Systematic Approaches To Color Interaction: Limited Palettes For Simultaneous Contrast Effects

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Abstract

The phenomenon of simultaneous color contrast, the illusory effect by which a color appears to change its identity when seen in the changing contexts of other colors, is examined in this paper as the basis for systematized color palettes. Artist James Mai explains the principles of simultaneous color contrast illusions; how these illusory effects may be predicted, organized, and diagrammed; and how the principles of simultaneous color contrast form the basis of his *color-interactive palettes*. The author identifies three distinct types of color-interactive palette: the *divergent*, *convergent*, and *compound*, and describes how these palettes serve as systems of color selection for simultaneous contrast effects in his paintings.

Introduction

Color is not a static and stable property of objects, but rather a dynamic and highly changeable visual phenomenon of human perception. It is a remarkable fact that a single color may appear simultaneously as two or more different colors simply as a consequence of being seen in proximity to other colors. For example, given two small areas of the same green, the first surrounded by a field of blue and the second surrounded by a field of yellow, human perception will see the former as a decidedly yellowish green and the latter as a bluish green. This is due not to any difference of spectral reflectance from the two areas of green—both are measurably identical greens—but rather to the adaptive manner in which the eye and brain apprehend colors in relationship to other colors. This phenomenon is known as *simultaneous color contrast* and constitutes one of the most interesting potentials of color for the artist. As a painter, I have for many years sought to examine simultaneous color contrast in my studio work by (A) making this color activity the organizing principle of my compositions; (B) articulating strategies for predicting and enhancing its illusory effects; and, most important to my work, (C) systematizing its use in limited color palettes, whereby maximal illusory effects may be attained within a minimal range of colors. While I shall discuss all of these in what follows, it is the last point that will be the focus of this paper.

Color Terminology and Diagrams

Before proceeding with a deeper examination of simultaneous contrast and color-interactive palettes, it will be useful to establish the color vocabulary important to the task. While the artist and colorist Josef Albers intended the term *color interaction* to include a wider variety of color illusions than our topic here, its usage has become so closely associated with *simultaneous color contrast* that I shall use these two terms interchangeably to denote the contextual relativity of color as described in the opening paragraph. Additionally, I shall employ the following terms and associated meanings to describe three variables of color: *hue* denotes the spectral identity of a color, that quality of color that distinguishes redness from

yellowness from blueness, etc.; *value* denotes the lightness or darkness of a color, such as the difference between "pink" (light-value red) and "wine" (dark-value red); and *intensity* denotes the purity or dullness of a color, such as the difference between "slate-grey" (low-intensity blue) and "sapphire" (high-intensity blue). I shall employ the terms *low-intensity* and *neutral* interchangeably to indicate the lowest possible state of de-intensification, what one would characterize as grey, devoid or nearly devoid of any identifiable hue. Every instance of perceived color includes simultaneously all three—hue, value, and intensity—in some measure, so we shall refer to these as *dimensions* of a color. The word *color* will refer to any perceivably unique combination of hue, value, and intensity; if one or more color dimension is changed by a perceptible degree, then a new *color* is experienced.

These relationships may be more clearly understood in diagrammatic form, as shown in Figure 1. Value and intensity have high and low limits, and so are shown as linear scales (vertical bars), while hue typically is diagrammed not linearly (as one might see in a light spectrum) but as circle of continuously changing hues. While it would be possible to establish more detailed increments and vocabulary, we must be content in the limited space of this paper to make approximate references, using five descriptors for value (*light, middle-light, middle-value, middle-dark, dark*) and intensity (*high, middle-high, middle-intensity, middle-low, low*), and twelve for hue (*yellow*, *red*, and *blue* as primaries; *orange*, *violet*, and *green* as secondaries, which are mixed from primaries; *yellow-green*, *yellow-orange*, *red-orange*, *red-violet*, *blue-violet*, and *blue-green* as tertiaries, which are mixed from primaries and adjacent secondaries).

