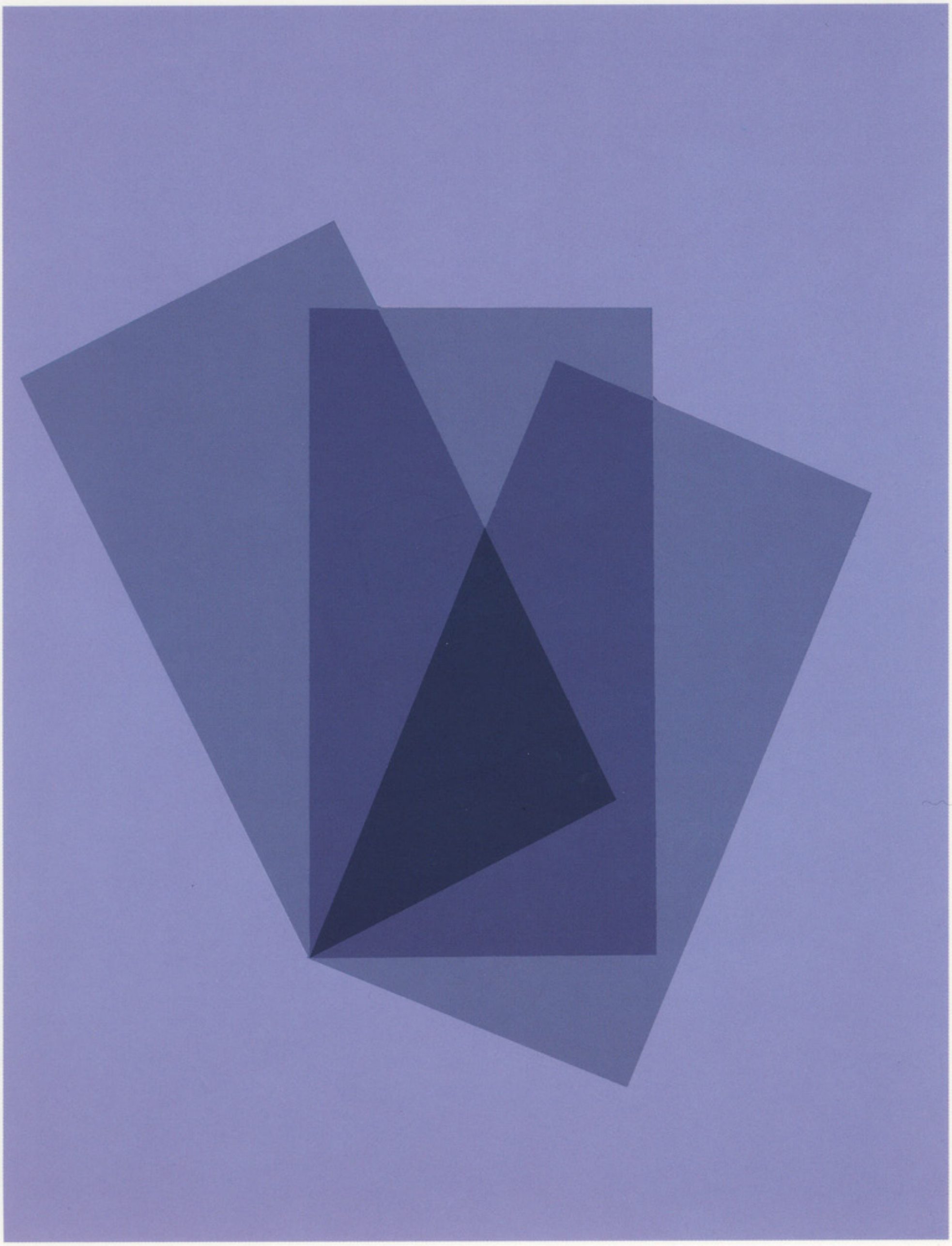
Josef Albers

Interaction of Color

Revised and Expanded Edition



VII 2 different colors look alike—subtraction of color

The fact that one and the same color can perform many different roles is well known and is consciously applied.

