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Color Harmony: An Annotated Bibliography.

This Bureau has not conducted any work on color harmony; it does not issue color charts showing what combinations of colors are harmonious.

The combination of various colors in pleasing ways is the concern of the artist, the architect, the landscape architect, the interior decorator, and the textile designer. The following bibliography on color harmony not only serves to indicate some important sources of information but also to give a summary of the several conclusions reached. Contradictions between conclusions by the various authorities are not infrequent, and, indeed, are to be expected because of the complexity of the subject.

Rumford, Nicholson's Journal, vol. 2, pp. 101-106, 1797. Rumford's rule: Two neighboring colors are in perfect harmony, - and then only, - when their mixture results in perfect white.

W. v. Goethe, Zur Farbenlehre (On the science of color), vol. 1, Cotta, Tübingen, p. 301, 1810. If the eye perceives a color, there immediately appears another color which, with the first, represents the totality of the hue circle. Hence, one isolated color excites in the eye the need to see the general group. Here is the basis of the fundamental law of color harmony. Yellow demands reddish-blue, blue demands orange, and purple demands green. The view of the whole hue circle causes an agreeable sensation.

Field, Chromatics, London, 1845. Field's rule for a good combination: The separate colors must be so chosen and their areas so adjusted that their mixture, or the result by viewing from a great distance, is a neutral gray. One way to accomplish this is to use 8 parts of blue, 5 of red, and 3 of yellow.

M. E. Chevreul, The Laws of Contrast of Color and Their Application to the Arts (translated from the French by J. Spanton), London, pp. 46-229, (1859). There are six distinct harmonies of color, comprised in two species, analogy and contrast. The harmonies of analogy are: (1) the harmony of lightness steps, - produced by colors of different lightnesses but of the same hue; (2) the harmony of hues, - produced by colors of nearly the same saturation and of neighboring hues; and (3) the harmony of a dominant hue, - produced by contrasting colors but one of them predominating as would result from the view of the colored samples through a slightly colored glass. The harmonies of contrast are: (1) the harmony of lightness contrast, - produced by two colors of the same hue having widely different

lightnesses; (2) the harmony of hue contrast, - produced by colors of different saturation and neighboring hue; and (3) the harmony of color contrast, - produced by colors of complementary or nearly complementary hues, often also of widely different saturation. The harmonies of analogy should usually be preferred; the harmonies of contrast unless employed sparingly result in distraction and in diffusing the attention. Gloss of the surfaces and form of the areas have their influence on these laws. Applications of these laws are given for painting (oil and water-color), tapestry design, calico prints, wall-paper, architecture, interior decoration, clothing, and horticulture.

W. v. Bezold, Die Farbenlehre im Hinblick auf Kunst und Kunstgewerbe (Science of color with regard to arts and crafts), Westermann, Braunschweig, pp. 202-256, 1874. Field's rule is false (1) because the color of one area has an effect on those of neighboring areas; (2) because the colors must accord with the design; and (3) because the best paintings and best ornamental designs show a distinctly dominant hue. The combination of 8 parts of blue with 5 of red and 3 of yellow often fails to yield a pleasing combination. Furthermore, no theory of color harmony based on an analogy between color and music has any value. In general, however, any hue (of highest saturation) may be combined with the hues most resembling it, but if the immediate hue neighborhood be skipped over then the combination is very bad. If the hue difference be further increased, however, the combination commences to improve, and finally for complementaries and near complementaries, the best combinations result. In a 12-hue circle, therefore, the best combinations result from skipping at least three hues, the poorest from skipping two, but combinations which skip less than one are good. For combinations of nearly the same hue, it is important to preserve the lightness relation natural to the hues as illustrated in the hue circle. Color triads should be chosen so as to give equal spaces around the hue circle; groups of four, however, should be two nearby complementary pairs.