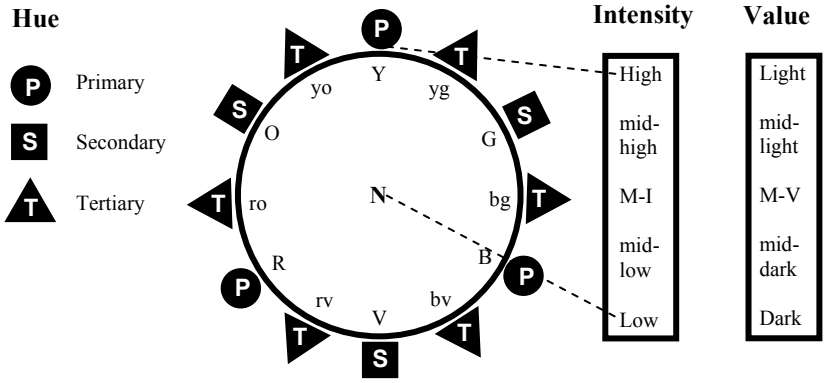

Figure 1: *The color-dimensions: hue, intensity, and value*.

The final term that will be important to our investigation is *complementary hues*; this denotes pairs of hues which, when mixed in the correct proportions, cancel each other in *neutral*. This fact permits us to see the integral relationship between hue and intensity, which together may be diagrammed in the circle (see dashed lines in Figure 1), where (A) complementary hues are positioned diametrically across from each other; (B) intensities change gradually from high at the outer edge of the circle to low intensity / neutral at the center of the circle; and (C) diametrical lines joining complementary hues display all intermediate intensities and neutral as varying proportions of the two complements in mixture. Note that in Figure 1 the intensity scale is separated from the hue circle to show its increment-terms and to explain its radial position within the circle; subsequent diagrams in this paper will be simplified, eliminating the verbal descriptors and displaying intermediate intensities at their appropriate positions within the circle.

These diagrams are also used in the description of my modular color palettes, of which these color-interactive palettes are special cases, and the reader is encouraged to consult [1] for a more extended explanation of the color dimensions, modulations, and terminology regarding these palettes and their diagrams. For further reading on two- and three-dimensional color models (of which there are many) and color nomenclature, the reader may find useful information in [2] and [3].

The Principles of Simultaneous Contrast

Although noticed and briefly commented upon by artists and scientists since at least as early as Leonardo da Vinci in the 15th century, it was not until the 19th and 20th centuries that simultaneous contrast began to be studied carefully and employed aesthetically by artists. The French colorist and chemist, M. E. Chevreul made the first extensive study of simultaneous color contrast in 1839 [4], and the phenomenon was further investigated and turned to modern aesthetic purposes by the artist, colorist, and educator, Josef Albers in the middle of the 20th century [5].

Constituent and Contexts. In simultaneous color contrast, a dominant *context* color exerts an influence on a smaller *constituent* color, causing an illusory shift in the hue, value, and/or intensity of the constituent color. Simultaneous color contrasts are usually most easily seen when: (A) each color is "flat" and unchanging, occupying an area with clearly defined edges; (B) the context color occupies more area than the constituent color (usually in a minimum ratio of approximately 15:1); (C) the context color completely surrounds and contacts the edges of the constituent color; (D) the constituent color is seen in two or more color contexts, such that the eye may compare and recognize the differing appearances of the constituent. The final point is particularly important because an illusory color shift is perceivable almost always only by comparing the constituent color in at least two different color contexts that exert different influences on the constituent—a single constituent in a single context produces no appreciable effect because it offers no comparative contrast.

Illusory Exaggeration. Simultaneous color contrast, as the term suggests, operates principally by contrastive effects of hue, value, and/or intensity. More particularly, the effect of simultaneous contrast may be described as *the illusory exaggeration of the actual differences* between context and constituent colors. For example, Figure 2a shows the same middle-value constituent on a light-value context at the left and on a dark-value context at the right; due to simultaneous color contrast, the constituent appears darker at left and lighter at right. Described another way, at left the middle-value constituent is *actually* darker than the context color, and that relationship is illusorily exaggerated to cause the constituent to appear even darker; the same is true in the opposite value direction at the right—and when the two relationships are compared, an illusory difference results. We may now employ our color diagram to chart this dynamic relationship between the *actual* value locations (black circles) and the *illusory* value shift (white circles), albeit the latter with approximated locations (Figure 2b).

