Experimental Determination of the Laws of Color Harmony. Part 4: Color Preference and the Color Harmony Content

Antal Nemcsics*

Department of Colour Dynamics, Budapest University of Technology and Economics, Ungvár utca 42, Budapest H-1185, Hungary

Received 18 December 2007; revised 24 February 2008; accepted 5 March 2008

Abstract: In 1956, we decided at the Budapest University of Technology and Economics to start a large-scale experiment on color harmony. The experiments and the processing of the experimental results have been completed in 2006. These experiments, described in this article, form a study of how much are people, participating in the experiment, influenced by their own personal color preference in judging the harmony content of a composition. These experiments have utilized the results of former (1958–1969) color preference experiments and the system of color preference indexes, which were developed by the generalization of those results. Within the framework of these experiments, conducted between 1998 and 2006 there were 24 compositions, shown to the participants, at first one by one, then in pairs and at last in groups of six. They had to assess the harmony content of the compositions and award a score on a scale between 0 and 10. Each composition possessed a specific amount of harmony content according to the rules of color space, based on the Coloroid harmony threshold and verified by former experiments. In these experiments the number of elementary observations were 135 568. The people participating in the experiment were approximately equal number of men and women, from the age group between 10 and 70 years. During processing, by using the color preference numerical indexing system, we compared the results of those experiments with the color preference of a similar age group, by using color compositions, identical to the ones used in the present experiment. We have found that the sensation of the color harmony and its intensity have a strong relation to how the observers relate to colors and also their color preferences. The sensation of color harmony is also influenced by the gender and the age of the observer. © 2009 Wiley Periodicals, Inc. Col Res Appl, 34, 210–224, 2009; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/col.20489

Key words: color harmony; color composition; color science; color theory; Coloroid color system; color preference; color preference index number system

INTRODUCTION

The fact, that people's relation to colors influences their judgment of the harmony content of different compositions, has been recognized long time ago, young people relate to color harmony differently than the middle aged or the elderly. This is the reason why we have studied how much is the observer influenced by his color preferences in evaluating the harmony content of a composition. Our aim was to compare color preferences of different age groups of men and women in their evaluation of harmony content of different compositions.

Although similar color preference investigations have started more than a century ago, nowadays researchers are still taking a great interest in it. We refer the reader to the following earlier researchers: Tragy (1894), Holden and Bosse (1900), Shinn (1904), Engelsberger and Zeigler (1905), Bullough (1906), Baldwin (1906), Welson és Washburn (1913), Paul and Ostwald (1922), Gordon (1923), Allen and Guilford (1936), Eysenk (1941), Birren (1952), Granger (1955), Frieling (1968), Crozier (1996), Hihara (1997), Ou and Luo (2002).[1–32] Our investigations differed greatly from each other in terms of aim, content, and volume. Some features however were common, i.e., they were related to some defined age groups and they have also comprised only some defined domains of the

*Correspondence to: Antal Nemcsics (e-mail: nemcsics.antal@t-online.hu).

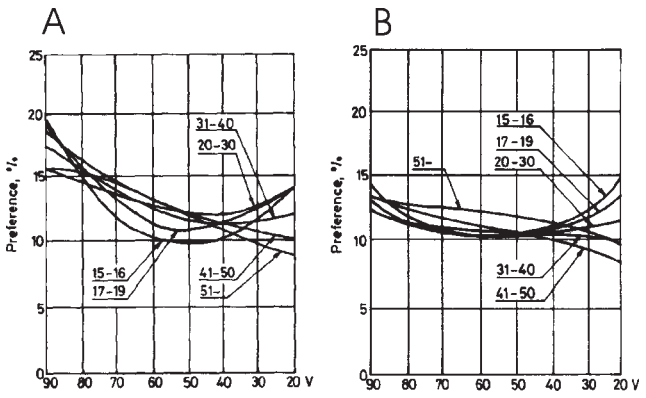

FIG. 1. The preference of colors on gray scale as expressed by men (A) and women (B) of different ages. The horizontal axis shows different brightness, the vertical one shows the relative preferences. Individual curves relate to different age groups.

color space. These experiments have been set up and organized, at the same time, to enable us to draw conclusions from their results, related to the evaluation of any age group relation to any color compositions of the color space.

Color preference in essence is a personal assessment, that one color is more appealing than the other. As the result of this, colors can be put in order according to their appeal, forming a scale. These preference scales are based on an individual judgment, therefore they are psychometric. The selection between two colors can only be accomplished effectively, when the index number, expressing the preference is not only representing a sequence but also locates the color on a psychometric scale with a well-defined starting and end point, according to the evaluation of the group of people. The idea of using scales for color preference purposes has emerged at first time during our experiments, conducted between 1958 and 1969. The introduction of these scales created the possibility of registering the preference of each member of the color space. As a result, a numerical indexing system of color preference has been established.

The introduction of the indexation of the color preference made the comparison possible between the contents of color harmony of different compositions and the personal color preference of these compositions, based on the assessment of people of different gender and ages.

THE SYSTEM OF THE NUMERICAL INDEXING OF COLOR PREFERENCE

To create a system for numerical color preference indexing, we have conducted a multistep color preference survey between 1958 and 1969 at the Budapest University of Technology and Economics. The series of experiments consisted of the following six stages: The definition of the continuous color circle, the gray and brightness scale, the saturation scale, the discrete color surfaces of the color space, all at 24 representative points of the color space and finally marking the color preference surfaces with the appropriate index numbers. The experimental subjects have to express their views about 291 color samples in total.

The experiments have been conducted with the participation of more than 70 000 individuals under the following personal and material conditions: The age of the experimental subjects has been selected from a very wide age range, from nursery age to the very old. During processing, the results of each age group have been handled together. The human life span has been divided into 12 age groups. The results have been processed according to the gender, age, education, profession, and environmental conditions. The processing has been carried out by the use of punched cards, sorting machines, and computers.

The sizes of the test color samples varied between 15 and 100 cm^2. The larger color samples were used in the experiments comparing pairs of samples, while the smaller ones were used in the experiments using ranking method. The samples have been shown on a horizontal surface so that the incidental angle of the light through the windows was $\sim 45^\circ$. As a general rule, the samples have been viewed from a distance of 100 cm with viewing angle of 90°. It was made certain that there were no color surfaces around producing color reflections and that the experimental environment was color free.

The results of the experiments have been processed for a number of aspects. The results were presented in a form of hundreds of diagrams. A substantial number of these diagrams have been published already in different publications.[33–42] Only a few of them will be presented here. Diagram "A" of Fig. 1 presents the color preference of gray colors with different brightness recorded on men of the following age groups: 15–16, 17–19, 20–30, 31–40, 41–50, and above 51 years. Diagram "B" shows that for women in the same age groups. Diagram "A" of Fig. 2 presents the color preference on dark blue (A54,V40) colors with different saturation recorded on boys and men, respectively, in the age groups of 15–16, 17–19, 20–30,

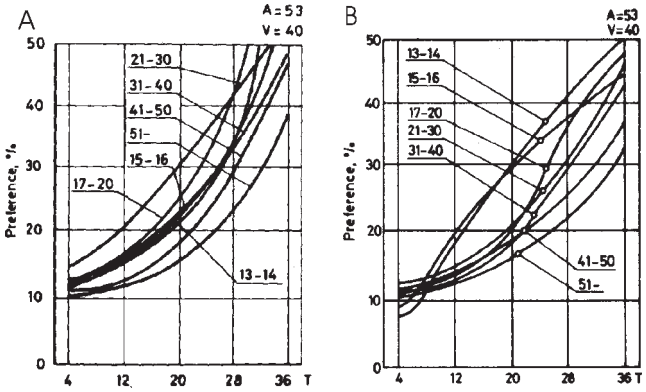

FIG. 2. The preference of blue (A53) colors with different saturations, darker than medium gray (V40), expressed by men (A) and women (B) of different age groups. The horizontal axis shows different saturation levels, the vertical one shows relative preferences. Individual curves relate to different age groups.

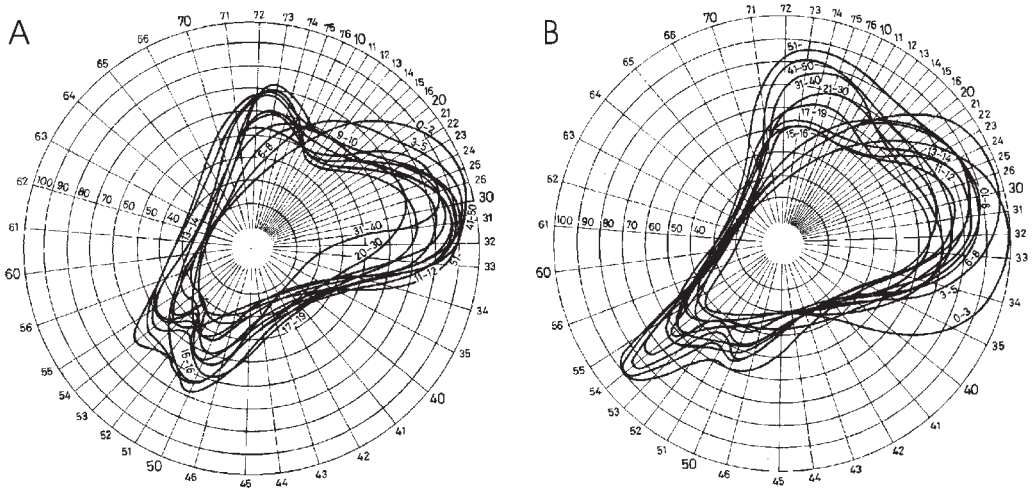

FIG. 3. The preference of colors in the Coloroid color circle—consisting of most saturated surface colors—of men (A) and women (B) of different age groups. On the perimeter of the circle, Coloroid notations of different Coloroid hues are indicated. The intensity of preference grows from the centre to the perimeter. Individual curves relate to different age groups.