E. Brücke, Die Physiologie der Farben für die Zwecke der Kunstgewerbe (Physiology of color for handicraft purposes), Hirzel, Leipzig, pp. 185-282, 1887. There are two sorts of hue intervals which make good combinations, the small intervals and the large. Hue intervals of intermediate size make poorer combinations. For the small intervals, a large lightness difference is particularly good, but in this case the hue difference should be as found in nature; for example, a blue surface illuminated by direct sunlight is light greenish blue (cyan) but in the shadows is dark blue (ultramarine), hence cyan and ultramarine form a pleasing combination. Only those large intervals which are greater than  $1/3$  of the hue circle are pleasing. We may, therefore, have large intervals in pairs and triads but not in larger groups. Black, white, or gray, however, may often be introduced, and small areas of very saturated color may be used as trimming. Each of the main hues may be used at different lightnesses, and also hues which make small intervals with the main hues. Complementary pairs make powerful, striking combinations;

some of these are pleasing, others are not; there is no general law. Association of ideas with particular colors alters the purely physiological considerations; for example, gold may be used more freely than yellow partly because it is associated with splendor and riches. Luster of the surface is important, however, and the relative areas occupied by the various colors. Field's rule, however, is doubly wrong because (1) the proportions of blue, red, and yellow given do not result, as he says, in gray when viewed from a distance; and (2) because the best paintings and ornaments show a dominant hue anyway. A strict numerical rule is not to be expected in color harmony.

O.N. Rood, Colour, 3rd Ed., London, pp. 273-323, 1890.

In general, two colors of nearly identical hue injure one another by contrast and produce a disagreeable combination; but if the two colors are also of widely different brightness so that they may be interpreted as the same surface illuminated to different degrees, they may be safely combined. In these cases it is important to have the direction of the hue change accord with that due to change in degree of illumination, otherwise a contradictory effect may be produced. Some pairs and triads of color are generally pleasing, others not; no simple general rule can be given. Harmful contrast is the most important source of unpleasantness, but an excess of helpful contrast is also harsh and unpleasant. Combining a warm color with a cold one increases this harshness; on this account violet and yellowish-green which are complementary combine with a minimum of harshness because they are of about equal warmth, while red and blue-green form the harshest combination. Large areas of green should be avoided because green is fatiguing; it is also cold so that it produces the contradictory impression of being intense and cold at the same time. Green is the most fatiguing color and yellow the least, the order being: green, violet, blue-violet, blue, red, orange, and yellow. There is less danger of fatiguing with violet or blue, however, because pigments of those colors are generally darker. Harmful contrast may be mitigated (1) by considerably darkening one color; (2) by reducing the area of one color considerably; (3) by adding a third color of considerably differing hue; (4) by using a large amount of gradation; and (5) by introducing beauty and variety of form. In a good triad the hues are separated by about one-third of the hue circle, and two of the colors are warm. Neighboring hues can be added and small areas of strange hues; white or gray may also be added. There should be an aesthetic balance in a color harmony, but aesthetic balance is different from optical balance. Field's rule is therefore false; furthermore, his assertion that red, yellow, and blue in the ratio 5:3:8 gives an optical balance is also untrue since it refers to subtractive combination of glass wedges filled with colored liquids. Aesthetic balance is reached when there is still an optical chromatic excess. No theory of color harmony based on analogy to sound and music can possibly have value.

C. J. Jorgenson, *The Mastery of Color*, Milwaukee, pp. 72-79, 1906. One color must dominate, but the complementary should always be suggested. Use the less saturated colors for the background. Harmonizing pairs are either complementary or not far from complementary. Soft harmonies may be made up from mixtures on one side of the balance point between the components of a harmonizing pair; contrasting harmonies result from a combination of colors on each side of the balance point. Charts are given showing all mixtures between ninety pairs of harmonizing colors.

E.C. Andrews, *Color and its Application to Printing*, Inland, Chicago, pp. 40-90, 1911. Ninety per cent of the work of finding a balanced color scheme lies in finding the proper lightness relations. Colors, disregarding the question of position, size, or shape, will balance in lightness if the contrasts which they make with the background are lightness steps that are visually equal. Thus, on white paper with black type-matter use for ornamentation any color of medium lightness, or any pair whose average lightness is medium, in which case it is best to balance a warm color against a cool one. If the type color is of dark rather than black and the paper light rather than white the lightness average of the ornamenting colors should still fall about midway between those of the paper color and type color. Colors of slightly differing hue but identical lightness and saturation form analogous harmonies. Colors of the same hue and saturation but widely differing lightness form the shade-tint harmonies which are the safest for the novice because lightness alone must be balanced. Another set of harmonies may be formed by combining analogous harmony with shade-tint harmony, as, for example, light blue with dark blue-green. A more difficult set of harmonizing colors is formed by keeping lightness and hue constant and varying the saturation in constant steps, sometimes proceeding through gray to the complementary or other hue. Good color-schemes are due to a balance which combines warmth and coolness (hue), light and shade (lightness), and colorfulness and grayness (saturation). The pleasing proportions of these qualities may be indicated for the novice by rules which the artist by his experience may often disregard with successful result. In general, colors of high saturation should be confined to small areas, and, conversely, the color of a large area should be unsaturated. In contrasting harmonies glaring effects should be avoided; use the law of contrast to make up deficiencies in color medium; avoid injurious contrast. The harmony of balanced contrasts is made up of a triad, the second color of which is neither analogous nor contrasting to the first color, and the third color holds the second color in place, obviating the injurious results of contrast.