Less well known is the possibility in the previous exercise of giving a color the look of reversed grounds.

Still more exciting is the next task, the reverse of the first: to make 2 different colors look alike.

In the first exercise it was learned that the more different the grounds, the stronger is their changing influence.

It has been seen that color differences are caused by 2 factors: by hue and by light, and in most cases by both at the same time.

Recognizing this, one is able to "push" light and / or hue, by the use of contrasts, away from their first appearance toward the opposite qualities.
Since this amounts virtually to adding opposite qualities, it follows that one might achieve parallel effects by subtracting those qualities not desired.

This new experience can be achieved first by observing 3 small samples of 3 reds on a white ground.
They will appear first of all—red.

Then when the 3 reds are placed on a ground of another red their differences, which are differences of hue as well as of light, will become more obvious.

Third, when placed on a red ground equal to 1 of the 3 samples, only 2 of the reds will "show," and the lost one is absorbed—subtracted.
Repeated similar experiments with adjacent colors will show that any ground subtracts its own hue from colors which it carries and therefore influences.

Additional experiments with light colors on light grounds and dark colors on dark grounds prove that the light of a ground subtracts in the same way that its hue does.

From this, it follows that any diversion among colors in hue as well as in light-dark relationship can be reduced if not obliterated visually on grounds of equal qualities.

Such studies provide a broad training in analytical comparison and usually evoke surprising results, leading the student to an intense study of color. (See plates VII-4, VII-5, and VII-7.)

VIII Why color deception?— after-image, simultaneous contrast

For a better understanding of why colors read differently from what they really (physically) are, we show now the cause of most color illusions.

In order to prepare for the second part of this demonstration, cut out in red and white color paper 2 equal circles (of ca. 3-inch diameter) and mark their centers with a small black dot.
(See plate VIII-2.)

Then paste them—horizontally related—the red circle to the left and the white one to the right, on the blackboard or a piece of black paper or black cardboard, ca. 10 inches high and 20 inches long, with about equal amounts of black before, between, and after the 2 circles.

Now, by staring steadily at the marked center of the red circle (up to half a minute) one soon discovers how difficult it is to keep the eye fixed on a point. After a while, moon-sickle shapes appear, moving along the circle's periphery. In spite of this, one must continue to focus on the red center point in order to assure the desired experience. Then quickly shift the focus to the center of the white circle.

From the class one usually hears noises which indicate surprise or astonishment. This happens because all normal eyes suddenly see green or blue-green instead of white. This green is the complementary color of red or red-orange.
The phenomenon of seeing green (in this case) instead of white is called after-image, or simultaneous contrast.

A plausible explanation:

One theory maintains that the nerve ends on the human retina (rods and cones) are tuned to receive any of the 3 primary colors (red, yellow, or blue), which constitute all colors.

Staring at red will fatigue the red-sensitive parts, so that with a sudden shift to white (which again consists of red, yellow, and blue), only the mixture of yellow and blue occurs. And this is green, the complement of red.

The fact that the after-image or simultaneous contrast is a psycho-physiological phenomenon should prove that no normal eye, not even the most trained one, is foolproof against color deception.
He who claims to see colors independent of their illusionary changes fools only himself, and no one else.

IX Color mixture in paper— illusion of transparence

It is obvious that in working with color paper there is no way of mixing the colors mechanically, as paint and pigment permit, and as they invite one to do on a palette or in a container.

Though this may first appear as a handicap, it is actually a challenge to study color mixture in our imagination, that is, so to say, with closed eyes.

