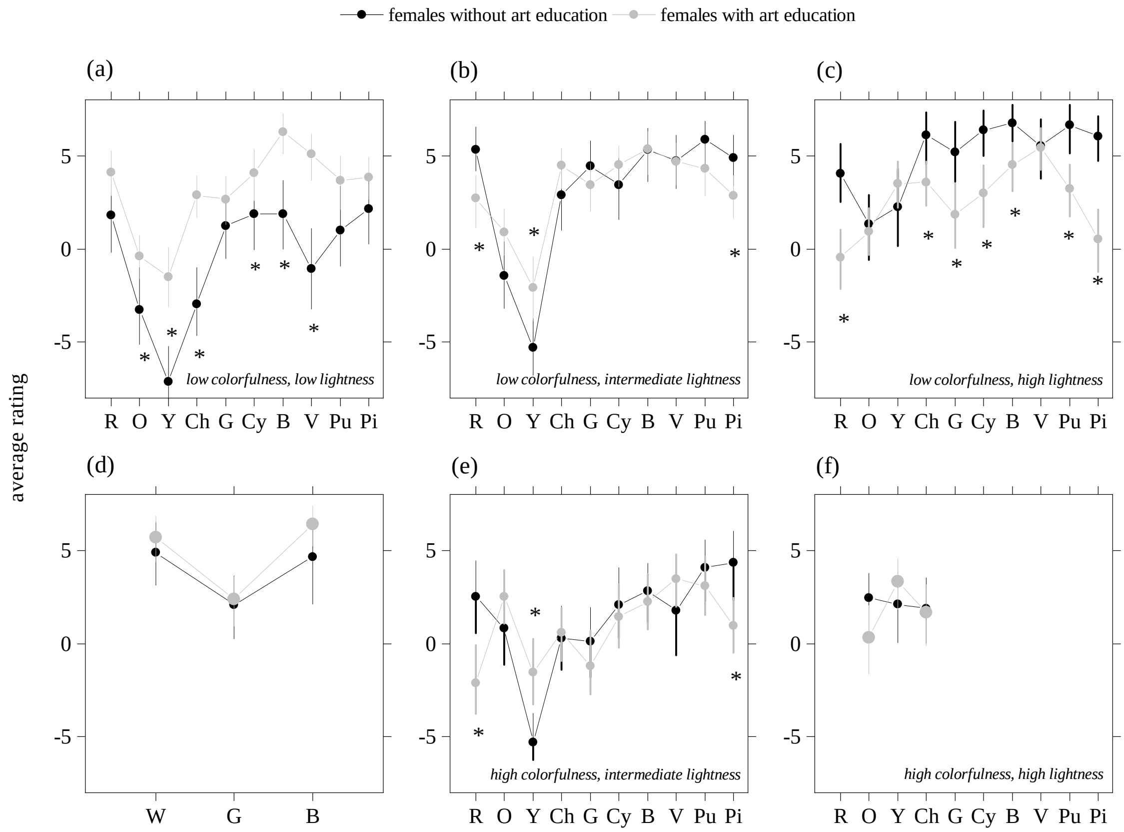

Fig. 7. Average rating for the 45 females with art education and 25 females without art education. For the chromatic samples, each panel represents the data for a specific level of colorfulness and lightness, as indicated. Error bars represent the confidence intervals obtained with bootstrapping, with 1000 iterations. Significant differences are signaled with an asterisk.

