# Compositional Constraints of Simultaneous Color Contrast: Toward a Classification of Types

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## Abstract

Simultaneous color contrast, the illusion of change in a physically constant color, is often explained as resulting from color relationships only, with little or no acknowledgment of the importance of shape relationships to the illusory effect. Taking the standard color interaction chart as the point of departure, the author identifies compositional features that are both necessary to and optimal for simultaneous color contrast illusions. A typology of compositional organizations is proposed, along with a diagrammatic system for mapping the color interactions. The four compositional types, *simple-uniform*, *simple duo-form*, *complex uniform*, and *complex duo-form*, are examined through diagrams and examples of the author's paintings and digital prints. The explication of compositional features, compositional types, and diagrams offers new strategies for artists to structurally integrate color and composition.

## Introduction

Colors are not constant in human perception, but instead change their identities—sometimes surprisingly and significantly—in response to other, neighboring colors. *Simultaneous color contrast*, also known as *color interaction*, is the name given to this illusory variation of a physically constant color. The principles of color and perception that govern simultaneous color contrast are understood well enough to provide artists with predictive strategies for "pushing" colors in different directions in "color space". For a more thorough explanation of these principles, see [1] and [2]. The principles of color interaction are taught to artists today in simple but effective charts designed by artist and color theorist Josef Albers, who developed them from earlier, similar charts designed by M. E. Chevreul and Johannes Itten [3,4]. Simultaneous color contrast is, of course, not limited to charts or paintings, but is a fact of human color perception generally. Although we undoubtedly see simultaneous color contrast in our day-to-day lives, we are almost never aware of those color changes because the visual field of everyday experience is uncontrollably complex and variable. Charts and artists' compositions simplify and focus color relationships in such a way that we may become aware of the contextual relativity of color perception. Artists and perceptual scientists who study color interaction usually emphasize the *color relationships* that are responsible for color interaction, with little or no acknowledgment that the *compositional distribution* of those colors contributes significantly to the perceptual illusion. Indeed, a group of colors capable of producing strong simultaneous color contrast illusions will produce no such illusion if they are not appropriately shaped and distributed on the picture plane. Simultaneous color contrast effects, then, are constrained by certain compositional distributions. This paper proposes to identify the necessary and optimal compositional features for simultaneous color contrast effects, and to initiate a definition of compositional types through an analysis of paintings by the author. Since a full understanding of the illusions and the ideas presented here depends upon color perception, the reader is encouraged to consult the color version of this paper.

## Definitions

The following definitions and assumptions will be employed in this paper: (1) Although the terms often are employed synonymously, we shall employ *simultaneous color contrast* to refer to the perceptual illusion of changing color identities in changing color contexts, and we shall employ *color interaction* to refer to Albers' specific investigation of the phenomenon and especially to his standard chart as employed in his color theory classes. (2) In charts and compositions, the color that exerts a modifying effect on another color will be referred to as the *context color*; the color that is modified by the context color will be referred to as the *constituent color*. These roles are not static but relative—one and the same color may be both context color in relation to a given constituent color *and* constituent to another color serving as a context. The terms distinguish the modifying color from the modified color in any given circumstance. (3) There are two fundamental functions of simultaneous contrast to which we shall refer: (a) *color divergence* occurs when a single color appears to be two or more colors; for example, the color orange can be made to appear yellowish and reddish when placed in two different color surroundings. (b) *color convergence* occurs when two or more physically different colors are made to appear as the same color; for example, a dull orange and a dull green may appear to be the same color if their respective color surroundings exactly compensate for their differences. Figures 1a and 1b illustrate value-based divergence and convergence, employing black, white, and grays. For a fuller explanation of the divergent and convergent functions, please see [1]. (4) We shall assume that all color-shapes that comprise charts and compositions possess determinate (*hard*) edges and a single, uniform color from edge to edge; color gradients and blurred (*soft*) edges will not be part of this examination. While simultaneous color contrast illusions can include color gradients, the effect usually requires edge-to-edge abutments of color areas, whether those areas are blended gradations or uniform expanses of a single color. That is, simultaneous color contrasts are not noticeable in a nebulous field of gradually changing color. (5) We shall assume that maximal and dramatic simultaneous color contrast effects are preferred over minimal and subtle effects, and we shall endeavor to identify compositional properties that yield those maximal illusions.