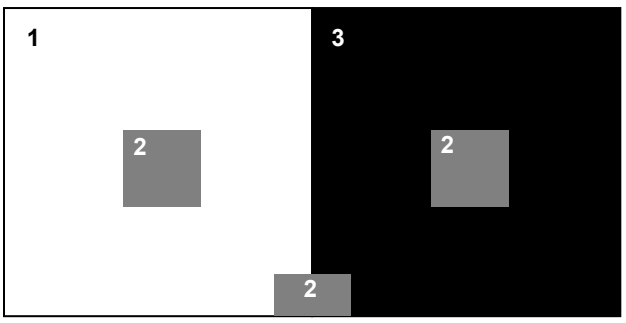

Figure 2a: *Divergent simultaneous contrast of value.*

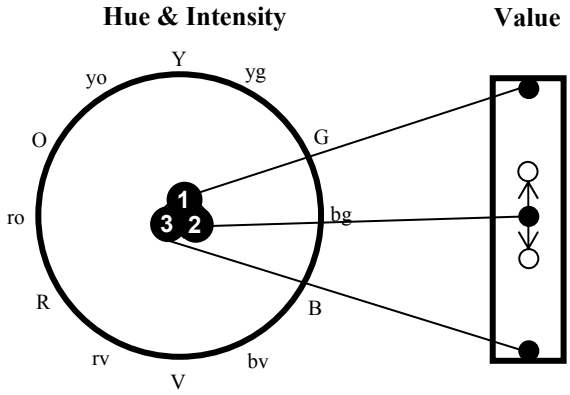

Figure 2b: *Diagram of palette used in Figure 2a.*

It must be noted at this juncture that value interactions are the only simultaneous contrast effects actually perceivable in the black and white printed version of this paper; the intensity and hue interactions below will be fully and accurately described and diagrammed, but to perceive the effects visually in the paintings the reader is strongly encouraged to access the full color, digital version of this paper.

Intermediate and Extremes. Simultaneous contrast depends upon the relationship between *intermediates* and *extremes*, where the constituent color must be intermediary in hue, value, and/or intensity between more extreme context colors. *Intermediate* and *extremes*, here, are relative rather than absolute terms; the requirement for simultaneous color contrast is simply that context colors be "more extreme" than the constituent, and that the constituent be intermediary between the given extremes. In Figure 2a, the simultaneous contrast effect would still occur, though to a different degree, if the context values were darker than white at the left and lighter than black at the right. This general principle also holds true for intensity and hue interactions, though it must be adapted to the different properties and extremes for each dimension. Intensity operates similarly to the value example discussed above. A middle-intensity color will appear more intense if seen in a lower-intensity context, and it will appear to be less intense if seen in a higher-intensity context. The middle-intensity can also be made to appear more intense by any color taken from the diametrical line joining that hue to its complement, including neutral and the various intermediate intensities of the complementary hue. The most dramatic influence in illusorily raising the intensity of the middle-intensity constituent would come from the complementary hue at high-intensity.

For hue, however, the structure is different. Since hue changes continuously around the circle and not linearly with absolute high and low limits, as we find with value and intensity, how do we locate extremes that will effect a change in the constituent? The strategy is to find the hue that is *complementary to the hue intended to be amplified* in the constituent. For example, if a constituent green is seen in an orange context, the green will appear bluer (the complement of orange), and if the green is seen in a violet context, it will appear yellower (the complement of violet). Other hues intermediate between the constituent and the complement of the induced hue will have, to lesser degrees, a similar effect on the green: while orange causes the green constituent to become more blue, so does yellow-orange, yellow, and even yellow-green; similarly, blue, blue-violet, or even blue-green cause, to differing degrees, a yellowing effect on the green similar to that caused by violet.

