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Technical Note 152

COORDINATED COLOR IDENTIFICATIONS FOR INDUSTRY

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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When a color is to be identified; the preciseness required of the identification is the first consideration. Usually this is determined by a trial-and-error method which can be both costly and time-consuming. For some uses, a color name consisting of a hue name or a hue name and modifier is sufficient while for others, a notation of the color in a color-order system will suffice. Where maximum precision is required, the color should be measured instrumentally and the results expressed numerically. This paper describes the coordinated series of five levels of fineness of color identification developed by ISCC Subcommittee for Problem 23, the Expression of Historical Color Usage, and is based on the ISCC-NBS method of designating colors. It lists the methods for changing from one level to another and gives examples of the use of each level.

1. Introduction

There has long been a need in industry and science for a coordinated series of different levels of fineness of color designation. Such a series was developed by the Inter-Society Color Council Subcommittee for Problem 23, the Expression of Historical Color Usage, that is, color trends. This series was mentioned in the report[11/] of that Subcommittee in connection with the necessary statistical analysis, and again in the paper, Some Problems of Color Identification[17/], given before the Fall Conference of the Building Research Institute incidental to the description of other color-order systems. This paper will bring into sharper focus the five levels of fineness of color designation inherent in this series.

This series is based on the method of color designation developed at the National Bureau of Standards with the cooperation of the Inter-Society Color Council as an answer to the problem of describing the colors of drugs and medicines in the National Formulary[1/] and in the United States Pharmacopoeia[40/]. In it the psychological color solid[30,41/] was divided into 319 blocks, to each of which was assigned a simple easily understood color name consisting of a hue name, such as red or green, and one or more modifiers to produce designations such as light yellowish brown or pale pink. Since each block is tridimensional, that is, since the color range included in it varies in hue (red, yellow, green), lightness (light, dark), and saturation (vivid, strong, weak), it was necessary to tailor the size and shape of each color-name block so that the color range included would represent the range of color associated by the average person with that color designation. The description of these 319 color-name blocks was included in the paper, Method of Designating Color[14/], published in 1939.

In 1946, this ISCC-NBS (Inter-Society Color Council - National Bureau of Standards) method was revised to take account of suggested changes in the color-name boundaries especially with relation to the textile industry. Some hue names were deleted and one added and the number of color names was reduced to 267. The color-name charts defining the boundaries of these 267 color-name blocks are contained in National Bureau of Standards Circular 553, the ISCC-NBS Method of Designating Colors and a Dictionary of Color Names[19/]. The instructions for determining these color names were extended to apply not only to drugs and medicines but rather to any powder, solid, liquid, or microscopic structure without restriction. The modifier weak was replaced with grayish due to the undesirable connotation of the former in such descriptions as a weak red brick.

2. Discussion

There are many applications in industry and science for which this division of the color solid into 267 parts would be sufficient, but perhaps the most important application of the ISCC-NBS method of designating colors is in serving as the basic structure by which the five levels of fineness of color designation are coordinated. It goes further and contains the first three levels.

For instance, there are nineteen modifiers for the hue range green not including those for yellowish green or bluish green. All of these from greenish white to vivid green can be described as greens; that is, these nineteen color names can be combined or "rolled up" into one hue name. Likewise the ten color names describing yellowish greens can all be described by the hue name yellowish green, and the nine color names describing bluish green colors can be described by the hue name bluish green. Also since yellowish green and bluish green are variations of green they can all be described by the generic hue name green. This then is why the ISCC Subcommittee for Problem 23 called this coordinated series of color-identification systems the color roll-up system, for all the 38 color names describing various greens can first be rolled up into yellowish green, green, or bluish green; and then these three, into the generic hue name green.

The five levels of fineness of color identification each embrace the whole psychological color solid and are related through the ISCC-NBS method of designating colors. In the first level, the color solid is divided into thirteen parts, ten described by a generic hue name, and three neutrals, white, gray and black. These generic hue names are pink, red, orange, brown, yellow, olive, green, blue, violet and purple. In the second level, the color solid is divided into 29 parts, that is ten of the original 13 parts are further divided and assigned intermediate hue names. These intermediate hue names are yellowish pink, reddish orange, reddish brown, orange yellow, yellowish brown, olive brown, greenish yellow, yellow green, olive green, yellowish green, bluish green, greenish blue, purplish blue, reddish purple, purplish red and purplish pink. In the third level, each part of the color solid described by a generic or intermediate hue name is subdivided and to each such subdivision is assigned that hue name and the appropriate modifier descriptive of its lightness and saturation as shown in the table of modifiers in Circular 553 on page 3. These modifiers include vivid, brilliant, strong, deep, very deep, very light, light, moderate, dark, very dark, very pale, pale, grayish, dark grayish, and blackish. The part of the color solid described by the color name gray, is subdivided into three parts to each of which is assigned a modifier descriptive of its lightness, light, medium or dark. This is the ISCC-NBS method of designating colors and consists of the 267 color-name blocks in Circular 553.