## 1. The Compositional Merits of the Standard Color Interaction Chart

The standard color interaction charts (Figures 1a and 1b) as designed by Josef Albers are comprised of a pair of colored squares (or sometimes non-square rectangles), each with a smaller colored square centered within. The larger color squares, the context colors, exert a modifying influence upon the smaller squares, the constituent colors. Smaller samples of the constituent colors also appear at the bottom of the chart, at the juncture of the context squares and in edge-contact with each other. This simple arrangement can tell the artist much about how to compose paintings that are predicated on simultaneous color contrast illusions. The charts possess in their arrangement of shapes and colors both necessary and optimal compositional features for the painter; identification and analysis of those features follow.

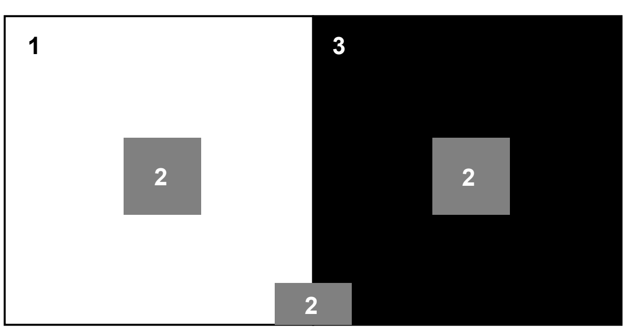


**Figure 1a:** *Standard color interaction chart, divergent function.*

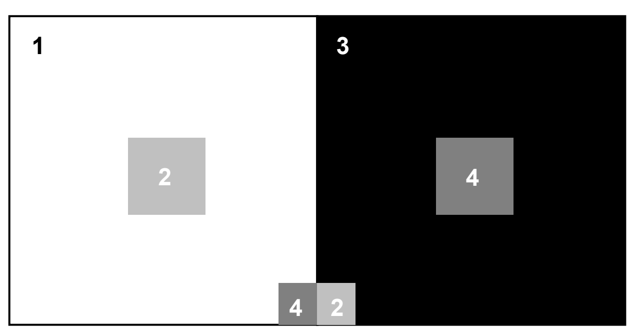


**Figure 1b:** *Standard color interaction chart, convergent function.*

**Simultaneous Views.** Simultaneous color contrast, as the term suggests, depends upon seeing two or more context-constituent groups simultaneously in the same field of view. The illusion of color change results from comparing constituent colors in different color contexts—a single constituent color, or even multiple constituent colors, in a single color context will produce no effect. And that comparison must be made simultaneously, not successively, in the same field of view. *Successive color contrast* is a color illusion that results from sequenced viewing, but its illusory effect differs from simultaneous color contrast in that the color is an after-image, a "phantom" color that is seen after the stimulus has been removed. Simultaneous color contrast effects are brought about by multiple stimuli at different positions in the same field of view, and the illusory effect is seen while the stimuli are present. The two context-constituent color pairs of the standard color interaction chart point to the necessary compositional condition of multiple, juxtaposed context-constituent groups.

**Maximal Edge Contact.** The position of the constituent square at the center of the context square exhibits the important condition of all-around edge contact between context and constituent colors. Edge contact is a necessary feature of simultaneous color contrast, and maximized edge contact seems to yield maximized effects. For example, if the constituent square were placed in the corner of the context square, so that the colors contact each other at only two edges of the constituent color, there would be some simultaneous color contrast effect, but it would be considerably less than the standard arrangement of contact along all four edges. The importance of edge contact is confirmed by "Mach bands," where the illusory effects of simultaneous contrast are more exaggerated at the contact edges and gradually lessen as distance increases perpendicular to the edges.