Divergence and Convergence. While the discussion up to this point might suggest that the only function of simultaneous color contrast is to "split" the appearance of a color into multiple appearances—to make a color *diverge*—it is also possible to invert that process and illusorily to bring two different colors into proximity—to make different colors *converge*. The latter illusion occurs when the hue, intensity, and/or value dissimilarities between two different constituent colors are exactly compensated for or cancelled by the context colors. Value, shown in a divergent interaction in Figures 2a and 2b, may also be employed in a convergent interaction, as shown in Figures 3a and 3b. In this convergent value interaction, a middle-light value, situated in a light context at left, and a middle-dark value, situated in a dark context at right, appear to be quite similar; the actual difference between these constituents becomes apparent only when we see them next to each other in the lower center of Figure 3a.

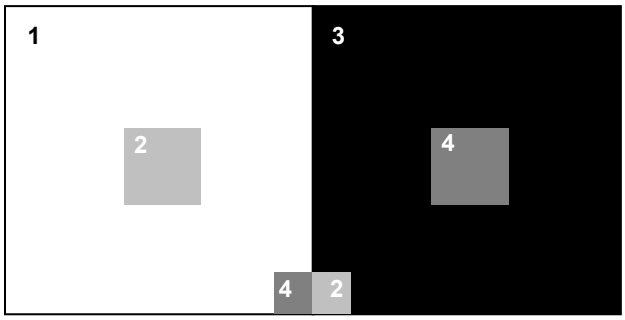

Figure 3a: *Convergent simultaneous value contrast*.

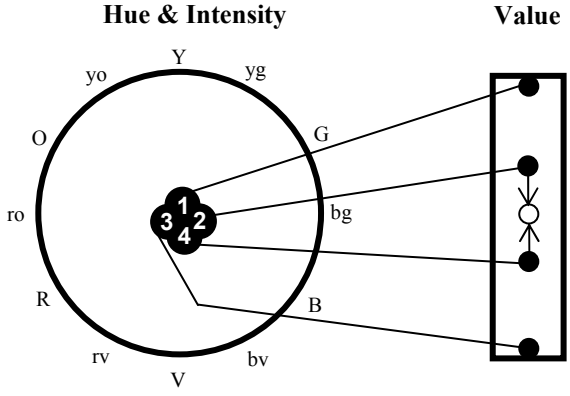

Figure 3b: *Diagram of palette used in Figure 3a*.

The Color-Interactive Palettes and Paintings

Over the years I have developed as the basis for my paintings *color-interactive palettes*, systematized selections of a small number of colors that are balanced and adjusted to one another so as to maximize simultaneous contrast / color interaction effects. In the discussion that follows, I shall introduce three different types of color-interactive palette: the *convergent*, *divergent*, and *compound* (a combination of convergent and divergent functions). Each will be discussed, diagrammed, and exampled by a painting in which I employed the given palette-type. This color-interactive palette strategy is an extension of that employed in my modular color palettes, whereby general *palette-types* are developed, each of which generates multiple *palette-versions* [1]. For example, a palette-type that calls for a secondary hue may give rise to three different versions when each of the three secondary hues is separately employed.

The Divergent Color-Interactive Palette. I often design color-interactive palettes for paintings in which a single, continuous colored line (the constituent) crosses over differently colored rectangular fields (the contexts). In the painting *Interchange (Violet)*, Figure 5, a violet line is "split" into four different color identities as it encounters four different color contexts. The palette-type for this painting is diagrammed in Figure 4, and the numbers on the diagram correspond to the numbered line and areas of Figure 5. This palette is built around a constituent color that is deliberately intermediate in all three color-dimensions: a secondary hue at a middle value and a middle intensity. This gives the constituent color the capability of diverging in all three color dimensions, yielding a total of six different directions of divergence.

