Form and Symmetry: Art and Science
Buenos Aires Congress, 2007

COLOR SOLIDS INFORMED BY SYMMETRY

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Abstract: Runge's Color Sphere, encompassing every possible pigment, set the standard for color models. It and all variations leave questions. There is a problem with purple. Based on the Nonné-Klee color triangle, a new color solid is proposed —one that is studied as a triangular prism, but finally transformed into its dual, a hexahedron.

The Runge Color Sphere (Farbkugel) is a powerful proposition. Most other models of color theory, dealing with pigments, are essentially variations of this model; but all have left questions. It is important, however, to keep in mind that any theory of pigmentary color is an idealization. Pigments come from concrete materials. The most challenging problem is obtaining true primary colors. Ironically, in practical terms, primary colors are not needed, excepting in convincing demonstrations of color theory principles. I was introduced to Runge's model at the Ulm School of Design in 1956-57 by Helene Nonné-Schmidt, student of the Bauhaus and wife of Bauhaus Master Joost Schmidt. In a practical exercise, she had our class execute what I call the Nonné-Klee (N-K) triangle. (She attributed the triangle to Klee, but I have not found it depicted in his pedagogic papers, though I have found a diagram and text that touch on it.) (Spiller 1961: 496-498) Among Nonné's other practical exercises, two are especially instructive for this initiative: (1) that (after Schopenhauer) the conspicuously different light intensities of the fully saturated hues have consequence; (2) that the red-green, blue-orange, yellow-purple complementary color pairs are not strictly accurate—along with how to find truer complimentary pairs. Despite the splendidness of Runge's Color Sphere, I quickly recognized, owing to the N-K triangle, some deficiencies; and I concluded that the color solid has to have a triangular midriff. Because of the antipodes of white and black, I envisioned a triangulated hexahedron (two tetrahedra sharing a common face at mid-plane). I made sketch notations some years ago, filed them away, and closed the book.

I was recently prompted, indeed provoked, into reviewing the whole color theory from top to bottom. In mid-2006, a rather complete image came to me: The color solid is a triangular prism with a major color plane that (as earlier considered) is tilted. The triangular major color plane has these features: (1) the primaries at the three vertices; (2) the fully saturated secondaries serially distributed along the triangle's three edges; (3) the desaturated tertiaries distributed inside the triangular ring of spectral colors; (4) middle grey at the centroid. The rest of the solid, its bulk, is given to the tints, rising to white, and the shades, descending to black. Though every single color is but a single point, for practical reasons, it has been conventional that select increments of color are allotted demarcated areas on the major color plane and volumes in the solid. Because the polar extremes are a single white point at the top and a single black point at the bottom, a feasible topological operation was preformed by converting the two points into a plane of white at the top and of black at the bottom. Many theorists have squeezed out the numbers of colors as colors approach the white and black vertices. Having Schopenhauer in mind, I resolved that each qualified color on the major color plane has a claim to all its tints and shades to the extremes. I re-designated my Color Prism a "study model"; for after all exploration and examinations are satisfied, the topological transformation of white and black apices to white and black planes, is to be reversed—duly preserving the prerogatives of the tints and shades of all colors of the major plane.

A little later, I had a realization: There is a problem with purple. For one, purple is not in the rainbow. "Although the spectrum ran in a straight band from red to [spectral indigo], Newton did the ingenious thing of twisting it into a circle. ... The connecting link was purple." (Birren 1969: 10) But the major problem with purple is that most color theorists concur that it has the lowest light intensity of all the fully saturated colors. The geometry of the N-K triangle fixes purple above the intensity of blue. If that mid-step on the triangle's edge is not purple, then, where is it? This raises a circular question: Do we know what yellow and red and blue really are—much less what the purplest purple is. Another problem with purple: Its complement is not yellow, but a yellow-green. Ostwald asserts that major complementary pairs are as follows: yellow / ultramarine blue; orange / turquoise blue; red / seagreen; purple / leafgreen. (Birren 1969b: 37) I confirm this, in principle, from Nonné's practical exercise, which involves (1) a stipulated color, (2) an assumed color, (3) a found color. Taking purple as the stipulated color to pair with its complementary partner, yellow is assumed from consulting the traditional color chart. Mix yellow into purple until the most neutral color is achieved. If that color, is too warm, add green to the yellow; if, too cool, add orange to the yellow. New tests are made, until the real complementary is found. For simplicity, I have stayed with the traditional notion of complementary pairs. The Ostwald complementaries merely call for the minor re-calibrations of secondaries.

I reviewed the proposals of past theorists. Certainly Philipp Otto Runge set the standard with his Color Sphere in 1810, a little short of three centuries after Magellan's fleet included in orderly fashion." (Birren 1969: 14) My model parts company with Runge's in its circularity. Newton made a ring of the spectrum in 1666; in 1766, Moses Harris layered watercolors in a circular plane, demonstrating how three colors, the primaries, made all secondary colors. Goethe, whose color theory is dated in the same year as Runge's, rendered one study in a triangle, which includes tertiaries of the first order. Klee treated the spectral color circle as a venerable familiar, but then wrote of the virtues of a "blue-yellow-red" equilateral triangle where notably "on every side of our flat triangle ... half-way points are neutral [italics added] points." (Spiller 1961: 496-498) These "neutral points" are orange, green, and purple.