**Unequal Areas.** Context and constituent colors can usually be identified by the relative areas they occupy: context color occupies more area than constituent color because, as a general rule, a greater area exerts a modifying effect on a lesser area. It should be acknowledged at this juncture that simultaneous color contrast is, in principle, always mutual—both colors exert a modifying influence upon each other. If the areas and distributions were equalized (e.g., two colors in alternating stripes of equal size), the modifying effect would be mutual but likely diminished compared to the unequal area arrangement. In the more dramatic examples of simultaneous color contrast, the areas are unequal and there is a clear distinction between the roles of context and constituent. Squares, of course, are not necessary shapes; circles or other shapes might be just as effective. But squares and rectangular shapes permit the artist to more easily control and compare the ratio of the areas occupied by context and constituent colors. In the standard color interaction charts, the constituent-to-context area ratios range from approximately 1 : 15 to 1 : 25; in other words, if the context area is divided into a 4x4 or a 5x5 grid, the constituent would be approximately equal to a single grid unit. If the ratio of the squares was reversed—a very large central square surrounded by a narrow border—the influence would also be reversed. That is, the large central square would exert a modifying influence upon the surrounding narrow border, and so the roles of context and constituent would be reversed. Unequal areas, while not always necessary, are sufficiently important to the illusion that we shall consider them an optimal compositional condition for maximizing simultaneous color contrast.

**Centrality.** In the standard color interaction chart, the central position of the smaller constituent square displays an important, if not altogether necessary, condition in that the constituent color is surrounded by an equal-sized border of context color. Centrality permits the context color to act upon the constituent color equally from all directions, assisting the eye in perceiving a mostly equal and uniform modifying effect across the whole shape of the constituent color. In other words, if the border thickness varies, then the effect may vary in different locations. Centrality in the standard color interaction chart helps to equalize the modification effect. Adapted to more complex and less symmetrical compositions, *centrality* will simply mean the effort to equalize the distribution and position of the constituent color within the context color (see examples of such modifications in the paintings illustrated in Section 4 below).

**Constituent Color Continuity/Contrast.** Perhaps the most important feature of the standard color interaction chart is the reoccurrence of the constituent colors on the bottom edge of the context squares. We shall distinguish these additional samples of the constituent colors as the *proof* occurrences and the central constituent squares as *illusory* occurrences. These are relative terms only, because colors always are seen in the context of other colors, and so all colors are modified by simultaneous color contrast; but for our purposes we shall employ these terms to distinguish between the maximized modification (*illusory occurrence*) isolated within the context color and the minimized effect (*proof occurrence*) where the constituent colors contact each other. In the standard color interaction charts, the proof occurrences are located at the bottom center and on the opposite context squares so as to minimize the effect of the original context color. The proof occurrences at the bottom of the divergent chart (Figure 1a) confirm that the two illusory occurrences are physically the same color—we see *continuity* (no edge) where the two proof occurrences meet. The proof occurrences at the bottom of the convergent chart (Figure 1b) show us not only that the two constituent colors are physically different, but also the degree to which those colors differ—we see the *contrast* of the two different constituent colors at the edge of contact. This comparison of the illusory and the proof occurrences is all-important to simultaneous color contrast, for without it we could not be aware that the illusion is even taking place. That is, in the case of color divergence, we would simply assume that we were seeing two physically different colors and not a single color in two guises. And in the case of color convergence we would assume that we were seeing two instances of the same color and not two physically different colors that appear to be the same. Illusion depends upon our awareness of a discrepancy between two contradictory interpretations of the same phenomena—a single interpretation is not an illusion.

Thus, when we are seeing color interactions, we are correlating three color relationships: (1) we compare the two illusory occurrences of constituent colors in their respective color contexts, and we decide whether those constituents appear to be the same or different; (2) we compare the two proof occurrences of the constituents at the bottom of the chart, and we realize that they are either the same (divergent function) or different (convergent function); (3) most importantly, we compare the illusory appearances with the proof appearances and gauge the differences between them. Our awareness of simultaneous color contrast illusion emerges from our conscious understanding that there is a discrepancy between (1) and (2). That is to say, (1) or (2) alone will produce no illusion; all three comparisons must be permitted by any chart or any composition that is intended to display simultaneous color contrast illusions. The standard color interaction charts do indeed possess the necessary conditions of including both the illusory and the proof occurrences of the constituent color(s); however, as will be discussed below, the chart's compositional distribution is insufficient for the demands of an art work.