31–40, 41–50, and above 51 years. Diagram "B" shows that for girls and women, respectively, in the same age groups. Curves in the circle diagram "A" of Fig. 3 depicts the preference to the most saturated surface colors of the Coloroid color circle, as shown by boys and men, respectively, in age groups of 0–2, 3–5, 6–8, 9–10, 11–12, 13–14, 15–16, 17–19, 20–30, 31–40, 41–50, and above 51 years. Diagram "B" shows the same for girls and women, respectively, in the same age groups. On the perimeter of the circular diagram, the Coloroid indicator numbers of different coloroid hues are shown (10–16 yellows, 20–26 oranges, 30–35 reds, 40–46 purples and violets, 50–56 blues, 60–66 cold greens, 70–76 warm greens). The intensity of the preference increases from the centre point toward the perimeter.

The numbers expressing the preference of 291 colors and evenly spaced in the color sphere have formed the basis of the numerical indexing system of color preferences. Using these basic data, we allocated a number to each color of the color sphere, between 0 and 100, proportional to the extent of preference of the color. We call the system of these numbers the index number system of color preferences. Preference indexes ordered to colors with identical hues, depending on their variation in saturation and brightness, can be characterized with continuous preference surfaces related to the Coloroid color planes in question. Figure 4 presents a color preference surface located above the Coloroid color plane containing colors of the same hue. The distance between the preference surface penetration point of a perpendicular, drawn in a color point of the color plane and the foot-end of the perpendicular, characterizes the preference of the color represented by the given color point. The numeric values of these distances are the color preference index values. The system of these values is called the color preference index system. The distance between the points on the surface and the color plane is proportional to the extent of preference of the color belonging to the point. These surfaces can be characterized with good approximation, for appropriately chosen 9 points, by using a quadratic function, with two variables. The tables of the color preference index number system have only been published before in abstracted forms, the complete data is deposited in the Color Dynamics Collection of the Library of the Budapest University of Technology and Economics. The subject matter of the experiments, described in this publication, have been selected from the compiled material.[43]

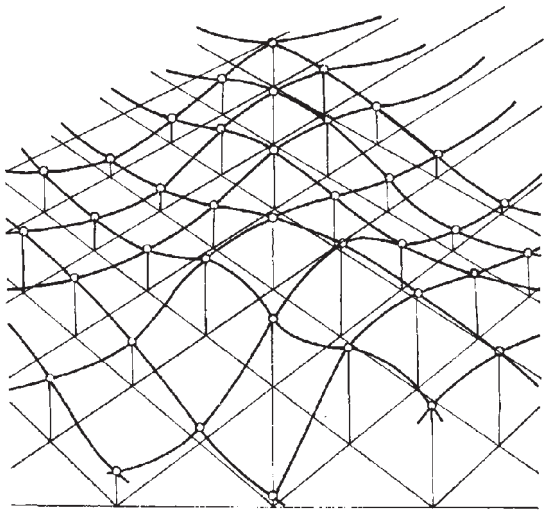

FIG. 4. Color preference surfaces are located above the Coloroid color planes containing colors of the same hue. Lines perpendicular to the color plane at different color points penetrate through the preference surfaces. The distance measured on a line between the foot-end of the perpendicular and the penetration point characterizes the preference of the color, represented by the color point. Numerical values of these distances are the color preference index values. The collection of these values is called color preference index system.

TABLE I. Compositions included in the experiments.

1	2	3	4	5	6
1	Monadic compositions	A10	570, 836		
2		A13	576, 062	1	5,11,17
3		A25	593, 981		
4		A31	610, 141		
5		A34	−496, 554		
6		A43	−539, 174		
7		A52	475, 449		
8		A55	484, 292	4	8,14,20
9		A62	495, 28		
10		A66	520, 396		
11		A71	548, 149		
12		A75	566, 783		
13	Diadic compositions	A10–A71	570, 836–548, 149		
14		A11–A51	572, 648–468, 715		
15		A13–A14	576, 062–577, 699		
16		A14–A52	577, 699–475, 449	3	7,13,19
17		A15–A75	579, 307–566, 783		
18		A20–A66	582, 640–520, 396		
19		A21–A22	584, 453–386, 419		
20		A22–A55	386, 419–484, 292	5	9,15,21
21		A25–A56	593, 981–487, 304		
22		A26–A24	597, 735–591, 060	2	6,12,18
23		A31–A65	610, 141–509, 193		
24		A42–A46	(−524, 590) to (−563, 846)	6	10,16,22

Column 1: Serial number of composition.
Column 2: Type of composition.
Column 3: Coloroid hue coordinates of the colors in the compositions.
Column 4: Characteristic wavelength of the colors in the compositions.
Column 5: Serial number of the composition within the article.
Column 6: Serial number of Figures related to the composition.

Because the color preference index number system was established 40 years ago, before the start of our recent experiments, we had to validate that data of the corresponding data of color preference of the human population today. From the different domains of the color space, we selected 100 different color pairs to be used in the investigations. The selected color pairs were set up into compositions both with nearby and with far away colors of the color space. The 250 experimental subjects, selected from different age groups, had the only task to decide, which color they prefer from the color pairs presented. In 99.7% of the evaluated cases, the color with the higher color preference index value has been preferred. The conclusion drawn from this is that the relation of humans to colors in terms of color preference has not changed during the past 40 years.

EXPERIMENTS

In our experiments, between 1998 and 2006, we have investigated the influence of the color preference of the experimental subjects, on assessing the harmony content of the composition related to the color content of each of the sample compositions.. The experiments have used the results of former (1958–1969) color preference experiments and the system of color preference indexes were developed by generalizing these results. Within the framework of those experiments, conducted between 1998 and 2006, there were 24 compositions (see Table I) shown to the experimental subjects, at first one by one, then in pairs and at finally in groups of six. At the selection of the compositions our aim was to make them evenly distributed in the Coloroid color space, to obtain a set of data from the results, valid for every color of the color space. The participants had to assess the harmony content of the compositions and grade them on a scale between 0 and 10. Each composition possessed a specific amount of harmony content according to the rules of color sphere, based on Coloroid harmony thresholds. According to our experiments, published before,[44–56] the prerequisite for a color harmony sensation is an exact relation between the Coloroid hues, and the Coloroid saturation and Coloroid brightness values of the color composition. The compositions used in the experiments have satisfied these conditions. In these experiments the number of elementary observations has been 135 568. The experimental subjects were grouped into age groups of 10, 20, 30, 40, 50, 60, 70 years. The average size of a group was 150, and half and half were men and women. At the data processing,

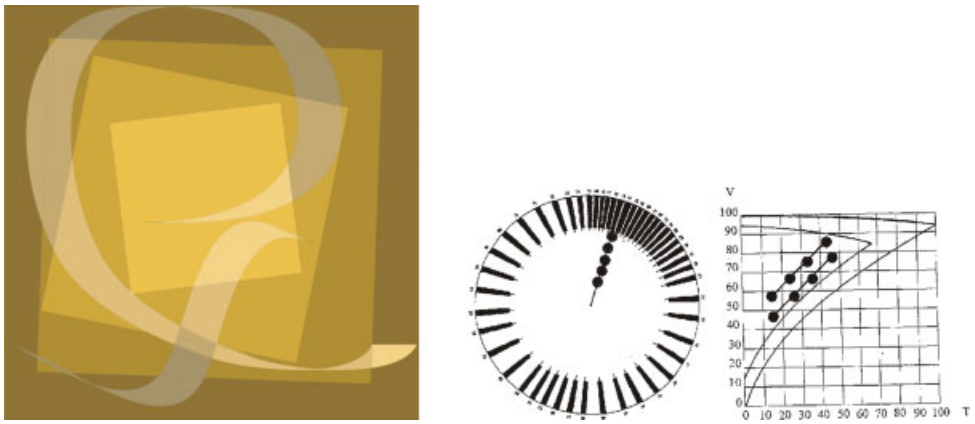

FIG. 5. A warm yellow (A13, 48) monochrome composition consisting of eight colors. The colors of the composition form two parallel scales containing colors with uniformly decreasing Coloroid hue and Coloroid brightness.

TABLE II. Data of the colors in the composition of Fig. 5.

	1 X	2 Y	3 Z	4 A	5 T	6 V	7 nm	8 H	9 V/C	10 d%
Color 1	70.10	73.07	39.13	13.48	41.36	85.48	576.85	5.0Y	9/6	4.66
Color 2	56.30	58.70	31.90	13.46	32.74	76.61	576.84	2.5Y	8/6	5.58
Color 3	43.99	45.89	26.38	13.47	24.12	67.74	576.82	5.0Y	7/4	4.01
Color 4	33.18	34.66	22.57	13.48	15.51	58.87	576.83	5.0Y	6/4	5.46
Color 5	59.15	61.45	20.03	13.45	47.94	78.39	576.84	5.0Y	8/8	2.75
Color 6	44.21	45.89	13.20	13.47	37.60	67.74	576.85	5.0Y	7/8	2.14
Color 7	31.41	32.60	8.84	13.48	27.26	57.10	576.85	5.0Y	6/8	8.32
Color 8	20.77	21.58	6.95	13.47	16.92	46.45	576.83	5.0Y	5/6	2.9

by using the system of color preference indexes, we compared the results of the experiment with the color preference of subjects of similar age to that of the participants, for the representative colors in the compositions.