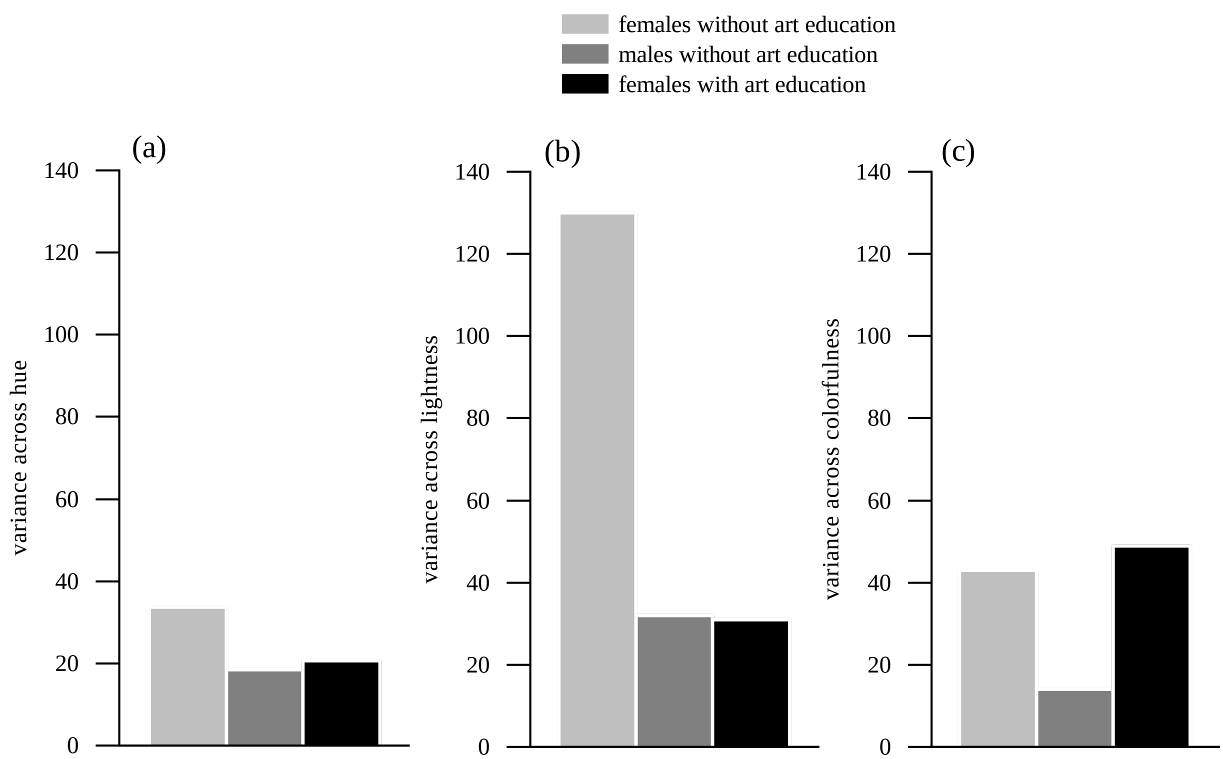

Fig. 8. Variance of the ratings across hue (a), lightness (b), and colorfulness (c). Data were represented for the 25 females and 25 males without art education and the 45 females with art education.

higher [Fig. 7(a)] and high lightness samples lower [Fig. 7(c)]. They also rated the samples more uniformly across hues (see also Fig. 8), with a less tendency to overrate red, purple, and pink samples. No significant differences were obtained for achromatic samples [Fig. 7(d)] or for samples with high colorfulness and high lightness [Fig. 7(f)]. More detailed statistical data are presented in S2 of Supplement 1.

Figure 8 shows the variance of the ratings across hues, lightness, and colorfulness. Data were represented for the 25 females and 25 males without art education and for the 45 females with art education. Females without art education exhibit greater variance than males without art education across all three dimensions. Additionally, they show markedly higher variance in hue and lightness compared to females with art education.

4. DISCUSSION

This study reports preference ratings for single colors in a balanced sample of males and females without art education, as well as in a sample of females with art education. Art education was considered formal enrolment in university-level art courses, e.g., painting, conservation and restoration, and art history. The ratings obtained from individuals without art education are similar to those reported using a comparable sample and technique [8]. For all lightness and colorfulness levels, blue is the favorite for the whole sample. Dark and intermediate lightness yellows are the least preferred. Also consistent with a previous study [9], white and black are highly rated, and gray a bit less.