Level four of our coordinated series is illustrated by the Munsell Book of Color[2,9,15,18,22,25,26,31]. There are about 1000 color samples in this book which have been prepared with great care to exemplify equally spaced scales of hue, lightness, and saturation, on which the boundaries of the ISCC-NBS color-name blocks are based. That is, the Munsell color system is a true color-appearance system and as such lends itself to interpolation and extrapolation among its color samples. So if the desired color is not found among the 1000 samples, its designation may be indicated by specifying its hue to the nearest half hue step out of the 100 hue steps in the Munsell hue circuit, to the nearest one tenth value step (lightness) of the ten value steps between white (Munsell notation 10/) and black (Munsell notation 0/), and to the nearest third chroma step (saturation). The chroma notation of the most saturated color sample in the Munsell Book of Color is /16. Thus the effective number of hues has been increased to 200 by interpolation alone from the 40 constant-hue charts of the Munsell Book of Color, a five-fold increase; the number of values has been increased from 10 to 100, and the number of chromas has been multiplied by 6. It may be said that by interpolation alone, the effective number of Munsell color samples has been increased by a factor of approximately 5 x 10 x 6 = 300 (or to a total of about 300,000 colors). Also since the boundaries of the ISCC-NBS color-name blocks are specified in terms of the Munsell system, it is easy to determine the ISCC-NBS color name equivalent to any Munsell notation throughout the color solid.

In level five, the color is measured on a colorimeter or spectrophotometer and the results expressed numerically[3,13,32]. The greatest accuracy required in the identification of a color can be realized in this level. The numerical results obtained from a colorimeter or spectrophotometer are usually expressed in chromaticity coordinates (x,y or a,b) and daylight reflectance (Y or R_d) and are reliable to two decimal places and sometimes to three. It is hoped that in the not too distant future, through the development of new spectrophotometers coupled with high-speed electronic computers, values of chromaticity coordinates and daylight reflectances obtained spectrophotometrically can be given correct to three decimal places and possibly to four.

Now let us consider an example whose color can be appropriately described on each of the five levels of fineness of color identification. It is possible that the manufacturer of snow-shovel handles who wanted red, green or blue handles for his product to satisfy his customer's desire for color variety, would be perfectly happy to have nearly any red, green or blue and would not be too fussy about the tolerances within which the handles matched his selected colors. He would thus be using level one. If, however, the green was found to be too yellowish or bluish, he could refine his tolerances by advancing to level two of our coordinated series by stating that he wanted a green handle and not a yellowish green or bluish green one. Suppose now as our manufacturer's knowledge of color increases, and his customers become more sophisticated, he may find through a color survey that he should have specified a vivid red instead of the less expensive uncontrolled red which he had been using. He may have found that vivid red has more eye appeal and further that it contrasts better with snow and green grass. He has thus advanced from level two to level three, that is, to the ISCC-NBS method of designating colors.

If, however, our industrialist's product is one which must "go with" another colored item, he may well find that this division of the whole color solid into 267 color-name blocks does not give him the color selection which he requires. He must then advance to level four and specify his color in terms of the Munsell color system or an equivalent color-order system. Now let us progress to another industrialist, one who produces refrigerators. He may well sublet the contract for the manufacture of the refrigerator bodies and doors to one manufacturer and that of the plastic cooling-compartment doors to another. Here the tolerances are much more stringent and even an interpolated Munsell notation may not suffice. He must then resort to a color measuring instrument, a colorimeter or a spectrophotometer. Both of these instruments have advantages and disadvantages and the industrialist must know both or his inspection costs may become too high. Our industrialist has now advanced to level five of our coordinated series of color identification systems.

From the descriptions of levels four and five, it can be seen that there is a considerable variation of fineness of designation for a color in each of these levels. In level four, for instance, the Munsell Book of Color contains about 1000 color samples, but this figure can be multiplied by approximately 300 through the use of interpolation alone, while other color-order systems which can also be used in this level contain from 943 to 7056 color samples. In level five, the variation in fineness of color designation is accomplished by increasing the number of decimal places used in the numerical notation. Remember that the number of color designations possible with two decimal places (for each of three coordinates) will be increased by a factor of 1000 with three decimal places and by a factor of 1,000,000 with four decimal places. This flexibility is most useful and fortunate in these levels since they will be used more and more in industry and science in the specification of colors and color differences.