## 2. Modification of the Standard Color Interaction Chart

In the standard color interaction chart, the proof occurrences of the constituent colors at the bottom edge serve the important pedagogical purpose of providing a point of comparison with the illusory occurrences so that the viewer may gauge the difference between fact and appearance. But to do so, the viewer must first understand the "rules of the game"—that the illusory and proof occurrences are in fact the same. Because they are separated, there is nothing in the chart itself to confirm this visually, so a verbal explanation is necessary to understand that color interaction charts are designed always to work this way. The central challenge for composing paintings based upon simultaneous color contrasts is to make clear to the viewer the above-mentioned discrepancy between fact and appearance.

The most straightforward and, ultimately, the most effective solution is to join the illusory and proof occurrences into a single, continuous shape that accomplishes both tasks (see Figures 2a and 2b). In the case of color divergence this means that the two instances of the same constituent color become joined as a single, continuous shape that spans the edge of the two adjoining contexts. In the case of color convergence this requires that the two constituent colors contact each other along an edge so that the physical difference between the constituent colors can be recognized. Isolated squares cannot, of course, accomplish this, so the constituent color-shapes must elongate to become continuous (divergent) or to make contact (convergent). However, these simple modifications are not without cost. A comparison of Figures 1a and 1b with 2a and 2b shows a lessened effect in the latter. The more isolated the constituent, the more effective is the illusion of change. But a work of art is not a chart. If art may be expected to create for the viewer a visually more complete and self-explanatory experience than a chart, then the joining of proof and illusory occurrences seems inescapable. It is the artist's task to develop inventive compositions that provide for both the simultaneous color contrast illusion and its self-explanation.


**Figure 2a:** *Modified color interaction chart, divergent function, combining "proof" and "illusory" occurrences.*

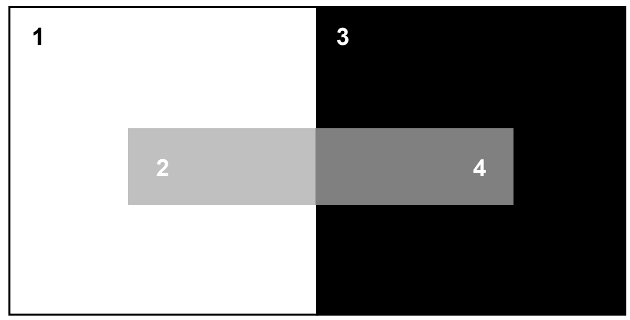


**Figure 2b:** *Modified color interaction chart, convergent function, combining "proof" and "illusory" occurrences.*

## 3. A Typology and Terminology for Simultaneous Color Contrast Compositions

The following typology of compositions is based upon the assumption that simultaneous color contrast occurs always and only as convergence, divergence, or a combination of the two; and it will also be assumed that all compositions motivated by simultaneous color contrast will always be designed around those same functions. In addition, all color-shapes must function as constituent, context, or both (as discussed above, if a color functions as both, it does so relatively but discretely as either modifier or modified color in relation to the other colors). With these premises, we may identify two fundamental characteristics of simultaneous color contrast compositions, each with two possible states:

**Uniform and Duo-form Functions.** Compositions that employ either, but not both, the divergent function or the convergent function will be referred to as *uniform*. Compositions that include both the divergent and the convergent functions will be referred to as *duo-form*.

**Simple and Complex Versions.** Uniform and duo-form compositions may be realized in either *simple* or *complex* versions. In the simple version, the roles of constituent and context are fixed; that is, a single color functions as either context or constituent, but not both. In the complex version, at least one color functions as both context and constituent.

**Four Types.** Combining the functions and versions yields four basic types of simultaneous color contrast composition: *simple uniform*, *simple duo-form*, *complex uniform*, and *complex duo-form*. Although there are only four types, each can engender many variations. Each type should be considered equally capable of producing creative and effective compositions—the types and their names are not intended to imply a qualitative hierarchy, but merely to distinguish different kinds of shape and color relationships. For example, although the standard and modified color interaction charts (Figures 1a, 1b, 2a, and 2b) are the minimum states of the *simple-uniform* type, this type has proved versatile enough to account for more paintings and digital prints in my studio work than any of the other three types. The compositional constraints discussed in the preceding sections of this paper—simultaneous views, maximal edge contact, centrality, unequal areas, constituent color continuity/contrast—should be considered always to be operative within each of the four types.