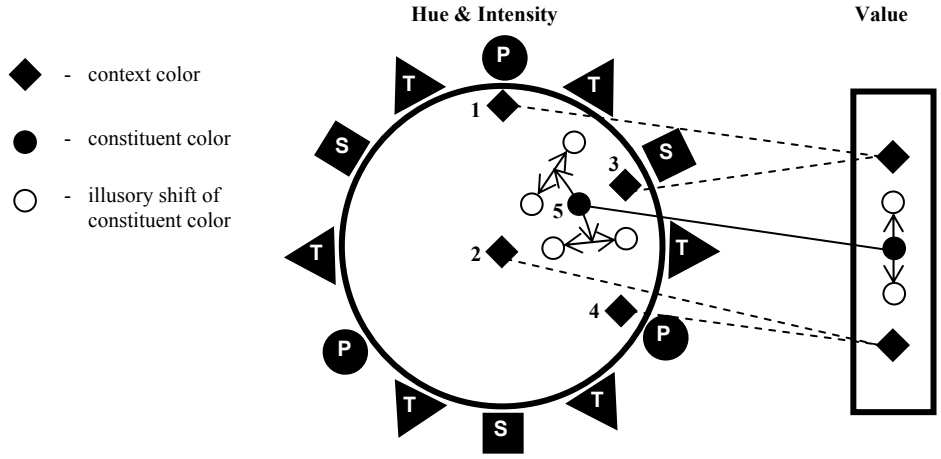

Figure 4: *Diagram of the divergent color-interactive palette-type used in the painting of Figure 5.*

Figure 5: *"Interchange (Violet)," acrylic on canvas, 22 x 42 inches.*

These six directions of illusory change in the line color—warmer and cooler hue, higher and lower intensity, and lighter and darker value—have been collapsed into four context areas of the painting, meaning that the line changes in some combination of hue, value, and/or intensity in the following ways: (A) in the lighter and higher intensity violet context at upper left (color 3), the constituent (color 5) appears darker in value and lower in intensity; (B) in the darker and neutral context at upper right (color 2), the constituent appears lighter and higher in intensity; (C) in the darker value, blue context at lower left (color 4), the constituent appears lighter in value and redder in hue; and (D) in the lighter value, red context at lower right (color 1), the constituent appears darker in value and bluer in hue.

The Convergent Color-Interactive Palette. As mentioned above, two or more different colors may be made to appear similar, or even the same, through simultaneous color contrast. This strategy is more complex because it involves color combinations that aim for specific changes in each constituent color that exactly compensate for the differences between them. This requires that the constituent colors possess a reasonable potential to appear similar to each other, so the differences between the constituent colors cannot be so wide as to be incapable of being "pushed" together by the context colors—for instance, a high intensity blue and a high intensity orange cannot be made to converge. Yet complementaries as different as a middle intensity blue and a middle intensity orange can, with careful color adjustments, be made to converge. This is the basis for the convergent color-interactive palette, diagrammed in Figure 6, employed in the painting *Convergence (Blue / Orange)*, shown in Figure 7.

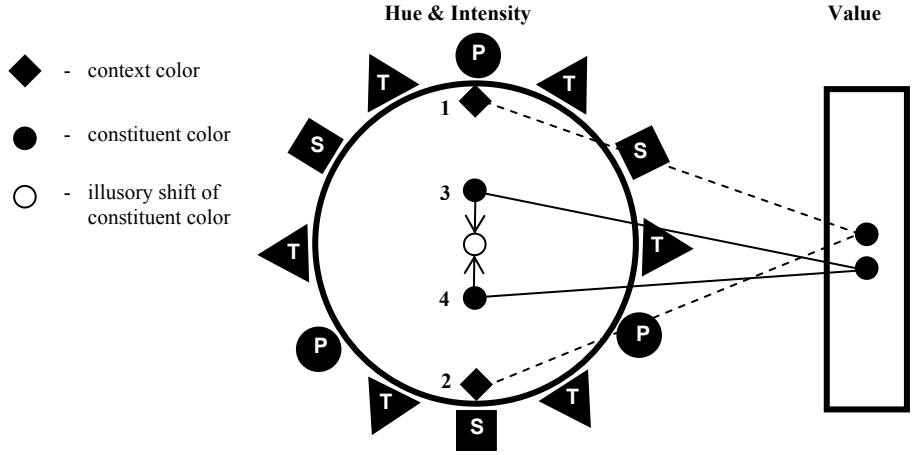

Figure 6: *Diagram of the convergent color-interactive palette-type used in the painting of Figure 7.*