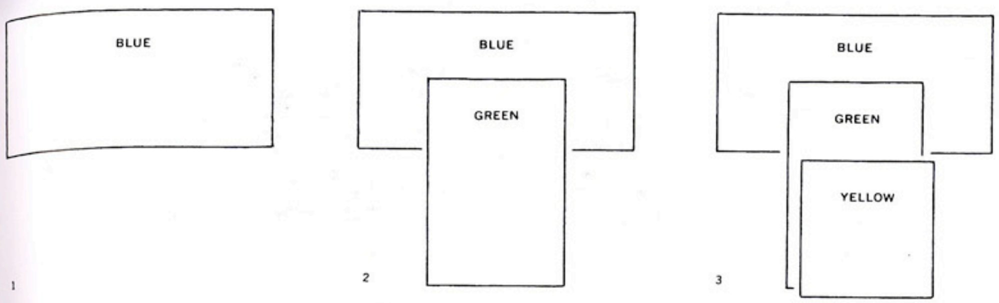
Starting with the simple and well-known fact that blue and yellow when mixed produce green, a blue and yellow are selected and held next to each other. One tries to imagine what kind of green would result from a mixture of these 2 colors.
Then a paper is selected appropriate to this imagined mixture.

In order to find out whether the "thought-out" mixture is acceptable—believable—convincing—the 3 colors (2 "color parents" and 1 "color descendant") are placed in 3 equal rectangles as follows:

Blue horizontally (1), green vertically (2)
so that its upper part overlaps the blue. The yellow is put on top of the green (3) so that its top edge coincides with the bottom edge of the blue.

In such placement, the green will be the "in-between" of the other colors and thus their mixture.

After the class has found several believable mixtures, these are collected for an exhibition (most practically, on the floor) and the most convincing ones are selected. Some are usually more successful than others. The class states their merits and shortcomings and suggests possible corrections and improvements.



By means of the exhibition, the students will be reminded that there are many blues and many yellows, and will conclude that there are innumerable mixtures descending from them. It is obvious that any 2 colors can produce many mixtures.

In addition to the illusion of mixture, another deception will be recognized—that, in an illusionary mixture in paper, 1 color seems to show through the other. The "mixture" paper, therefore, loses its opacity and appears transparent or translucent.

In order to make the eye read this double illusion of mixture and of transparence, the colors must be placed in overlapping shapes.

In the drawing on page 26 the hatched parts belong to each of the overlapping shapes and are therefore the logical place for the mixture.

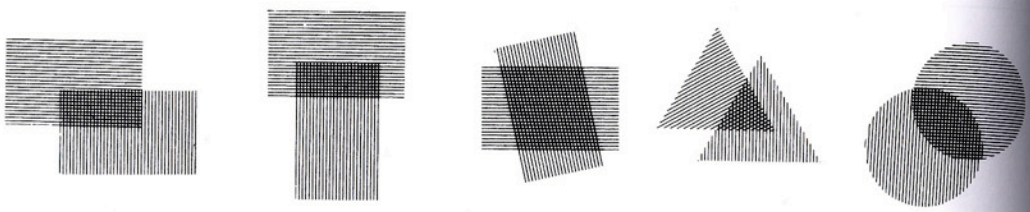
After simple mixtures, such as blue and yellow producing green—red and blue producing violet—black and white producing grey—less common pairs, such as pink and ochre, present a further challenge.

For a more intensive experience, keep the area of the mixture larger than those of the 2 mixing ones. (See plate IX-1.)

If we name 2 mixture parents A and B, and their mixture C,

then our first task is to find C's, which are mixtures of A and B,						
another task will be	"	"	B's, conditioned by	A	"	C,
or, a third task,	"	"	A's " "	B	"	C.

This invites one to draw conclusions backward, that is, to guess—
from a mixture and 1 mixture parent—the other mixture parent.



X Factual mixtures—additive and subtractive

Though the color class (as a rule) abstains from the use of colorants (meaning pigments and paints) for reasons explained before, the color studies in paper are related to the actual use of paint as often as possible.