**Diagrams.** In Section 4, we will see how the simultaneous color contrast effects of each painting can be reduced to an identification of context/constituent colors in some combination of contacts. To understand these basic relationships, we shall employ a graphic system of lines, dots, and circles. In these quasi-graphs, the dots represent constituents, the hollow circles represent contexts, and the lines represent only the constituent-to-context and constituent-to-constituent contacts (context-to-context edge-contact will be ignored since these do not contribute directly to the simultaneous color contrast effect). For example, Figures 3a and 3b are the diagrams of the two modified color interaction charts seen in Figures 2a and 2b; these are the *simple uniform* type. The diagrams will graph the color and shape relationships, and consequently will also help us to confirm the composition type of each sample painting.

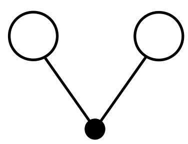

**Figure 3a:** *Diagram of color interaction chart Fig. 2a, divergent function, simple uniform type.*

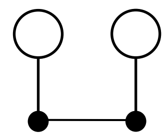

**Figure 3b:** *Diagram of color interaction chart Fig. 2b, convergent function, simple uniform type.*

## 4. The Paintings and Digital Prints

**Simple Uniform Type.** The diagram in Figure 3a can be extended with the addition of more contexts, more constituents, or both, and yet remain the *simple uniform* (*divergent)* type. "Circuitous (Orange)" (Figure 4a) is such a composition. A single constituent (the orange line) passes through seven contexts (rectangular areas). The diagram (Figure 4b) indicates only five contexts because three of the areas are the same color (white); an additional, eighth area (lower left corner) is not part of the diagram because it is not a context (in fact, it is the same color as the constituent). The diagram maps only those compositional relationships that participate in the simultaneous color contrast functions.

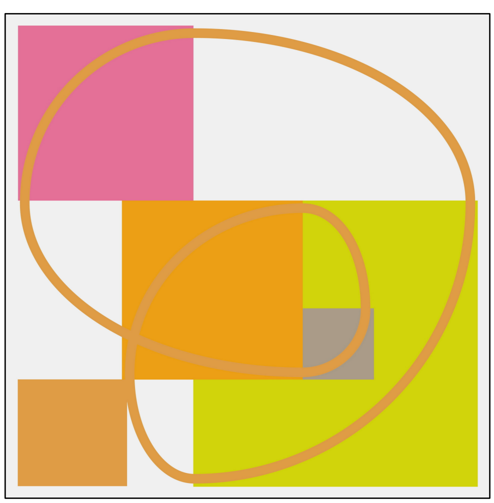

**Figure 4a:** *"Circuitous (Orange)" digital print, 28x28".*

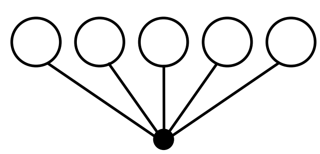

**Figure 4b:** *Diagram of "Circuitous (Orange)" simple-uniform type, divergent.*

**Simple Duo-form Type.** The painting in Figure 5a exhibits both divergent and convergent functions. The yellow-green line at left and the blue-green line at right are each diverging into different hues: Yellow-green appears yellower on the green context in the upper left, and it appears greener on the yellow context left of center. The blue-green constituent appears bluer on the green context at the upper right and greener in the blue context right of center. At the same time, the blue-green in the blue context and the yellow-green in the yellow context participate in illusory convergence, appearing to be the same (or similar) green. While this composition shows both functions, each color is restricted to a single role as context or as constituent, and therefore this composition is of the *simple duo-form* type.