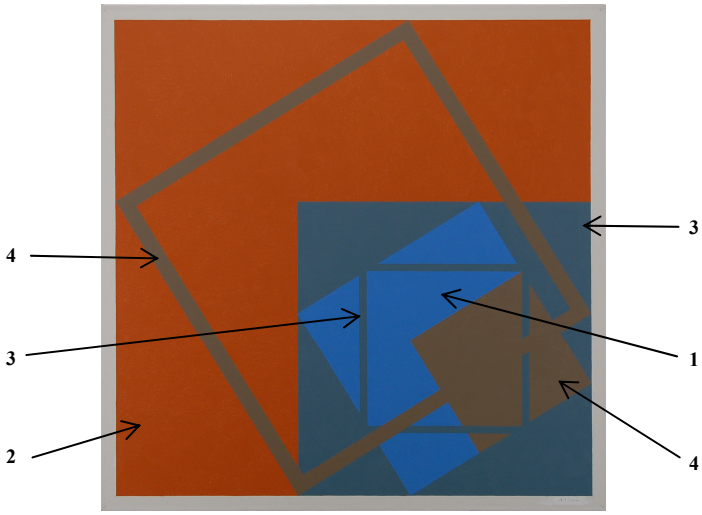

Figure 7: *"Convergence (Blue / Orange)," acrylic on canvas, 32 x 32 inches.*

The interactive effects in *Convergence (Blue / Orange)*, one of a series of three paintings utilizing the same palette-type, are as follow: (A) in the upper left, a middle-intensity orange line (color 4) appears to be neutral on a high intensity orange context (color 2, the large L-shaped area); (B) in the lower right, a middle-intensity blue line (color 3) appears to be neutral on a high-intensity blue context (color 1, the smaller L-shaped area contained inside the square at the lower right); (C) in the lower right square area the two constituents (colors 3 and 4) are juxtaposed so that the actual difference between them may be seen. The illusory result, of course, is that the two constituent middle-intensities appear to be the same color, neutral. Recognition of both the illusory similarity and the actual difference depends upon a compositional organization that permits the viewer to follow a color from one context to another and to know that it is actually the same color. In this case, it is vital that the viewer be able to recognize that the line in the upper left is not actually neutral, but is the same "brownish" middle-intensity orange seen in the lower right. The same is true of the middle-intensity blue line.

The Compound Color-Interactive Palette. This palette combines the convergent and divergent functions in the same group of colors; the following simple example employs only two constituent colors and four context colors. White is also used for compositional purposes, but it plays no role in the interactions. The palette is used for the painting, *Territorial (Orange / Green)*, seen in Figure 9. In this composition, two color-lines, one orange and the other green, are made to converge in the following ways: (A) in the lower left quadrant, the middle-low intensity green line (color 5) appears to be neutral on the high-intensity green context (color 6); (B) in the lower right quadrant, the middle-low intensity orange line (color 1) also appears to be neutral on the high-intensity orange context (color 2). As those lines emerge into the upper quadrants, their differences become apparent and they diverge as follows: (C) compared to the lower left quadrant, at the upper left the green line appears to be bluer, darker, and more intense on a high-intensity yellow context (color 4); and (D) in the upper right quadrant the green line appears yellower, darker, and more intense on a high-intensity violet context (color 3); (E) compared to the lower right quadrant, at the upper right the orange line appears to be yellower, lighter, and more intense; and (F) in the upper left quadrant the orange line appears darker, warmer, and more neutral—indeed, the orange line is pushed past neutral towards violet, the complement of the yellow context, appearing to be similar to the violet of the upper right quadrant. Such is the malleable nature of color.

This compound palette derives from a palette-type that generates three palette-versions by means of secondary hue substitutions, but because of the complexity of the color relationships in this painting, the diagram in Figure 8 is the palette-version specific to this orange and green painting. Although the details of the diagram require some interpretive effort, one may readily see how a single physical color (each black circle) is illusorily shifted to multiple locations. It becomes clear both in the diagrams and the paintings that our color perceptions are not static, but instead move about dynamically in color space.