A comparison between females and males revealed significant differences, particularly in the reds, purples, and pinks, with females rating these hues higher than males. Similar sex differences have been reported in other studies [10,12,14,42]. Females with art education revealed significant differences from those without. They tend to rate colors more uniformly across lightness and hues with less tendency to overrate red, purple, and pink.

The method employed here involved the individual sample ratings, preceded by a preliminary anchoring procedure. While there is some debate about how this methodology compares to pairwise color comparisons [15], both techniques yield similar results [43]. The selection of colored samples was based on the NCS standard color set, which is known to represent natural colors better than the Munsell set [38]. Furthermore, the samples were physical rather than colors displayed on a monitor screen. These particularities of the methodology did not seem to interfere with the results as they show high compatibility with previous data.

Adaptation to the lighting conditions lasted approximately 5 min before the experimental procedure began, ensuring full or near-full chromatic adaptation. More than 50% of the total color appearance to a steady background is known to take place by a mechanism with a half-life of 10 ms [44]. Even for complex images, adaptation is almost complete after a few seconds [45]. Although the color appearance of the samples varies with the chromatic composition of the light source, color constancy mechanisms under full adaptation minimize these changes perceptually. This was estimated by comparing the colors under the experimental illumination to those under the standard illuminant D50 in the CAM02-UCS color space (see Section 2). Using a different light source, particularly one with a higher color temperature, may influence color preferences for individual samples. However, given the minimal changes in appearance, the overall impact is unlikely to be significant.

Another point to consider is whether the experimental setup and procedures were consistent for the two groups tested: those with and those without art education. Although the individuals without art education were tested at the Color Science Laboratory of the University of Minho and those with art education at the Faculty of Fine Arts of the University of Lisbon, the equipment, procedure, and experimenter were the same which rules out any undesirable methodological asymmetries. Additionally, our study did not investigate whether females without formal art education were art enthusiasts or amateur painters. However, the magnitude of those potential influences is not substantial enough to overshadow the effects of formal art education.

It is well known that hue preferences vary more among females than males, with a bias toward red or pink [12] even in industrialized non-Western cultures [10,13]. Such dimorphism seems to generalize even to remote, non-industrialized cultures [42]. These sex differences have been related to evolution in the context of the hunter–gatherer theory, which proposes that females should be optimized for gathering ripe red fruits and berries [12]. The ecological valence theory, which associates color preference with affective responses to color-associated objects [8], has been tested in sex differences with little success [37].

The data presented here suggest that art education influences females' color preferences, promoting a more balanced distribution across the perceptual dimensions of hue and lightness. What may explain this effect?

Art education seeks to balance foundational knowledge and the encouragement of creativity. The reduced variations in color preferences across perceptual dimensions such as lightness and hue, as observed in our results (Fig. 8), likely reflect these dual objectives. On the one hand, exposure to diverse color theories, historical and aesthetic paradigms, and practical applications within the curriculum may foster a more uniform appreciation of the entire color palette. On the other hand, greater consistency in aesthetic values across colors may provide artists with more freedom in their creative use of color. Although this study did not include a comparable sample of males with art education, it is reasonable to expect that the effects observed here may also apply to males, an assumption that is consistent with the limited data obtained for males (see S3 and S4 of Supplement 1).

One could argue that art education nurtures a deeper understanding of colors as tools for expression, which may moderate extreme preferences or aversions to certain colors. On the other hand, females who pursue art education may already exhibit more uniform color preferences due to their artistic personality traits. Whatever the reason, these findings imply that, at least for Western females, art education is associated with distinct and more uniform color preferences.

Funding. Fundação para a Ciência e a Tecnologia (UIDB/04650: Physics Center of Minho and Porto Universities (CF-UM-UP), 26/ECUM/CFUM/2022).

Acknowledgment. We are grateful to the Faculty of Fine Arts at the University of Lisbon and to Professor Ana Bailão for providing access to their facilities.

Disclosures. The authors declare no conflicts of interest.