In 1943 there was published at the National Bureau of Standards a paper[18] including graphs illustrating the chromaticity coordinates and tables listing the daylight reflectances of the 405 color samples in the 20-hue edition of the Munsell Book of Color. Also in 1943 the Optical Society of America published the results of an extensive study[26] of the

Munsell system which attempted through graphs and tables to define an ideal Munsell color system. To distinguish Munsell notations determined through the comparison of a color with the color scales of the Munsell Book of Color, called Munsell book notations, from notations in the ideal Munsell color system, the latter are called Munsell renotations. From either of these sets of graphs, it is possible to convert chromaticity coordinates and daylight reflectances to Munsell book notations or renotations. The latter are usually used. Lately through elegant programs for highspeed computers[35], it has been possible to determine in a matter of seconds the Munsell renotation of a color from its chromaticity coordinates and daylight reflectance.

Now let us summarize the levels of fineness in reverse order. For maximum accuracy, a color should be measured instrumentally and the results expressed numerically or in terms of a Munsell renotation (level five). If this accuracy is not required, a carefully interpolated Munsell book notation may suffice (level four). If one wants a quick understandable color designation such as that of a moist soil sample before its color changes due to drying, a description in terms of the ISCC-NBS color names can be recorded (level three). If one is interested in the color of a thin section of a sample under the microscope where the thickness of the section is not easily controlled, the hue name of the color in question is usually sufficient (level two). Level one is useful when a quick approximate designation of a color is sufficient or when color changes or trends are being plotted and where more than thirteen lines on a graph would be confusing.

It has long been the hope of the National Bureau of Standards and the Inter-Society Color Council that someday color charts could be added to the color-names dictionary with a characteristic color sample illustrating each of the color-name blocks. These most characteristic colors were considered to be those representing the centers of the blocks and thus are called centroid colors. The ISCC-NBS centroid colors were defined at the National Bureau of Standards by specifications determined mathematically[16] in terms of Munsell renotations, some of the centroids being outside the color range of available pigments. Through financial support from the Inter-Society Color Council the prototype centroid colors meeting the tolerances prescribed by this Bureau were produced by Davidson and Hemmendinger of Easton, Pa., for 214 of the 267 color-name blocks. Mass produced constant-hue name centroid-color charts are in preparation and will be available through the Standard Materials Program of the National Bureau of Standards, Washington 25, D.C. at about $2.00 per complete set.

Through the publication of the Munsell notations of part or all of the color samples of such well known and much used color-order systems as Maerz and Paul (first edition, 7056 colors[20,28]), Ridgway (1115 colors[10,36]), Plochere (1248 colors[21,33]), and the Color Harmony Manual (third edition, 943 colors[8,12,38]), these color-order systems can be used in place of the Munsell Book of Color in level four. Each of these color-order systems has as many as, or more color samples than, the Munsell Book of Color and these samples are arranged systematically throughout the whole color solid. There are other collections of color samples, smaller than the Munsell Book of Color, whose Munsell notations have been published; these include the ninth edition of the Standard Color Card (216 colors[34,39]), produced by the Textile Color Card Association of the United States (now the Color Association of the United States), the Horticultural Colour Chart (800 colors[4,27]), the 256 colors shown in the Nickerson Color Fan[29], the 88 colors used by the American Association of Textile Chemists and Colourists[37], Federal Specification TT-C-595 (first edition, 187 colors[7]), the 17 colors for molded urea[5] and 12 colors for polystyrene plastics[6], the rock colors (115 colors, 1951[24]), and the 196 for soil colors (1954[23]). These smaller collections besides their specific applications, can be used in level three of our coordinated series of color identification systems. In addition to the color samples in the Munsell Book of Color, those in the Color Harmony Manual (third edition) and in the ninth edition of the Standard Color Card have been measured spectrophotometrically and the corresponding chromaticity coordinates, daylight reflectances, and Munsell renotations have been published.

To assist in coordinating the color identifications derived from these many collections of color samples, there are listed in the third part of NBS Circular 553, the color names dictionary, all of the color names used in these color-order systems with their equivalent ISCC-NBS color designations. In the second part of NBS Circular 553, all of these color names are listed, each under its equivalent ISCC-NBS color name. Opposite each of these color names in part two, is listed the numerical or letter designation used in each collection to identify the color sample.

3. Summary

It was the stated purpose of this paper to describe the method, developed by ISCC Subcommittee for Problem 23, of coordinating the five levels of fineness of color designation. The application of this method to the color problems of industry and science is increasing. The change is slow but sure and the dye man in the shop is finding that the advertising man is beginning to understand what he, the dye man, is talking about and vice versa. As the use of this method spreads, men from different industries will find that they have finally a common language for the designation of colors and color differences. One commercial firm is applying this coordinated series to the study of color selection and color trends involving all products that offer the intermediate customer a choice of colors on the manufacturing level as well as the ultimate consumer on the retail level. Through the use of this method it is possible by statistical treatment to correlate marketing data on products whose colors are described in any one of the five levels of fineness of color designation.

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