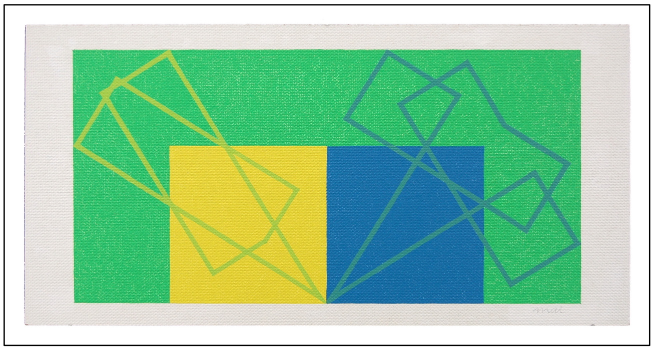

**Figure 5a:** *"Orpheus & Eurydice (YG & BG)" acrylic on panel, 12x24".*

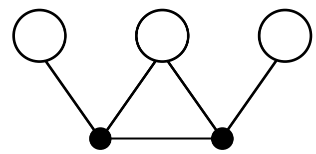

**Figure 5b:** *Diagram of "Orpheus & Eurydice (YG & BG)" simple-duo-form type.*

**Complex Uniform Type.** The painting in Figure 6a is composed of only four colors: a high intensity green, a low intensity green (neutral gray), and two intermediate greens, middle-high and middle-low intensities. The middle-high intensity green occupies the upper right rectangular context and it is the lower constituent line. The middle-low intensity green occupies the lower left rectangular context and it is the upper constituent line. Each line crosses the other three color contexts and appears to change its color (diverges) more and less intensely in the different contexts. Note the *proof occurrences* above and below center, where the constituent lines contact their respective context areas. Because two colors function as both constituent and context, this is a *complex* type, but insofar as the illusion is divergent only, it is *uniform*. This arrangement is diagrammed in Figure 5b; note the new element of a dot inside a circle, indicating a color functioning as both context and constituent.

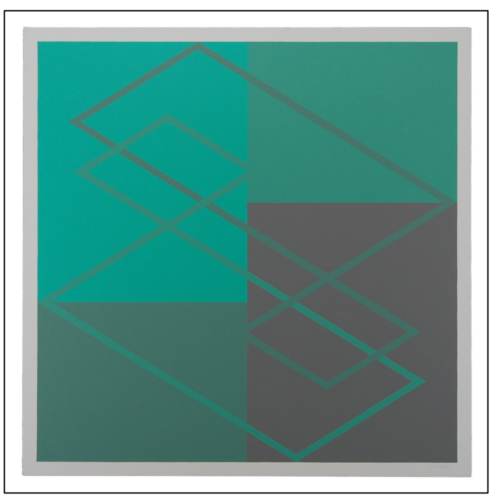

**Figure 6a:** *"Contending (Green)" acrylic on canvas, 32x32".*

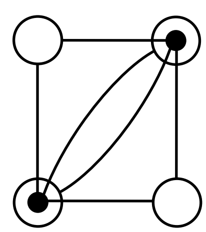

**Figure 6b:** *Diagram of "Contending (Green)" complex uniform type.*

**Complex Duo-form Type.** The painting shown in Figure 7a employs only four colors: high-intensity blue, middle-low intensity blue, high intensity orange and middle-low intensity orange. The middle-low intensity blue and orange serve the dual roles of contexts (areas) and constituents (lines); they are represented in the diagram (Figure 7b) as dots within circles. Those two colors also participate in both divergent and convergent functions. The divergent function may be seen where the middle-intensity orange line appears brighter at the lower right and grayer at the upper left, and where the middle-intensity blue line appears brighter at the right (on the middle-low intensity orange context) and grayer at the left (on the L-shaped blue context). The convergent function may be seen when comparing the appearances of the middle-low intensity blue and orange lines in their respective L-shaped contexts—both colors converge toward a similar gray. This complex of relationships emerges from a minimum number of colors in maximally strategic contacts. If one looks closely at the continuities of each color-shape, it becomes evident where colors change roles from constituents (lines) to contexts (areas).

**Figure 7a:** *"Convergence (Blue & Orange)" acrylic on canvas, 32x32".*

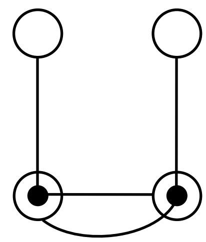

**Figure 7b:** *Diagram of "Convergence (Blue & Orange)" complex duo-form type.*

These few examples offer only a cursory view of the many possibilities that can arise from these compositional features and types. Indeed, not only are there many distinct diagrams possible for each compositional type, but for each diagram there are myriad compositional variations employing different proportions, shapes, and colors. The compositional constraints of simultaneous color contrast should be understood not as constraints upon creative potential but as clarification of new strategies for creating color-motivated compositions. Theory and practice are always bi-directional for me; years of making paintings like those discussed here have contributed to formulating this typology, and in turn this typology promises to generate new compositional expressions of simultaneous contrast in my paintings.

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