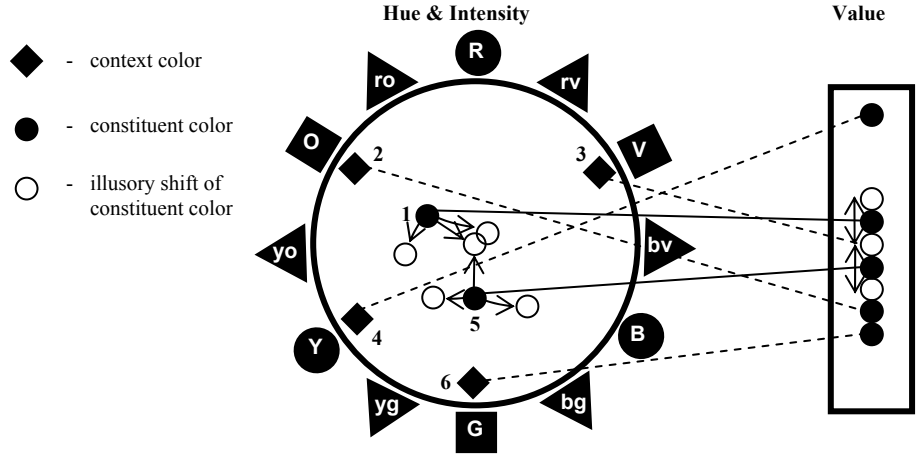

Figure 8: *Diagram of the compound color-interactive palette-version used in the painting of Figure 9.*

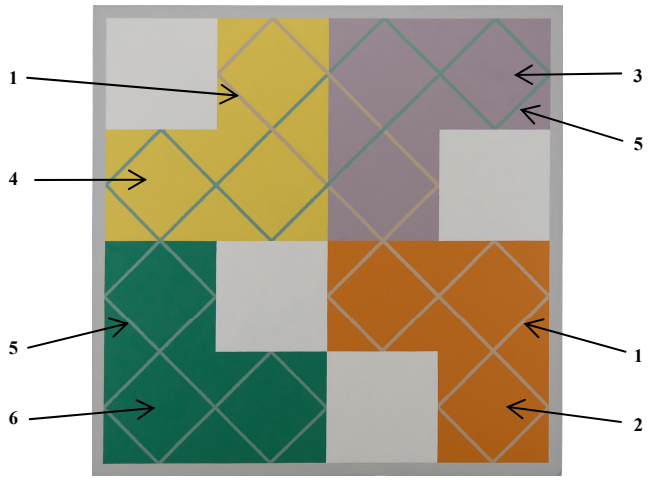

Figure 9: *"Territorial (Orange / Green)," acrylic on canvas, 34 x 34 inches.*

Conclusion

It is important to note that these color-interactive palettes have developed only after many years of empirical work in the studio, using colored papers and paints to test and adjust these color relationships until optimum solutions were found. From that accumulated experience, I have sought to articulate some principles by which simultaneous contrast operates, and subsequent to that I have developed these palettes at an attempt to systematize the color selections. But the dynamic exchange between theory and practice is ongoing. The implications of color interaction go far beyond visual tricks. In my paintings, simultaneous contrast effects serve at least three metaphoric and philosophical purposes: (A) Color does not reside well in memory; its subtlety and richness are best understood in the moment of perception—so the content of my paintings is in part about one's self-awareness of the act of seeing. (B) The color shifts of simultaneous contrast make it clear to the attentive viewer that perception is not simply passive reception, but rather an active and ongoing interpretation of stimuli acting on us—my paintings are meant to heighten awareness that the world as we know it is restructured, or even in some sense constructed, by act of perceiving. (C) That the appearance of a color is contextually relative implies that our engagement with the world is one of adapting to ever-changing relationships, which implies a shift of attention from the "nouns" to the "verbs" of existence—and so, by metaphoric extension, my color-interactive paintings are meditations on our engagement with the world as fundamentally one of *becoming*, more than of *being*.

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