R. Beaumont, *Color in Woven Design*, Whittaker, London, pp. 58-59, 1912. The supposition that 8 parts of blue plus 5 parts of yellow plus 3 parts of red makes a harmonious composition is of no practical use. Acute and cultured discriminative power for color is of more consequence in this art than theoretical directions. Color harmony is intricate and more or less incapable of being reduced to rigid principles, yet its general qualities may be

clearly defined. No one color should be conspicuous in the design; balance is an essential. The most saturated colors should be sparingly employed. When the various colors are of equal saturation the areas may be made more equal, variations being introduced only for imparting precision to the leading features of the design.

J.A.H. Hatt, *The Colorist*, VanNostrand, New York, pp. 35-53, 1913. Beauty in color is a matter of individual taste, and this taste is largely a matter of civilization, the child or savage preferring saturated colors, the mature or civilized individual preferring unsaturated colors. In an aesthetic sense, beauty consists either of harmony of hue produced by saturated colors of nearly identical hue, or of colors of neighboring hue combined in varying lightnesses (law of variety). In pictorial art, the lightness variation is large, in decorative art small, and in sartorial art small to intermediate. Large areas of contrasting colors are not beautiful; contrast should be used for accent and then sparingly. In this case, the contrasting colors should be grouped together in a relatively small space and in such proportion that viewed from a distance the result is gray or nearly gray. Combinations of a saturated color with its mixtures with gray, black, or white are pleasing and should be added for variety's sake to combinations of neighboring hues. The range of permissible hues in a combination is very small for saturated colors but progressively widens as saturation is decreased until it takes in the whole hue circle. Chevreul's false law of the contrast of hues had to be invented because of his wrong choice of subtractive primary colors; his harmony of lightness contrast is a restatement of the law of variety.

M.A. Rosenstiehl, *Traité de la couleur au point de vue physique, physiologique et esthétique, comprenant l'exposé de l'état actuel de la question de l'harmonie des couleurs* (Treatise on color from the physical, physiological, and aesthetic viewpoints, including a discussion of the actual state of the question of color harmony), Dunot-Pinat, Paris, pp. 194-267, 1913. Conditions of color harmony have been sought by two methods: (1) analogy with music (Unger, Newton, Seeman, Spangenberg); (2) physiological properties of the eye (Rumford, Goethe, Rosenstiehl). The first method is entirely unreliable. The second method leads to the rule of complementaries in such proportions as to produce white. Studies of the works of the old masters have resulted (Brücke, Schreiber, v. Bezold) in a repudiation of this rule; the use of complementaries should be limited. Chevreul, however, repudiates the rule only for saturated colors of the same lightness; in other cases he recommends its use. Chevreul's solution was good but his chromatic circle contained bad errors. A saturated color next to its saturated complementary is unpleasant because of the brusque transition, but complementaries are pleasant if the transition is gradual (examples, solar spectrum, hue circle). The brusque transition is unpleasant because of the chromatic aberration of the eye which causes us to see the colors in different planes. Hence, color harmony depends on two factors:

(1) retinal fatigue which suggests the use of complementaries; and (2) chromatic aberration which prohibits the use of saturated complementaries in juxtaposition.

M. Luckiesh, *Color and Its Applications*, VanNostrand, New York, pp. 312-326, 1915. Warns against drawing analogies between color and music as recently done by Rimington and Scriabine.