For the experiments we used compositions of identical formats, half of the compositions with monochromatic, the other half with dichromatic colors. The compositions were painted with acryl technology onto 50 cm $\times$ 50 cm birch-wood plates. The colors of the compositions were modified according to the experimental plan until it reached the required tint. The appropriate measurements were performed with a Datacolor 550^{TM} spectrophotometer. Although the present article shows only six of the compositions studied, the conclusions are drawn on the results of all of the 24 compositions. The vertically standing compositions, illuminated with reflected light from the Northern sky, of 45° incidence, were viewed by the participants from a distance of 150 cm, in a viewing angle of 90°. The level of illumination at the compositions varied between 1600 and 1800 lx. The experimental subjects were selected from people with good color vision and with good taste for the arts. In the age groups under 30 year, students from art schools were in majority, while in the groups over 30 year a number of painters have taken part. Each age group consisted of 70–80 members. The subjects participated individually in the experiment, and viewed the compositions for undefined duration, generally for about 4–6 min. In the second step of the experiment, when every composition were shown paired up with other compositions, the comparison between pairs allowed the participants to modify their former assessment of each of the composition, viewed before. There was another possibility for modification: The collective observation of the compositions in one group, where the 24 compositions divided into four groups with six compositions each, provided further opening for modification. The evaluation has been registered in printed forms. The assessed values for each composition were averaged. In every age group, there were some participants with assessment results significantly different from that of all the others, which otherwise showed only a little variation. These data were discarded at the calculation of the average.

RESULTS

The first composition (see Fig. 5) out of the compositions presented in this article, consists of eight colors, with identical Coloroid hues of warm yellow color, exhibiting different saturation and brightness variations. These colors form two parallel scales with evenly decreasing Coloroid saturation and Coloroid brightness, in the intersection with the axis (color plane) containing the colors with the characteristic wavelengths of 576.85 nm in the Coloroid color space (See the diagram). For the visual presentation of the relation between the colors of both the current and the other compositions, the location of the colors of each composition, in the color space, is shown in a Coloroid diagram next to the composition. On the circular figure of the diagram, the hue of the colors, on the square figure, the saturation and brightness are indicated. The colors of the composition are given in Table II. It is highly probable that printing technology cannot reproduce colors of the current compositions and future ones with high accuracy, and it is also highly probable that readers have a Munsell rather than a Coloroid color atlas, therefore the colors of the compositions are marked in the appropriate tables (Tables II to VII) with CIE XYZ color components

TABLE III. Data of the colors in the composition of Fig. 6.

	1 X	2 Y	3 Z	4 A	5 T	6 V	7 nm	8 H	9 V/C	10 d%
Color 1	46.32	31.14	6.33	26.00	38.43	55.81	597.735	10.0R	6/14	3.84
Color 2	57.11	47.80	32.79	26.03	26.84	69.14	597.733	10.0R	7/8	5.44
Color 3	71.28	68.02	63.12	26.01	15.24	82.47	597.734	10.0R	8/4	6.13
Color 4	74.84	73.63	69.01	24.37	14.03	85.81	592.09	7.5YR	9/2	3.43
Color 5	50.30	47.80	40.89	24.38	14.03	69.14	592.07	2.5YR	7/4	4.45
Color 6	31.03	27.53	18.83	24.37	14.03	52.47	592.09	5.0YR	6/4	5.55
Color 7	17.05	12.82	2.81	24.39	14.03	35.81	592.08	5.0YR	4/8	5.52

TABLE IV. Data of the colors in the composition of Fig. 7.

	1 X	2 Y	3 Z	4 A	5 T	6 V	7 nm	8 H	9 V/C	10 d%
Color 1	79.62	83.34	80.12	14.04	10.97	91.29	577.76	5.0YR	9/2	5.02
Color 2	63.94	66.74	59.38	14.02	13.71	81.69	577.74	7.5YR	8/2	4.12
Color 3	50.02	51.98	40.66	14.03	16.45	72.10	577.75	7.5YR	8/2	6.32
Color 4	37.84	39.06	23.94	14.04	19.19	62.50	577.76	5.0YR	7/4	3.21
Color 5	79.58	83.34	102.29	52.00	12.90	91.29	475.45	7.5B	9/2	3.67
Color 6	56.64	59.07	80.19	52.02	17.74	76.85	475.43	10.0B	8/2	2.6
Color 7	37.67	38.96	62.63	52.03	22.58	62.42	475.45	2.5PB	7/4	3.32
Color 8	22.66	23.02	49.61	52.01	27.42	47.98	475.44	5.0PB	5/6	4.91

(columns 1 to 3), as well as with Coloroid coordinates (columns 4 to 6) and with characteristic wavelengths (column 7). The color notation nearest to be found in the Munsell atlas (columns 8 and 9) and its deviation from the Coloroid color in percentage are also given (column 10).

The colors of the second composition (Fig. 6) selected from orange-red colors, of two near lying Coloroid color planes. The characteristic wavelength of each color on the color plane with Coloroid hue of A26 and A24.37 is equal to 597.735 and 592.09 nm, respectively. The colors of the composition of warm feeling form two scales. Colors of the first scale (A24) have identical Coloroid saturations and have steadily diminishing brightnesses, while the colors of the other scale (A26) exhibit a steadily falling Coloroid saturation and a steadily growing Coloroid brightness (see the diagram of Fig. 8). Data of the colors are given in Table III.

The third composition (Fig. 7) consists of eight colors, out of which four belong to the yellow Coloroid hue, denoted A14, while the other four belong to the blue Coloroid hue denoted A52. The characteristic wavelength for yellow colors, belonging to identical Coloroid color plane is 577.76 nm and that for blues belonging also to identical color plane is 475.449 nm. These two hues are complementary to each other. Both colors, the one belonging to yellow Coloroid hue and the other colors belonging to blue Coloroid hue, form scales. Both scales have evenly growing Coloroid saturation as well as a steadily falling Coloroid brightness (see the diagram of Fig. 11). The data for the above colors are given in Table IV.

The fourth composition (Fig. 8) consists of nine cold blue colors with identical Coloroid hues with Coloroid labeling of A55.39. The characteristic wavelength of all these colors is 485.55 nm. The colors in the composition create two scales, approximately perpendicular to each other. In the first scale both the Coloroid saturations and the Coloroid brightnesses of the colors are decreasing. In case of the other scale the Coloroid saturation of the colors is decreasing while their brightnesses is increasing (see the diagram of the figure). The data of these colors are tabulated in Table V.

The fifth composition (Fig. 9) is made of eight colors, half of them are orange color (A22) the other half are cold blue (A55). Characteristic wavelength of the orange colors is 586.419 nm and that of the blues is 485.55 nm. The two colors are approximately complementary to each other. The colors of the composition form two scales of different directions. In the first case, both the Coloroid saturation and the Coloroid brightness of the colors are decreasing. In the other case, the Coloroid saturations of the colors are increasing but their brightnesses are decreasing (see the diagram of the figure). The data of the colors are shown in Table VI.

The sixth composition (Fig. 10) consists of eight colors. Half of them are violet-purple (A42), the other half are violet-blue (A46). It emanates a mystic atmosphere. The characteristic wavelength of violet-purple colors is -524.59 nm and that of the bluish violet ones is -564.22 nm. The two Coloroid color planes containing the colors of the composition are at an angle of 40°, satisfying the rules of Coloroid harmony system. The colors of the composition create two parallel scales. The Coloroid saturation members of the scale are evenly increasing, while their brightnesses are steadily decreasing (see the diagram of the Figure). The data of these colors are shown in Table VII.

The details of the further 18 compositions forming part of the experiment but not given in the current article are

TABLE V. Data of the colors in the composition of Fig. 8.

	1 X	2 Y	3 Z	4 A	5 T	6 V	7 Nm	8 H	9 V/C	10 d%
Color 1	38.38	49.45	85.87	55.39	78.33	70.32	485.55	2.5B	7/8	4.58
Color 2	33.15	41.83	70.08	55.40	60.03	64.68	485.54	2.5B	7/8	4.15
Color 3	28.53	34.85	55.00	55.38	41.72	59.03	485.56	2.5B	6/6	4.63
Color 4	24.51	28.50	40.61	55.41	23.42	53.39	485.55	2.5B	6/4	2.36
Color 5	21.10	22.79	26.91	55.39	5.11	47.74	485.53	5.0BG	5/2	5.52
Color 6	59.57	62.97	69.61	55.38	2.55	79.35	485.55	10.0G	8/2	7.68
Color 7	41.65	44.88	52.57	55.39	9.08	66.99	485.54	5.0BG	7/2	4.36
Color 8	26.64	29.84	38.87	55.40	15.61	54.62	485.56	10.0BG	6/2	1.66
Color 9	14.54	17.86	28.49	55.39	22.14	42.26	485.55	2.5B	5/4	3.74

TABLE VI. Data of the colors in the composition of Fig. 9.

	1 X	2 Y	3 Z	4 A	5 T	6 V	7 nm	8 H	9 V/C	10 d%
Color 1	47.17	39.57	7.46	22.00	40.97	62.90	586.42	7.5YR	7/12	5.41
Color 2	38.60	33.59	11.70	22.01	28.60	57.96	586.41	7.5YR	6/8	4.03
Color 3	30.50	28.10	16.48	22.03	16.24	53.01	586.40	7.5YR	6/4	5.99
Color 4	22.86	23.10	21.79	22.00	3.87	48.06	586.42	7.5YR	5/2	5.6
Color 5	59.57	62.97	69.61	55.39	2.55	79.35	485.55	10.0G	8/2	7.68
Color 6	41.65	44.88	52.57	55.40	9.08	66.99	485.54	5.0BG	7/2	4.36
Color 7	26.64	29.84	38.87	55.38	15.61	54.62	485.56	10.0BG	6/2	1.66
Color 8	14.54	17.86	28.49	55.39	22.14	42.26	485.55	2.5B	5/4	3.74

identical to that of the 6 compositions presented here. The number of colors used in the compositions varied between 7 and 9. Ten compositions contained monochromatic while eight compositions contained dichromatic variations. The allocation of the monochromatic compositions were as follows: one to each of the yellow (A10), orange (A25), purple (A43) and blue (A52) color domains, two to the red (A31, A34) and four to the green (A62, A66, A71, A75) color domains. The colors of the dichromatic compositions represented in the following color domains: cold yellow (A10) and warm green (A71), medium yellow (A13) and medium warm yellow (A14), orangey yellow (A15) and warm yellowish green (A75), orange (A20) and cold green (A66), yellowish orange (A21) and reddish orange (A22), orange red (A25) cold blue (A56), red (A31), and medium green (A65). The colors of these compositions were located on straight lines of different directions lying on different Coloroid color planes, similarly to that of the compositions presented. Each composition, similarly to the ones presented here possessed a particular emotional content. The entirety of the color set used by the compositions were evenly distributed in the color space of Coloroid (see again in Table I).