I was only recently introduced to Arthur Pope's color theory—and gratified to find that he had a tilted major color surface. Then I hastily dismissed his work when a key diagram betrayed a flaw. On a traditional circular diagram of fully saturated hues, he drew a straight line from red to orange and wrote: "If a red pigment is mixed with orange, the mixture falls approximately along the line R-O—there is slight loss of the [saturation] of the two hues. ... If the R is mixed with Y, the mixture falls along the line R-Y, and the halfway point is ... still nearer the [grey] center." (Pope 1949: 17) The fault of Pope's arranging the spectral colors circularly and then straight-lining their relationships, had me overlooking his immensely valuable observation: Orange is closer to grey than red or yellow are. This was hard to get into my mind. Orange is part of the spectral array of pigmentary colors. Slowly it seeped through. Mixing brilliant red with brilliant yellow produces a color that is less brilliant. It is called a secondary, not a tertiary; nonetheless, it approaches grey. That same information is inherent in the N-K triangle. Klee has called those same colors, half-way on the sides of his triangle, "neutral." In late 2006, I found in Birren's edition of Ostwald, the 1758 color solid of Tobias Mayer, which was "never built" (Birren 1969b: 9-10)—a triangular prism—virtually my study solid. I also noticed in Birren's edition of Munsell, the Munsell "Color Tree" (Birren 1969a: 26-27), which loosely approximated my Color Prism—though without the tints and shades.

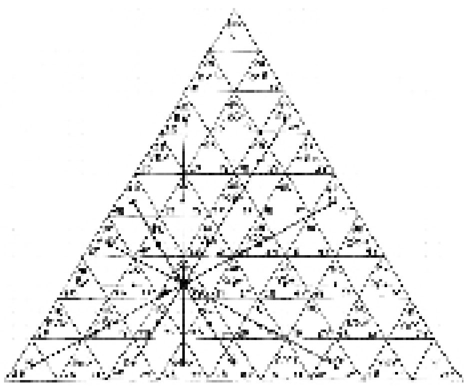

Figure 1: Diagram of the Nonné-Klee triangle as the major color plane, mapping the tertiary indigo or blue grey. (Numbers indicate exponential graduations.) The geometry of the N-K triangle is re-validated in this diagram. All simple mixes of colors that can produce the same indigo can be mapped on the N-K triangle with straight-line relationships that pass though a single point. Straight lines drawn between the same paired spectral colors, when arrayed in a circle, will not pass through that unique point where indigo is located.

In mid-2007, while putting together my notes from the past year, one pesky question re-emerged: How can yellow and purple be complementary, if yellow has the highest light intensity and blue, not purple, has the lowest light intensity in my model? I revisited two geometric features of the N-K triangle: (1) purple falling between red and blue; (2) purple being opposite to yellow, with middle grey between. I decided on a new study model: I returned the N-K triangle to the horizontal plane of the color solid and had tints rise and shades descend from it, This forms a prismatic solid with two parallel triangular ends that are titled, rather than the major color plane; this re-emphasizes the primacy of the N-K triangle. The major color plane is a fact. All the major dynamics of color take place within it: More brilliant colors cannot be found outside this plane; richer tertiaries cannot be produced outside this plane. The different light intensities of each color of the major plane determines how the tints and shades are resolved. Yellow and purple meet in a straight line at middle grey—with purple being closer to grey, as both Klee and Pope point out.

A consideration of pigmentary color as a Galois Group is informative. Newton's complete set of spectral color, importantly including his purple, constitutes a Galois Group. The third law of Group (identity member) is satisfied by white light: white light, added to any colored light, leaves that colored light unchanged. The fourth law (reciprocity) is satisfied: There is a complementary colored light for any given colored light, and the two added together will produce white light. But pigmentary colors, totally embodied in any Color Solid, do not constitute a Group. They do have Group property: Any two, mixed together will produce another color that is within the parameters of all colors. However, there is no identity color. White is not it here. Neither is middle grey, though it is common to all complementaries. Middle grey (or white), added to another pigmentary color, will change that color. The deficiency that keeps this splendidly organized set of pigments from being a Group is profound. Something is awry. Nonetheless, the Nonné-Klee color triangle is a concrete actuality. The direct argument of purple having higher light intensity than blue is stronger than the indirect argument of purple (or true complementary) having to have the lowest light intensity because yellow has the highest one. The imperative test of complementaries is to meet at middle grey, again the Nonné-Klee triangle shows that purple (or Ostwald complementary) is already half the distance to grey that yellow has to go.

The two prismatic study models are deformations of one another. The reversal of the transformation of both prismatic studies back to hexahedra (into their topological duals) is in line with both Paul Klee's proposed three-dimensional solid of under a century ago and my earliest considerations, as a student of Nonné, a half century ago.

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