Data availability. Data may be obtained from the authors upon reasonable request.

Supplemental document. See Supplement 1 for supporting content.

REFERENCES

1. J. Cohn, "Experimentelle Untersuchungen über die Gefühlsbetonung der Farben, Helligkeiten und ihrer Kombinationen," Philos. Stud. Bd. X. S. **10**, 562–603 (1894).
2. H. J. Eysenck, "A critical and experimental study of colour preferences," Am. J. Psychol. **54**, 385 (1941).
3. A. Hurlbert and A. Owen, "Biological, cultural, and developmental influences on color preferences," in *Handbook of Color Psychology*, A. J. Elliot, M. D. Fairchild, and A. Franklin, eds., Cambridge Handbooks in Psychology (Cambridge University Press, 2016), pp. 454–478.
4. G. W. Granger, "An experimental study of colour preferences," J. Gen. Psychol. **52**, 3–20 (1955).
5. G. W. Granger, "Objectivity of colour preferences," Nature **170**, 778–780 (1952).
6. S. E. Palmer, K. B. Schloss, and J. Sammartino, "Visual aesthetics and human preference," Annu. Rev. Psychol. **64**, 77–107 (2013).
7. J. P. Guilford and P. C. Smith, "A system of color-preferences," Am. J. Psychol. **72**, 487–502 (1959).
8. S. E. Palmer and K. B. Schloss, "An ecological valence theory of human color preference," Proc. Natl. Acad. Sci. U. S. A. **107**, 8877–8882 (2010).
9. L. Álvaro, H. Moreira, J. Lillo, *et al.*, "Color preference in red-green dichromats," Proc. Natl. Acad. Sci. U. S. A. **112**, 9316–9321 (2015).
10. V. Bonnardel, S. Beniwal, N. Dubey, *et al.*, "Gender difference in color preference across cultures: an archetypal pattern modulated by a female cultural stereotype," Color Res. Appl. **43**, 209–223 (2018).
11. C. Taylor, A. Clifford, and A. Franklin, "Color preferences are not universal," J. Exp. Psychol. Gen. **142**, 1015–1027 (2013).
12. A. C. Hurlbert and Y. Ling, "Biological components of sex differences in color preference," Curr. Biol. **17**, R623–R625 (2007).
13. M. Saito, "Comparative studies on color preference in Japan and other Asian regions, with special emphasis on the preference for white," Color Res. Appl. **21**, 35–49 (1996).
14. I. L. Child, J. A. Hansen, and F. W. Hornbeck, "Age and sex differences in children's color preferences," Child Dev. **39**, 237 (1968).
15. D. Jonauskaite, N. Dael, L. Chèvre, *et al.*, "Pink for girls, red for boys, and blue for both genders: colour preferences in children and adults," Sex Roles **80**, 630–642 (2019).
16. M. Dittmar, "Changing colour preferences with ageing: a comparative study on younger and older native Germans aged 19–90 years," Gerontology **47**, 219–226 (2001).
17. Y. Ling and A. Hurlbert, "Age-dependence of colour preference in the U.K. population," in *New Directions in Colour Studies* (2011), pp. 347–360.
18. W.-Y. Lee, S.-M. Gong, and C.-Y. Leung, "Is color preference affected by age difference," Int. Assoc. Soc. Des. Res., 1837–1846 (2009).
19. G. M. Press, "Color preference according to age," Am. J. Psychol. **35**, 79–87 (1924).
20. C. Taylor, K. Schloss, S. E. Palmer, *et al.*, "Color preferences in infants and adults are different," Psychon. Bull. Rev. **20**, 916–922 (2013).
21. A. Nemcsics and J. Takács, "Change in colour preference in 50 years duration and its dependence on age," Color Res. Appl. **44**, 622–629 (2019).
22. K. B. Schloss, R. Nelson, L. Parker, *et al.*, "Seasonal variations in color preference," Cogn. Sci. **41**, 1589–1612 (2017).
23. N. Humphrey, "Colour and brightness preferences in monkeys," Nature **229**, 615–617 (1971).