Figures 11–16 are showing the relative harmony content of the compositions given in Figs. 5–10 as judged by men and women of different ages. From Fig. 11 it is clearly visible that the harmony content of the yellow composition (Fig. 5) is assessed both by men and women higher with progressing ages, reaching the highest score between 50 and 60 years of age. From that age on the harmony content of the composition is judged somewhat lower. The diagram of Fig. 12 shows that the harmony content of the broken orangey-red composition (Fig. 6) is judged higher as by men and women as their age progressed and at an age of 40 they gave the highest value. While this evaluation remains nearly constant for men until 50, women, as their age progressed, felt it less and less harmoneous. According to Fig. 13, the harmony content of blue-yellow complementary composition (Fig. 7) gets the highest score from men at the age of 20 while from women at the age of 30. This composition is being evaluated as least harmoneous by both genders in the age of 70. From the diagram of Fig. 14, it can be seen that the harmony content of the cold blue composition (Fig. 8) is evaluated the highest by men of 30 years and by women of 40 years of age. This composition is felt least harmoneous by both genders of 10 and 70 years of age. According to the diagram in Fig. 15, the harmony content of the orange-blue composition (Fig. 9) is judged the highest by both men and women at an age of 50. This composition is felt least harmoneous by both genders of 10 and 70 years of age. According to Fig. 16 both men and women judged the harmony contents of the violetish-purple and violetish-blue the highest at the age of 20. Men at 70 and women at 50 felt these least harmoneous. Women judged the harmony content of these color compositions always higher than men. Similar results can be seen from these diagrams, gained as a result of scoring, carried out on further 18 experimental compositions. Compositions, consisting of broken red colors, have been felt both by men and women of all ages more harmoneous than those compiled of more saturated red colors. Mostly women felt the compositions of broken warm green colors more harmoneous and mostly men felt those composed of cold greens more harmoneous, etc.

Based on the color preference index number established on the basis of our former experiments, a color prefer-

TABLE VII. Data of the colors in the composition of Fig. 10.

	1 X	2 Y	3 Z	4 A	5 T	6 V	7 nm	8 H	9 V/C	10 d%
Color 1	52.51	47.32	60.87	42.00	19.41	68.79	.−524.59	2.5RP	7/4	3.78
Color 2	39.19	32.05	45.74	42.01	22.51	56.61	.−524.58	2.5RP	6/6	3.96
Color 3	28.70	19.75	33.84	42.00	25.61	44.44	.−524.57	2.5RP	5/10	2.33
Color 4	21.3	10.41	25.16	42.02	28.71	32.26	.−524.59	2.5RP	4/16	3.63
Color 5	50.14	47.32	72.08	46.08	15.67	68.79	.−564.22	2.5P	7/4	3.43
Color 6	36.45	32.05	58.74	46.06	18.18	56.61	.−564.21	2.5P	6/6	3.57
Color 7	25.58	19.75	48.62	46.09	20.68	44.44	.−564.22	2.5P	5/10	1.77
Color 8	17.53	10.41	41.74	46.08	23.19	32.26	.−564.23	2.5P	4/14	4.74

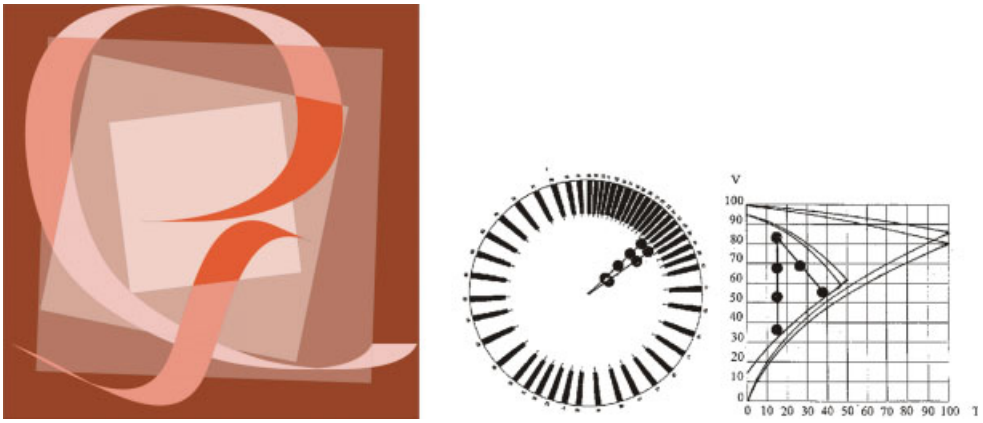

FIG. 6. Composition containing seven dichromatic colors, creating a warm feeling, consisting partly of more orangish red (A24), partly of less orangish red (A26) colors. The colors of the composition form two scales. Colors of the first scale (A24) have the same Coloroid saturation and their brightness decreases uniformly, the colors of the second scale (A26) have uniformly decreasing saturation and uniformly increasing Coloroid brightness.

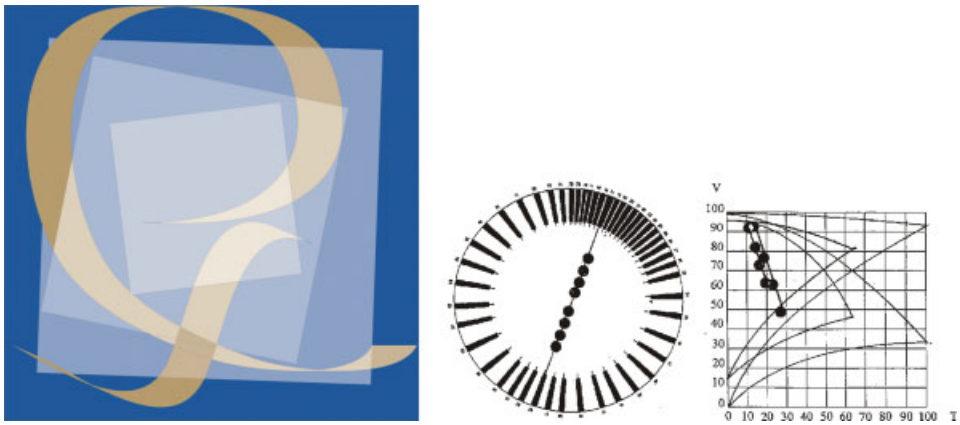

FIG. 7. Composition consisting of eight dichromatic colors, half of yellow (A14) colors, half of blue (A52) colors, having a complementary relationship with each other. The colors of the composition form two parallel scales with uniformly increasing Coloroid saturation and with uniformly decreasing Coloroid brightness.

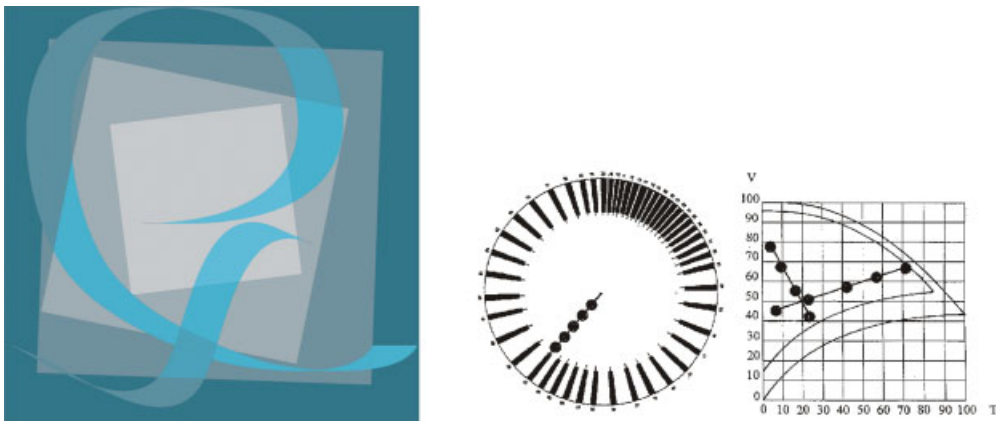

FIG. 8. A monochrome, cold blue (A55.39) composition consisting of nine colors. The colors of the composition form two scales running approximately perpendicular to each other. The colors of the first scale have a uniformly decreasing Coloroid saturation and Coloroid brightness. The colors of the other scale have a decreasing Coloroid saturation and increasing brightness.