C.W. Hackleman, *Commercial Engraving and Printing*, Indianapolis, pp. 574-590, 1921. For a pleasing artistic effect, use on colored stock, darker ink of the same hue. Use saturated colors for the reading matter, unsaturated colors for the ornamental. Color preference is largely a matter of individual taste, but in general, saturated colors are more pleasing to women than to men; also, there are definite racial trends, for example, Italians, as a race, are pleased by warm, saturated colors, while in England, dark unsaturated colors prevail. In the use of contrasting colors, lightness should be kept about constant. Use saturated colors only as accents amid larger areas of unsaturated color. Complementary harmonies result from taking any two diametrically opposed members of the hue circle, and unsaturated colors give the best complementary harmonies. Analogous harmonies result from combining two or more colors of neighboring hue. Balanced harmonies result from any triad whose members are equally spaced around the hue circle. A self-toned harmony is made up of colors of the same hue but different lightnesses. A dominant harmony is obtained by mixing ink of any one color with a series of inks of other colors. In any harmonious combination variations in lightness may be made, and black, white, or gray added. These rules prevent bad combinations from being chosen; but a skillful artist will produce beautiful combinations without following them.

W. Ostwald, *Die Farbenfibel (The Color Primer)*, Unesma, Leipzig, pp. 43-46, 1922. Colors between which there exists a logical connection are pleasant; if there is no connection the combination is either unpleasant or indifferent. Hence, harmony is identical with order. All possible harmonies may be found by tracing all possible arrangements in the color solid. The simpler the order, the more striking and comprehensible the harmony, as, for example, the hue circle of constant lightness, and the triangle of constant hue but varying saturation and lightness. Some combinations of constant saturation and lightness are immediately harmonious; others are strange, but can be appreciated after they have become familiar. Complementary pairs of this sort make good combinations. Triads should be equally spaced around the hue circle. In the color triangle of constant hue, good combinations may be chosen from any one row of colors (for example, mixture with black, or mixture with white). The two kinds of harmony may be developed in an endless number of combinations.

A. H. Munsell, A Color Notation, Munsell, Baltimore, pp. 78-88, 1923. Warns against the use of musical terms in drawing analogies with color. Good combinations result from colors chosen along any path of the color solid; thus we have combinations in which lightness alone varies, combinations in which hue alone varies, and those in which saturation decreases through zero and then increases in the complementary hue. Other paths are composed of these three in combination. Small areas of saturated color can be used to balance large areas of unsaturated color.

A.B. Klein, Colour-Music, The Art of Light, Crosby-Lockwood, London, 1926. Chapter V, The Problem of Colour Harmony, gives a scholarly and critical review of opinions on color harmony. As advocates of color harmony by analogy with music he lists Aristotle, Newton, Castel, Avison, Field, Hay, Jameson, MacDonald, Barrett, Garbett, Hughes, Seemann, Campbell, Wilkinson, Drobisch, Taylor, and Tudor-Hart. As advocates of harmony by neutral balance, all components cancelling to neutral gray by additive or subtractive admixture, the harmony of complementary colors, he lists Darwin, Rumford, Chevreul, Munsell, Rosenstiehl, and Beaudeneau. As advocates of harmony by measured and ordered divisions of the sensation scales of hue, brightness, and saturation, he lists Helmholtz, Rood, Church, Tanner and Ostwald. The second and third groups are, however, practically one. The final conclusion is that by some sort of regular division of the chief sensation-factor ranges we get color combinations which are not disagreeable. This constitutes a safe method, but it does not exclude the success of combinations which would not, on analysis, be found to conform to this condition. The bibliography on color harmony contains 11 titles, the bibliography on related subjects lists more than 100.

W.J. Miskella, Practical Color Simplified, Finishing Research Laboratories, Inc., Chicago, 1928. Harmony of colors exists only when there is a common color present. Add gray to any two colors to make them harmonize, or add black to one and white to the other. Harmonies are of four kinds; (1) one-hue harmony, (2) associated harmony, (3) true complementary, and (4) split complementary harmony. Complementary colors harmonize only when both have considerable gray in them or when the areas are in proportion to the lightness.

Arthur Pope, An Introduction to the Language of Drawing and Painting, vol. 1, Painter's Terms, Harvard Univ. Press, Cambridge, Mass., 1929.