24. N. K. Humphrey, ""Interest" and "pleasure": two determinants of a monkey's visual preferences," Perception **1**, 395–416 (1972).
25. P. Skalníková, D. Frynta, A. Abramjan, *et al.*, "Spontaneous color preferences in rhesus monkeys: what is the advantage of primate trichromacy?" Behav. Processes **174**, 104084 (2020).
26. K. B. Schloss, D. Hawthorne-Madell, and S. E. Palmer, "Ecological influences on individual differences in color preference," Attention, Perception, Psychophys. **77**, 2803–2816 (2015).
27. C. Racey, A. Franklin, and C. M. Bird, "The processing of color preference in the brain," Neuroimage **191**, 529–536 (2019).
28. M. W. St. George, "Color preferences of college students with reference to chromatic pull, learning, and association," Am. J. Psychol. **51**, 714–716 (1938).
29. I. M. Hanafy and R. Sanad, "Colour preferences according to educational background," Procedia - Soc. Behav. Sci. **205**, 437–444 (2015).
30. I. Bakker, T. Van Der Voordt, P. Vink, *et al.*, "Color preferences for different topics in connection to personal characteristics," Color Res. Appl. **40**, 62–71 (2015).
31. E. Cubukcu and I. Kahraman, "Hue, saturation, lightness, and building exterior preference: an empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgments," Color Res. Appl. **33**, 395–405 (2008).
32. J. Jue and J. H. Ha, "Exploring the relationships between personality and color preferences," Front. Psychol. **13**, 1–8 (2022).
33. A. K. Fetterman, T. Liu, and M. D. Robinson, "Extending color psychology to the personality realm: interpersonal hostility varies by red preferences and perceptual biases," J. Pers. **83**, 106–116 (2015).
34. S. M. C. Nascimento, J. M. M. Linhares, C. Montagner, *et al.*, "The colors of paintings and viewers' preferences," Vision Res. **130**, 76–84 (2017).
35. S. Nakauchi, T. Kondo, Y. Kinzuka, *et al.*, "Universality and superiority in preference for chromatic composition of art paintings," Sci. Rep. **12**, 1–12 (2022).
36. A. Hård and L. Sivik, "NCS—natural color system: a Swedish standard for color notation," Color Res. Appl. **6**, 129–138 (1981).
37. C. Taylor and A. Franklin, "The relationship between color-object associations and color preference: further investigation of ecological valence theory," Psychon. Bull. Rev. **19**, 190–197 (2012).
38. R. C. Pastilha, J. M. M. Linhares, A. I. C. Rodrigues, *et al.*, "Describing natural colors with Munsell and NCS color systems," Color Res. Appl. **44**, 411–418 (2019).
39. CIE, *Colorimetry*, 4th ed. (Central Bureau., 2018).
40. B. Efron and R. J. Tibshirani, *An Introduction to the Bootstrap*, 1st ed. (Chapman and Hall/CRC, 1993).
41. I. C. McManus, A. L. Jones, and J. Cottrell, "The aesthetics of colour," Perception **10**, 651–666 (1981).
42. P. Sorokowski, A. Sorokowska, and C. Witzel, "Sex differences in color preferences transcend extreme differences in culture and ecology," Psychon. Bull. Rev. **21**, 1195–1201 (2014).
43. Y. Ling and A. C. Hurlbert, "A new model for color preference: universality and individuality," Final Progr. Proc. - IS T/SID Color Imaging Conf., pp. 8–11 (2007).
44. O. Rinner and K. R. Gegenfurtner, "Time course of chromatic adaptation for color appearance and discrimination," Vision Res. **40**, 1813–1826 (2000).
45. A. Werner, L. T. Sharpe, and E. Zrenner, "Asymmetries in the time-course of chromatic adaptation and the significance of contrast," Vision Res. **40**, 1101–1113 (2000).