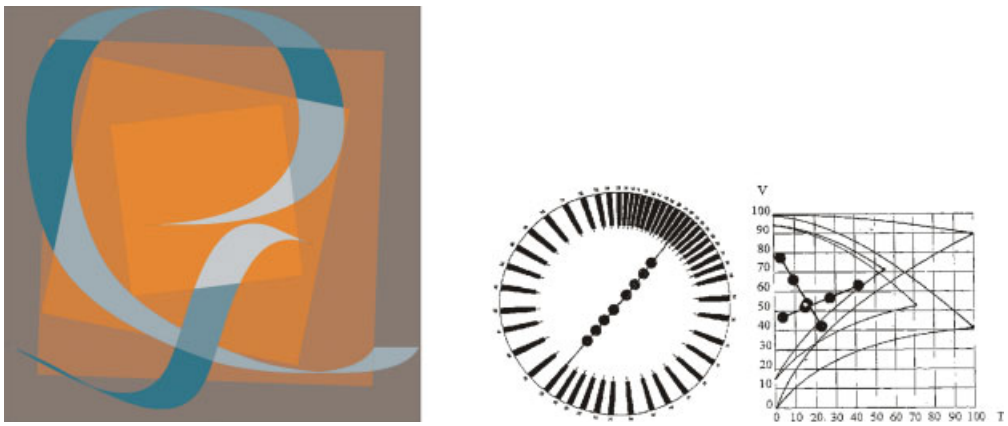

FIG. 9. Composition consisting of eight dichromatic colors, half of orangey yellow (A22) and half of cold blue (A55) colors, in an approximately complementary relationship with each other. Colors of the composition form two scales of different directions. The colors of the first scale have uniformly decreasing Coloroid saturation and Coloroid brightness. The colors of the other scale have an increasing Coloroid saturation but decreasing brightness.

FIG. 10. Composition with a mystic sensation, consisting of eight dichromatic colors, half of violet-purple (A42) and half of blue-violet (A46) colors. The two Coloroid color planes containing the colors of the composition meet at 40° according to the Coloroid harmony rules. The colors of the composition form two parallel scales. The Coloroid saturation for the scale colors increases uniformly, while their brightness decrease uniformly.

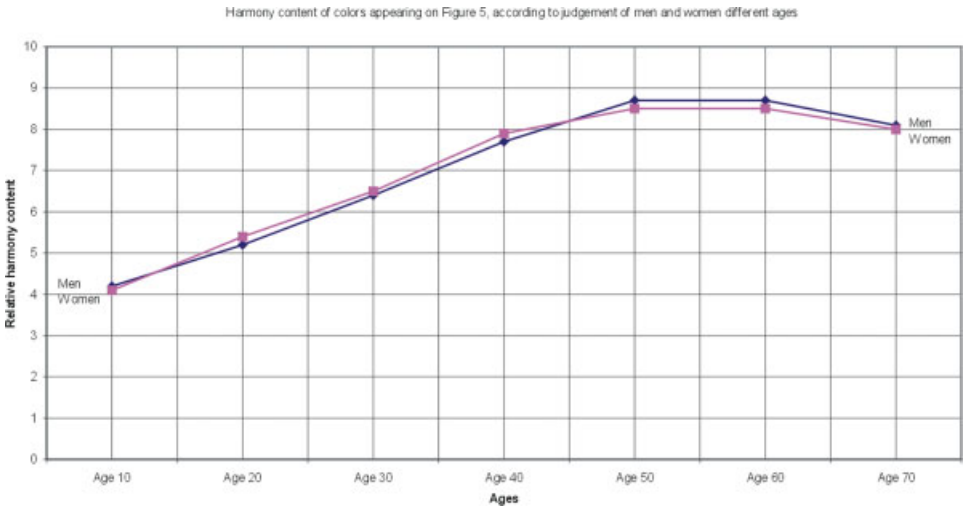

FIG. 11. The harmony content of the composition shown in Fig. 5, based on the evaluation of men and women of different ages.

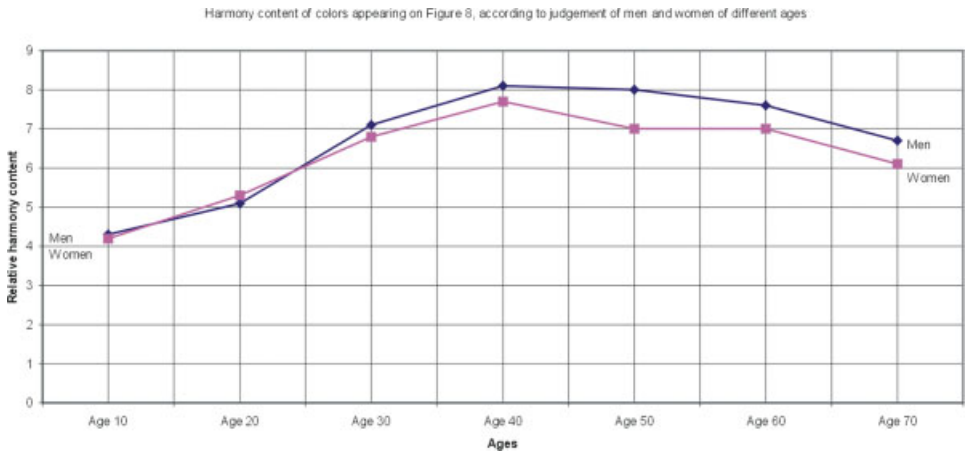

FIG. 12. The harmony content of the composition shown in Fig. 6, based on the evaluation of men and women of different ages. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

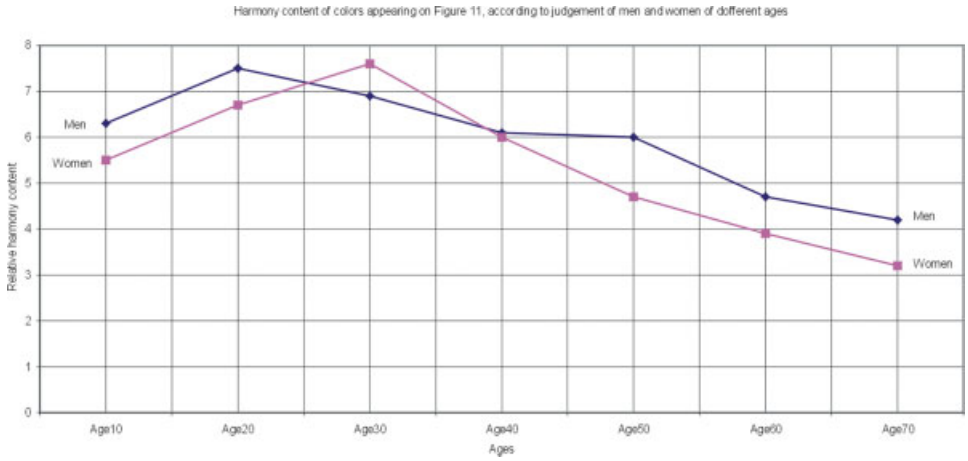

FIG. 13. The harmony content of the composition shown in Fig. 7, based on the evaluation of men and women of different ages. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

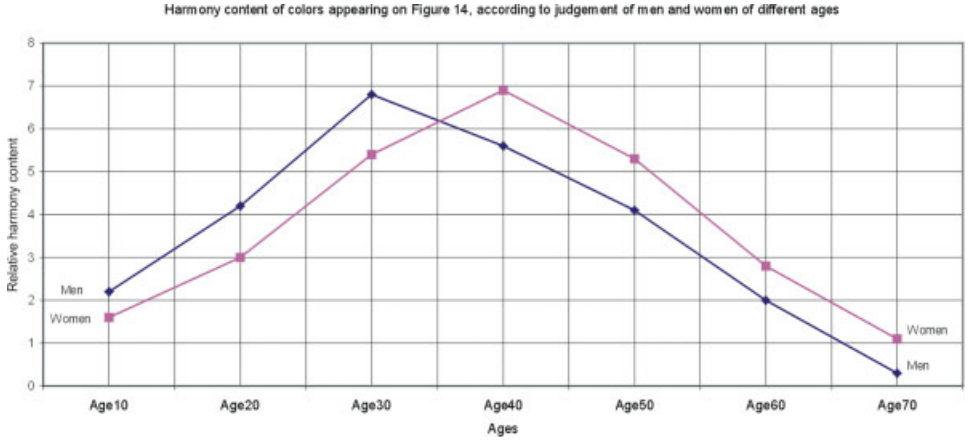

FIG. 14. The harmony content of the composition shown in Fig. 8, based on the evaluation of men and women of different ages. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

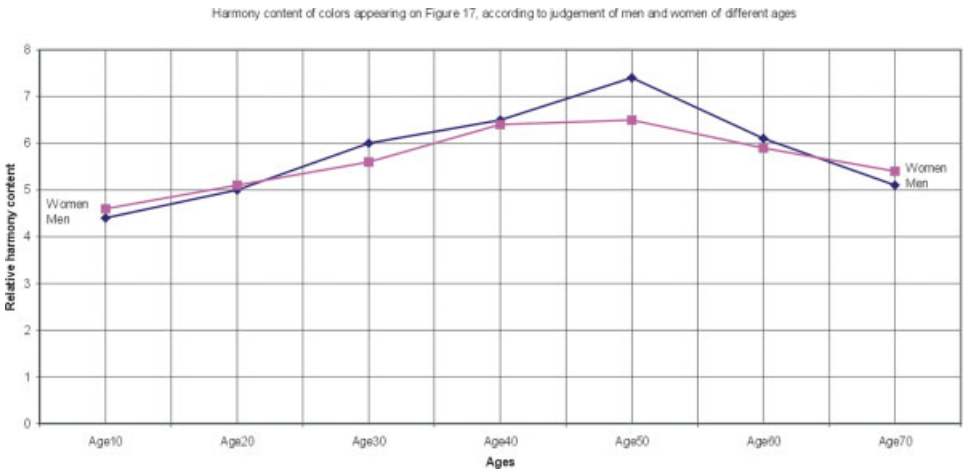

FIG. 15. The harmony content of the composition shown in Fig. 9, based on the evaluation of men and women of different ages. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

ence index value was allocated to each color of the composition corresponding to the color preference of men of different ages, as shown in Figs. 17–22. The resulting curves demonstrate how much individual colors are preferred by men of different age. The average of the curves, the thick line of the diagram, indicates the collective preference of the particular color. By comparing the shapes of the thick curves one can see the extraordinary similarity to the curves of Figs. 11–16 based on the given values by men on the harmony content. The experiment has given the color preference index value curves not only for men but also for women. In case of women, the course of the average curve of the color preference index values and also that of the curve of harmony content show again resembling similarity. Because of the restricted size of this article these curves are not shown.