E. H. Lewis, Modern Color Charts and the New Color Theory, Albany, 1932. Harmonies are classed as related, complementary pairs, or complementary triads.

G.H. Opdyke, Art and Nature Appreciation, Macmillan, New York, 1933. The chapter, Color Harmony and Contrast, divides harmonies into analogous and complementary, the former quiet and restful, the latter lively and likely to be too forceful. The analogous harmonies, however, require a touch of the complementary to be perfectly satisfying. Short quotations on color harmony are given from the writings of Henri, Parker, Moreau-Vauthier, Matthews, Vanderpoel, Neuhaus, Hatton, Day, Sargent, Boigey, Rood, Carpenter, Weinberg, and Chase. A statement in another chapter (p. 323), "There is an instrument at the Government Bureau of Standards at Washington that can give the exact color needed to harmonize with any color you may submit." is wrong; and, indeed, the implication that for every color there exists one, and only one, other color required to produce the perfectly harmonizing pair is not consistent with the discussion summarized above.

J. Littlejohns, Colour Harmony, J. Roy. Soc. Arts, 81, 592 (1933). Criticizes all systems of color harmony and proposes an experimental attack.

Faber Birren, The Printer's Art of Color, Crimson Press, Chicago, 1934. Harmonies are formed from colors of the same or adjacent hues; spectacular effects may be produced by combination of opposite or complementary hues, these are primarily forceful and "eye-catching" rather than beautiful. If one color is to be used with black (print) and white (paper) it should contrast equally with both; that is, it should be of medium lightness; a color chart of six hues reproduced at a medium lightness is given for the guidance of printers desiring to embellish a page of black print on white paper. Warmth and coolness, activeness and passiveness, isolation, diffusion, design, and the use of chromatically colored stock rather than white are discussed in relation to color harmony.

Elizabeth Burris-Meyer, Color and Design in the Decorative Arts, Prentice-Hall, New York, 1935. Chapter IV deals with Color Harmony. Whether two adjacent colors produce a pleasing or harmonious effect depends somewhat upon the previous experience of the observer. The development of color appreciation in an individual may be described in terms of three stages: recognition, imitation, creation. A set of rules may be written as a guide in the creation of color combinations; good and bad combinations result both from following these rules and from disregarding them, but the chance of getting a good combination is greater if the rules be followed. Only a few people are capable of cutting themselves free from all rules. These rules are as follows: (1) Use only a few colors of high saturation in the same scheme; but all hues may be used together if of low saturation. Small areas of strong colors balance or harmonize with large areas of low saturation into a pleasing scheme. (2) Lightness contrast is essential to a harmonious color scheme; if there



is no lightness contrast there is no movement or interest to the composition. The center of interest in a composition must be accented by a sharp lightness contrast. (3) Hue contrast should be chosen to give aesthetic rather than optical balance; the Munsell 5-hue division is more helpful than the division according to the three pigment primaries, red, yellow, and blue. Related harmonies are obtained from combinations of one hue with various grays and from combination of several colors of the same or nearly the same hue but of varying lightnesses, saturations and textures. Contrasting color schemes are given by a pair of complementary hues, by the double complementary combination consisting of any two pairs of complementary hues, by the split complementary combination consisting of one isolated hue balanced against two analogous hues which taken together are the complementary of the isolated hue, by the analogous-complementary combination consisting of a group of analogous hues with an accent of the complementary of the group, by the adjacent complementary triad consisting of a complementary pair with an additional color whose hue is equally distinct from either member of the pair, or by a triad whose hues are equally spaced in the hue circle.

Marjorie S. Cautley, Garden Design, Dodd-Meade, New York, 1935. The chapter on color harmony indicates two types: complementary hues, and analogous hues. Use of grays is advised to avoid glaring combinations. Charts are shown of certain of the Munsell samples illustrating the effect of background on garden design.

E.C. Allen and J.P. Guilford, Factors Determining the Affective Values of Color Combinations, Am. J. Psych. 48, 643-648 (1936). This is a report of an experiment on color harmony. Whether a pair of colors is pleasing depends largely upon whether each one individually is pleasing. There is some evidence that either very small or very large hue differences give more pleasing combinations than do medium differences, especially for women. Pairs exhibiting large differences in lightness are preferred especially by men. There is a slight preference by women for combinations with small differences in saturation.