The summary of the results of all 24 compositions used in the experiment is given in Table VIII. The table shows the evaluation of the compositions given by the experimental subjects of the age intervals of 10, 20, 30, 40, 50, 60, 70 years. The numbers in column "HC" indicate the value of the harmony content of the compositions. The data in column "PI" shows the normalized values—in an interval of 0 to 10—of the average color preference index values of the colors in the composition. From these data it can be seen that according to the evaluation of a certain composition by people of a certain age, the difference between the values of columns "HC" and "PI" falls always below the value of unity and they are mostly between the values of 0.1 and 0.5.

CONCLUSIONS

To summarize, the exactly definable link between the hues of the Coloroid colors and the Coloroid saturation and brightness is not only the prerequisite of the origin of the color harmony sensation but also the observers' well-defined preference level of the collective coloring content of the color.

A composition constructed of not preferred colors is not felt so harmonic. The more the colors of the compositions are preferred, the higher is the feel of the overall harmony of the composition.

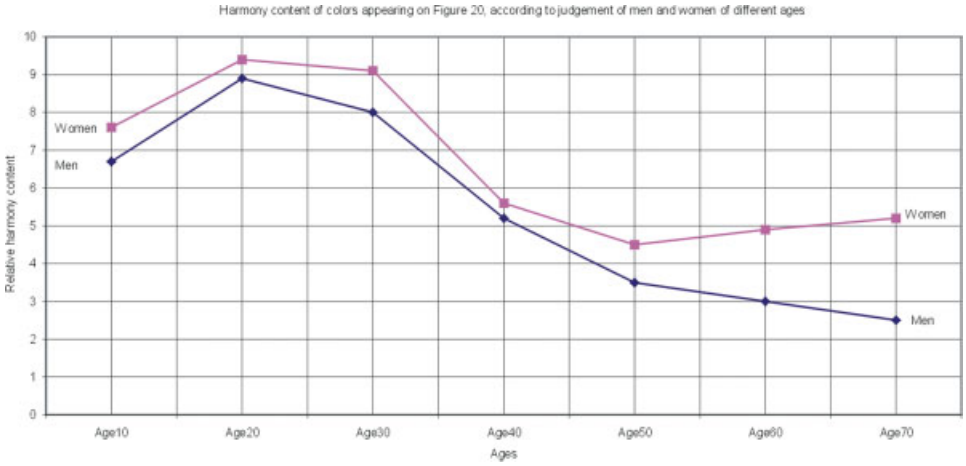

FIG. 16. The harmony content of the composition shown in Fig. 10, based on the evaluation of men and women of different ages. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

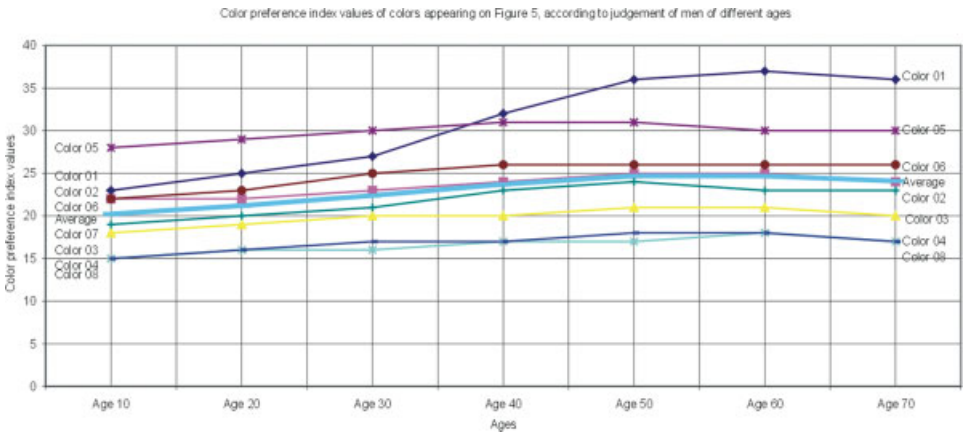

FIG. 17. Color preference index values and averages related to colors in Fig. 5 based on the assessment of men of different ages.

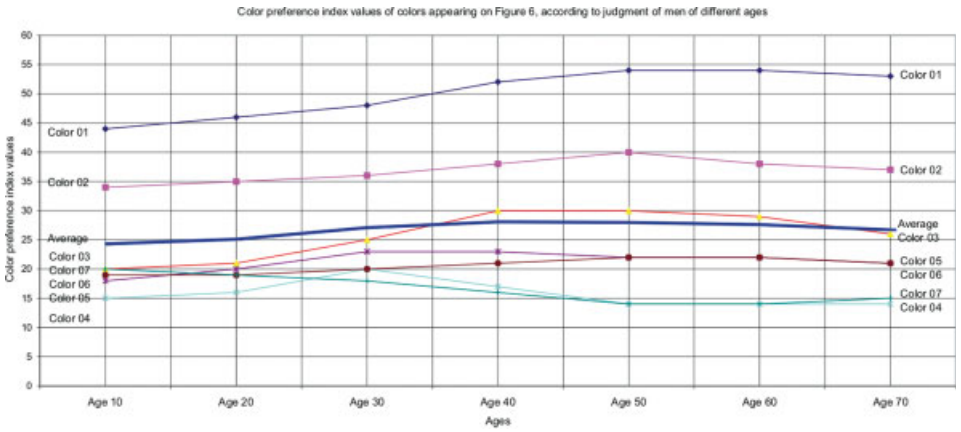

FIG. 18. Color preference index values and averages related to colors in Fig. 6 based on the evaluation of men of different ages.

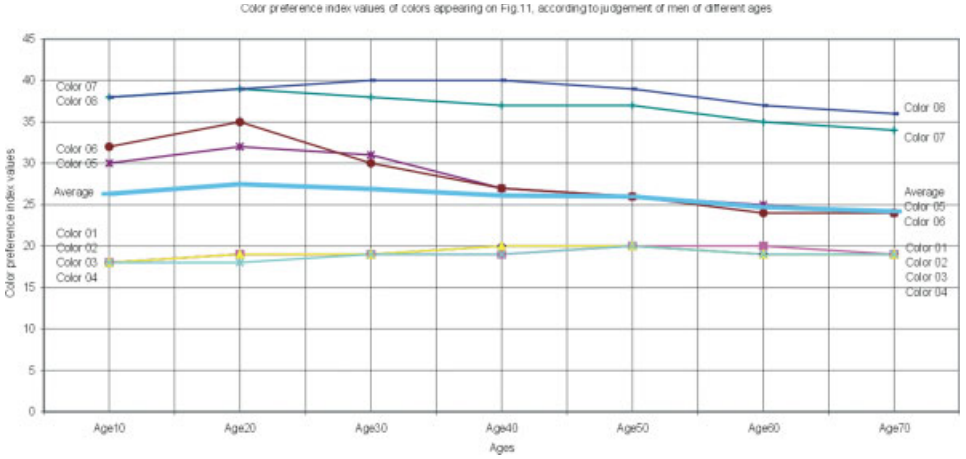

FIG. 19. Color preference index values and averages related to colors in Fig. 7 based on the evaluation of men of different ages.

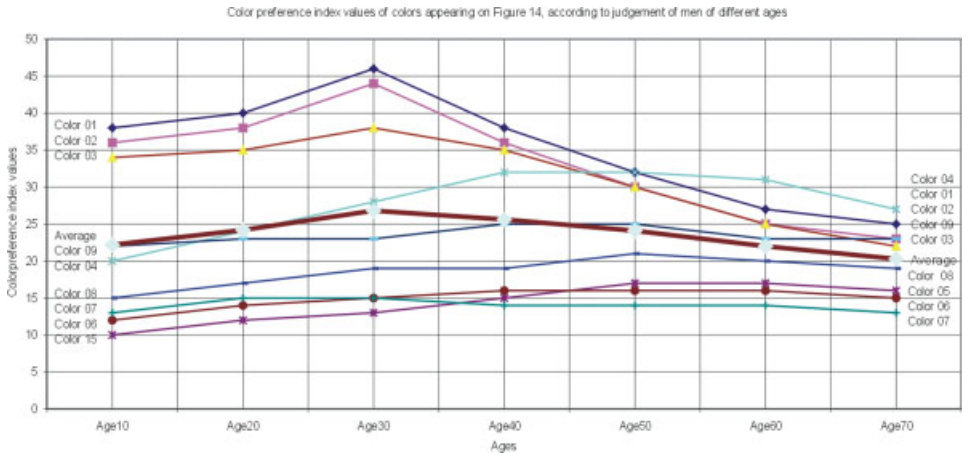

FIG. 20. Color preference index values and averages related to colors in Fig. 8 based on the evaluation of men of different ages.

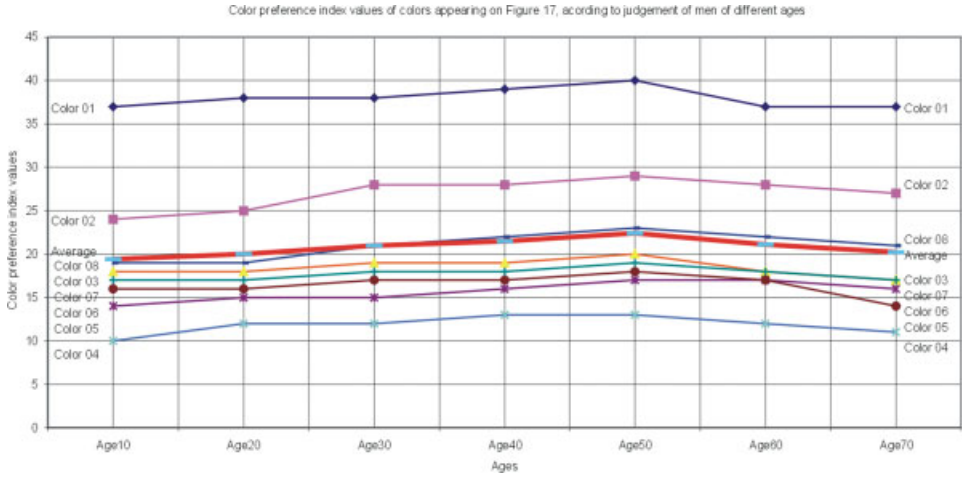

FIG. 21. Color preference index values and averages related to colors in Fig. 9 based on the evaluation of men of different ages.

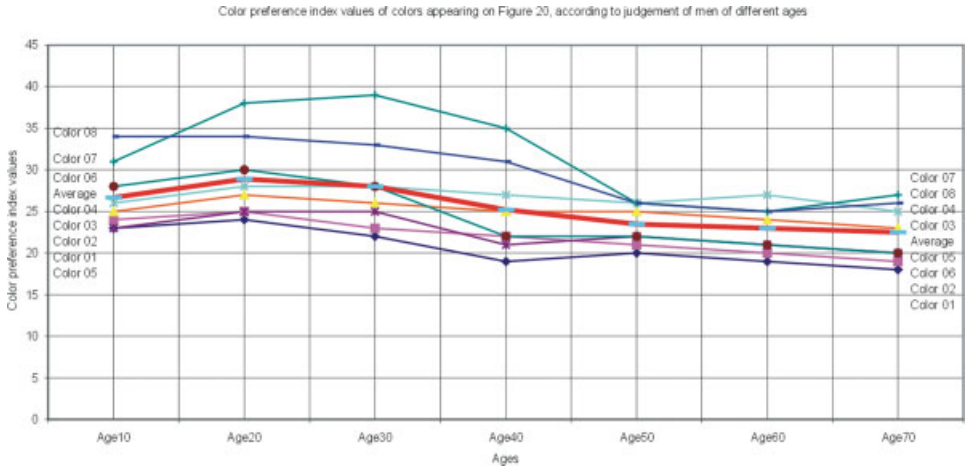

FIG. 22. Color preference index values and averages related to colors in Fig. 10 based on the evaluation of men of different ages.

TABLE VIII. Summary of results.

				Age 10		Age 20		Age 30		Age 40		Age50		Age 60		Age 70	
				HC	PI	HC	PI	HC	PI	HC	PI	HC	PI	HC	PI	HC	PI
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		A10 (570.836)	Men	0.92	0.98	1.19	1.22	1.72	1.69	2.41	2.4	3.2	3.2	3.02	3.14	2.62	2.59
			Women	1.69	1.72	1.79	1.82	1.89	1.91	2.31	2.3	2.5	2.5	2.44	2.38	2.11	2.08
2	1	A13(576.062)	Men	0.21	0.2	1.21	1.19	2.41	2.4	3.69	3.7	4.7	4.7	4.69	4.7	4.11	4.1
			Women	0.11	0.12	1.4	1.41	2.49	2.48	3.89	3.9	4.7	4.69	4.68	4.69	4.1	4.12
3		A25(593.981)	Men	3.81	3.78	3.89	3.91	3.69	3.71	3.51	3.5	3.4	3.4	3.69	3.71	3.92	3.94
			Women	3.49	3.51	3.52	3.51	3.41	3.43	3.32	3.3	3.2	3.19	3.31	3.29	3.51	3.53
4		A31(610.141)	Men	8.09	8.11	8.22	8.25	7.78	7.81	7.4	7.4	6.3	6.4	5.41	5.4	5.49	5.52
			Women	6.62	6.58	6.92	6.88	7.19	7.2	6.92	6.9	6.2	6.2	6.05	5.99	6.11	6.08
5		A34 (−496.554)	Men	2.59	2.6	2.18	2.21	2.02	2.05	2.21	2.2	2.32	2.4	2.69	2.7	2.98	3.01
			Women	2.71	2.72	2.11	2.1	2.11	2.09	2.19	2.21	2.2	2.2	2.61	2.59	2.71	2.73
6		A43 (−539.174)	Men	1.6	1.62	1.61	1.65	1.72	1.68	2.19	2.2	2.7	2.8	3.01	2.99	3.11	3.08
			Women	1.2	1.32	1.31	1.32	1.3	1.3	1.32	1.3	1.6	1.7	1.78	1.81	1.73	1.67
7		A52 (475.449)	Men	2.51	2.48	3.23	3.21	3.99	4.01	4.39	4.39	4.5	4.6	4.51	4.48	4.42	4.4
			Women	1.4	1.41	2.06	2.02	4.03	4.05	1.51	1.5	1.71	1.6	1.82	1.79	1.71	1.69
8	4	A55 (484.292)	Men	2.2	2.21	4.2	4.19	6.81	6.79	5.61	5.6	4.1	4.1	1.99	2	0.3	0.29
			Women	1.59	1.61	3	2.99	5.4	5.41	6.9	6.9	5.3	5.3	2.81	2.79	1.09	1.1
9		A62 (495.280)	Men	7.22	7.2	7.61	7.57	7.71	7.73	7.44	7.4	6.91	6.9	5.5	5.49	6.7	6.72
			Women	5.29	5.32	6.41	6.38	6.7	6.68	6.38	6.4	5.8	5.82	4.23	4.25	6.31	6.29
10		A66 (520.396)	Men	0.82	0.99	1.24	1.44	1.52	1.66	1.72	1.8	1.92	1.9	1.8	1.79	1.72	1.74
			Women	0.53	0.66	1.11	1.15	1.61	1.59	1.94	1.91	2.4	2.42	2.33	2.36	1.94	1.95
11		A71 (548.149)	Men	2.22	2.23	3.24	3.22	4.02	4.01	4.29	4.3	4.4	4.42	3.82	3.79	3.81	3.79
			Women	2.62	2.63	3.09	3.08	3.41	3.44	3.7	3.72	3.61	3.6	3.33	3.29	3.2	3.18
12		A75 (566.783)	Men	3.3	3.28	3.39	3.41	3.59	3.6	3.9	3.9	4.19	4.22	4.4	4.42	4.7	4.68
			Women	3.72	3.69	3.6	3.59	3.42	3.39	3.31	3.3	3.54	3.6	3.79	3.81	4.19	4.2
13		A10 (570.836)–	Men	2.8	2.77	3.09	3.1	3.48	3.5	4.39	4.4	5.02	5.1	6.02	6.04	6.42	6.39
		A71 (548.149)	Women	3.21	3.19	3.6	3.58	4.01	4.03	4.4	4.42	5.9	6.01	6.79	6.8	7.11	7.14
14		A11(572.648)–	Men	4.8	4.79	5.68	5.7	6.29	6.31	7.07	7.1	7.51	7.5	7.27	7.3	6.48	6.51
		A51 (468.715)	Women	4.29	4.3	5.7	5.72	6.68	6.71	7.49	7.52	7.59	7.6	7.61	7.62	7.49	7.5
15		A13 (576.062)–	Men	7.57	7.6	6.79	6.81	6.42	6.38	5.81	5.8	5.88	5.9	6.29	6.3	6.82	6.77
		A14 (577.699)	Women	7.28	7.31	7.19	7.2	6.6	6.63	6.5	6.49	6.7	6.72	7.03	7	7.19	7.2
16	3	A14 (577.699)–	Men	6.29	6.3	7.5	7.48	6.89	6.9	6.11	6.1	6.02	6.1	4.7	4.68	4.2	4.18
		A52 (475.449)	Women	5.49	5.51	6.69	6.71	7.6	7.58	6.02	6.03	4.7	4.69	3.88	3.91	3.17	3.21
17		A15 (579.307)–	Men	5.41	5.37	6.08	6.1	7.1	7.09	7.85	7.87	7.8	7.79	7.7	7.69	7.7	7.73
		A75 (566.783)	Women	4.4	4.38	6.02	6.05	7.39	7.4	8.32	8.3	8.41	8.4	8.17	8.2	7.9	7.88
18		A20 (582.640)–	Men	3.51	3.5	4.4	4.37	4.59	4.61	4.79	4.8	4.9	4.92	5.22	5.19	5.27	5.32
		A66 (520.396)	Women	4.09	4.11	4.4	4.38	4.8	4.79	5.61	5.6	6.19	6.2	6.03	6.01	5.79	5.8
19		A21 (584.453)–	Men	4.05	4.02	3.57	3.6	3.3	3.27	3.5	3.49	4.5	4.48	5.5	5.53	5.69	5.71
		A22 (386.419)	Women	5.69	5.7	4.81	4.83	4.42	4.45	5.08	5.1	6	5.99	6.32	6.3	6.08	6.1
20	5	A22 (386.419)–	Men	4.39	4.4	5.02	5	6.02	6	6.49	6.5	7.41	7.4	6.1	6.07	5.1	5.13
		A55 (484.292)	Women	4.6	4.62	5.09	5.1	5.6	5.61	6.41	6.4	6.51	6.49	5.89	5.9	5.38	5.4
21		A25 (593.981)–	Men	2.53	2.5	3.7	3.67	4.79	4.82	5.19	5.2	5.2	5.18	5	4.98	4.12	4.09
		A56 (487.304)	Women	1.89	1.91	3.39	3.4	5.02	5	6.21	6.2	6.1	6.11	5	5.03	4.9	4.88
22	2	A26 (597.735)–	Men	4.3	4.32	5.09	5.1	7.1	7.07	8.11	8.1	8	8.01	7.6	7.57	6.7	6.68
		A24 (591.060)	Women	4.2	4.18	5.3	5.33	6.8	6.78	7.7	7.7	7.02	6.99	7	6.96	6.09	6.1
23		A31 (610.141)–	Men	4.41	4.39	5.33	5.29	6.03	6	6.6	6.59	6.4	6.38	5.53	5.5	5.02	6.93
		A65 (509.193)	Women	4.74	4.76	5.9	5.93	6.9	6.87	7.19	7.2	6.1	6.07	6	5.97	5.21	7.53
24	6	A42 (−524.590)–	Men	6.7	6.68	8.9	8.92	8	8.05	5.21	5.2	3.48	3.5	3.02	3	2.5	2.52
		A46 (−563.846)	Women	7.61	7.57	9.4	9.38	9.1	9.08	5.59	5.6	4.5	4.48	4.1	4.07	5.2	5.18

Column 1: Serial number of compositions included in the experiments.
Column 2: Serial number in the article of the compositions presented in the article.
Column 3: Coloroid hue coordinates and characteristic wavelengths of the colors in the compositions.
Column 4: Gender of the experimental participants.
Columns 5 to 18: Results related to experimental subjects of different ages.
HC, harmony content; PI, preference index number.

The feeling of harmony content of a color composition is influenced by the gender and age of the observer.

The data from the color preference number system is also a contributory factor in the creation of harmonic color composite effect, for people of defined gender and age, in addition to the well-defined relation between the hues of the composition, the saturation and brightness, fixed in the Coloroid color space.

The perception of harmony starts to develop more strongly both in men and in women at the age of 20–30 years.

Women, after the age of 30, are more susceptible to harmony sensations than men.

The intensity of harmony sensation of each composition is synchronized with the color preference of the composition, bearing the harmony, for both men and women.

In case of men monadic compositions, in case of women diadic compositions provide a higher experience for harmony.

Both men and women feel more harmony in those compositions with more saturated colors in their younger ages,

broken colors between the age of 30 and 50, while in older ages they tend again toward more saturated colors.

ACKNOWLEDGMENT

I am indebted to Dr. J. Takacs of Oxford University for his valuable comments on the manuscript.

1. Tragy F. Psychology of childhood. J Psychol 1984;2:8–12.
2. Holden WA, Bosse KK. The order of development of color and of color preference in the child. Arch Opthalmol 1900;29:261.
3. Shinn M. The development of the senses in the childhood. Univ Cal Public Educ 1904;4:148.
4. Engelsberger A, Zeigler O. Beiträge zur Kenntnis derphysischen und psychischen natur des sechsjährigen in die Schule eintretenden Kindes. Exp Pat 1905;2:49.
5. Bullough E. The perspective problem in the esthetic appreciation of single colors. Br J Psychol 1906;2:409.
6. Balldwin JM. Mental Development in the Child and in the Race. 1906. Chapter 3, Brown., Boston; 1906.
7. Binet A. Les idées Modernes sur les Enfants. Paris: Flamarion; 1910.
8. Norris EL, Twiss AG, Washburn M. An effect of fatique on judgments of the affective value of colors. Am J Psychol 1911;22:112.
9. Powelson-Washburn MF. The effect of verbal suggestion on judgments on the affective value of colors. Am J Psychol 1913;24:267.
10. Paul C, Ostwald W. Die Lieblingsfarben der Kinder. Die Farbe 1922;24.
11. Gordon K. A study of aesthetic judgements. J Exp Psychol 1923;6:36.
12. Allen EC, Guilford JP. Factors determining the affective values of colour combinations. Am J Psychol 1936;48:643.
13. Eysenck HJ. A critical and experimental study of color preferences. Am J Psychol 1941;54:385–394.
14. Thomas M. Harmonie des Couleurs. Balliére, Brussel; 1948.
15. Birren F. Your Color and Yourself; the Significance of Color Preference in the Study of Human Personality. Sandusky: Prang; 1952.
16. Granger GW. An experimental study of colour preferences. J Gen Psychol 1955;52:3–20.
17. Guilford JP, Smith PC. A system of colour preferences. Am J Psychol 1959;72:487–502.
18. Bopst H. Color and Personality. New York: Vantage Press; 1962.
19. Frieling H. Farbe in Kultur und Leben. München: Battenberg Verlag; 1963.
20. Saburo-Ohba S. On the color emotive value of Japanese people. Tokyo; 1963.
21. Déribéré M. La Couleur. Paris: Presses Universitaires de France; Dounod, 1964.
22. Frieling H. Das Gesetz der Farbe. Gottingen: Muster-Schmidt; 1968.
23. Déribéré M. La Couleur dans la Publicité et la Vente. Paris: Dunod; 1969.
24. Motokawa K. Physiology of Color and Pattern Vision. Tokyo: Igaku Shoin; 1970.
25. Den Tandt JB. Vorm en kleur bij het kind. [Form and color among children]. Antwerp, Belgium: Standaard Uitgeverij; 1971.
26. Frieling H. Mensch und Farbe. Munich, Germany: Heyne; 1972.
27. Hihara M. Two typical patterns of color preference and Japanese sensitivity. Proc AIC Color 97, Kyoto, Japan, 2, 723. 1997.
28. Kobayashi, S.- Iwamatsu, K.: Development of six methods of volor psychological study. Proc. AIC Color 97. Kyoto; 1997. p 727.
29. Crozier WR. The Psychology of Colour Preference. Rev Prog Coloration 1996;26:63.
30. Xin JH, Cheng K. Quantitative evaluation of colour emotion. ISPS Fund Meeting 71–86, 2000.
31. Sato T, Kajiwara H, Nakamura T. Quantitative evaluation and categorising of human induced by colour. Adv Colour Sci Technol 2000;3:53.
32. Ou L, Luo MR, Woodcock A, Wright A. A study of colour emotion and colour preference, Part II: Colour emotions for two-colour combinations. Color Res Appl 2004;29:292–298.
33. Nemcsics A. Bestimmung von Farbenpraferenz-Indexwerte für farbige Raumgestaltung. Proc Interfarbe 66, Musterschmidt Verlag Göttingen, Zürich; 1966. p 562–574.
34. Nemcsics A. Die bearbeiteten Ergebnisse der ungarischen Farbenpraferenz-Unterzuchungen bezüglich, der Gestaltung des Indexzahlensystems. Proc Interfarbe 67, Drezden; 1967. p 153–176.
35. Nemcsics A. Das Farbenpraferenz-Indexzahlensystems im Dienste der farblichen Raum-gestaltung. ÉKME Tud. Közl. 13, No. 1–2, 1967. p 21–261.
36. Nemcsics A. Die Anwendung der Ergebnisse von Farbenpraferenzunterzuchungen in der Praxis der farblichen Raumgestaltung. Proc Interfarbe 68, Drezden; 1968. p 2–18.
37. Nemcsics A. Préférence de coleurs chez l,homme dans des différentes époques historiques et aujourd, hui. Proc Interfarbe 69, Musterschmidt Verlag, Göttingen, Frankfurt, Zürich; 1969. p 1096–1105.
38. Nemcsics A. Farbenpraferenz-Indexwerte als Farbenkenngrössen. Period Politech Arch 1970;14:14–50.
39. Nemcsics A. A színpreferencia Indexszámrendszer kialakítása. [Elaboration of the Color Preference Index Number System]. Kolorisztikai Értesítő 1979;12:275–286.
40. Nemcsics A. A színdinamika követelményei a színpreferencia vizsgálatokkal és azok eredményeivel szemben. [Requirements of color dynamics for color preference examinations and their results] Kolorisztikai Értesítő 1979;12:264.
41. Nemcsics A. Anforderungen an die Farbenpaferenz-Unterzuchungen. Die Farbe 1980;27:157–167.
42. Nemcsics A. Ausgestaltung eines Farbenpraferenz-Indexzahlen-Systems. Die Farbe 1980;27:168–182.
43. Nemcsics A, Béres E. A Coloroid Színrendszer 48 tengelymetszetének színeihez kapcsolt színpreferencia indexszámok táblázatai I-IV. [Tables of Color Preference Index Numbers for Colors in 48 Axial Sections of the Coloroid System I-IV.] Budapest: Kutatási Jelentés, BME Színdinamikai Gyűjtemény; 1978.
44. Nemcsics A. Colour Dynamics. Environmental Colour Design. New York: Ellis Horwood; 1993.
45. Nemcsics A. Coloroid colour system. Color Res Appl 1980;5:113–120.
46. Nemcsics A. Color space of the coloroid color system. Color Res Appl 1987;12:135–146.
47. Hunt RGW. Measuring Color. New York: Ellis Horwood; 1987.
48. Nemcsics A. Recent experiments investigating the harmony interval based colour space of the coloroid colour system. In: Proceedings of AIC 9th Congress, Rochester, 2001; p 1223–1231.
49. Nemcsics A, Neumann A, Neumann L. Quantitative dichromatic color harmony rules based on coloroid system. In: Proceedings of AIC Color 05, Granada, Spain, 2005, p 1573–1577.
50. Nemcsics A. Experimental revealing of harmony correlations definable within the colour space of coloroid colour system. In: Proceedings of AIC Color 05, Granada, Spain, 2005, p 1391–1395.
51. Nemcsics A. Coloroid colour harmony finder. Patent Reg. No. 203,597, 1992.
52. Nemcsics A, Novak A, Neumann L. Coloroid harmony wizard softwer. CDROM, Coloroid Bt, 2001.
53. Neumann L, Nemcsics A, Neumann A. Computational color harmony based on coloroid system. In: Computational Aesthetics 2005, Girona, Spain, 2005, p 231–240.
54. Nemcsics A. Experimental determination of laws of color harmony, Part 1: Harmony content of different scales with similar hue. Color Res Appl 2007;32:477–488.
55. Nemcsics A. Experimental determination of laws of color harmony, Part 2: Harmony content of different monochrome color pairs. Color Res Appl 2008;33:262–270.
56. Nemcsics A. Experimental determination of laws of color harmony, Part 3: Harmony content of different hue pairs. Color Res Appl 2009;34:33–44.