Therefore, after the introductory studies of mixture as illusion, factual mixing is analyzed. There are 2 kinds of physical mixture:

a) Direct mixture of projected light,
b) Indirect mixture of reflected light.

a) Color light, or direct color, probably is most familiar through its practical application in theater and advertising. The scientific analysis of the physical qualities (wave length, etc.) is not the problem of the colorist; it is the concern of the physicist. When he mixes his colors, he projects them on a screen, 1 on top of or overlapping the other. In any such mixture where there is overlapping, it will be obvious that every one of these mixtures is lighter than any of the mixture parents. By means of a prismatic lens, the physicist easily demonstrates that the color spectrum of the rainbow is a dispersion of the white sunlight. With this he proves also that the sum of all colors in light is white. This demonstrates an additive mixture.

b) When pigment or paint is mixed on a palette or in a container it is seen by the eye as reflected light. This mixing will never result in white as the sum of colors. On the contrary, the more color that is mixed, the more the mixture approaches a dark grey leaning toward black. This we call subtractive mixture. Also, the psychologist, who mixes colors of reflecting colorants optically on the rotating wheel, is not able to arrive at mixtures lighter than the lighter color parent of the mixture.

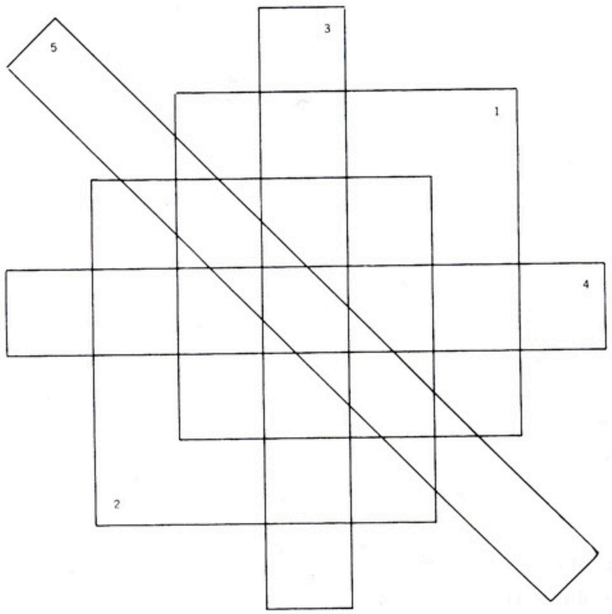
As optical mixture usually means less loss of light
than mechanical mixture, the psychologist's sum of all his colors
normally approaches a middle grey instead of the dark grey of the painter.

The conclusion is: mixtures gain light only in direct color, as in (a),
whereas mixtures of reflected colors lose light, as in (b).

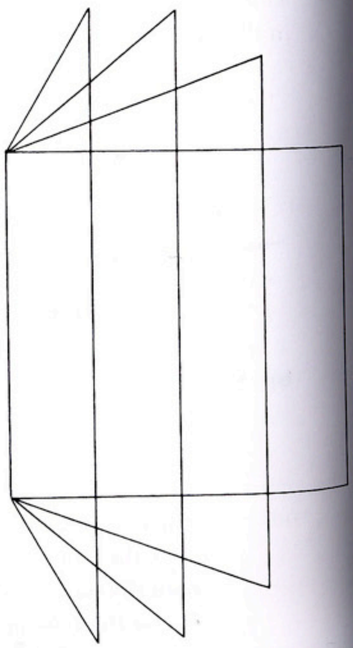
Though direct color or color light normally is not the medium of the colorist, examples of this effect should be indicated. Additive and subtractive mixtures should be made in appropriate studies in transparence illusions. These will provide a preparatory training for studies to follow.

For the sake of simplicity and to avoid difficult complications, these mixtures should be done in 1 thin color mixing preferably with white (or black), and then reversing the first study. (See plate X-1.)

Sample arrangements:



AND REVERSED



AND REVERSED

XI Transparence and space-illusion
Color boundaries and plastic action

A study of color mixture in paper leads to 3 important discoveries.

First, under normal conditions, a subtractive mixture is not as light as the lighter of the color parents nor as dark as the darker one. Furthermore, the mixture is reciprocally neither higher nor lower in color intensity than the color parents.

Second, a mixture depends upon the proportion in which colors are mixed. Varying amounts of blue and yellow, for instance, define the character of a green. This indicates a possible predominance of 1 color parent.

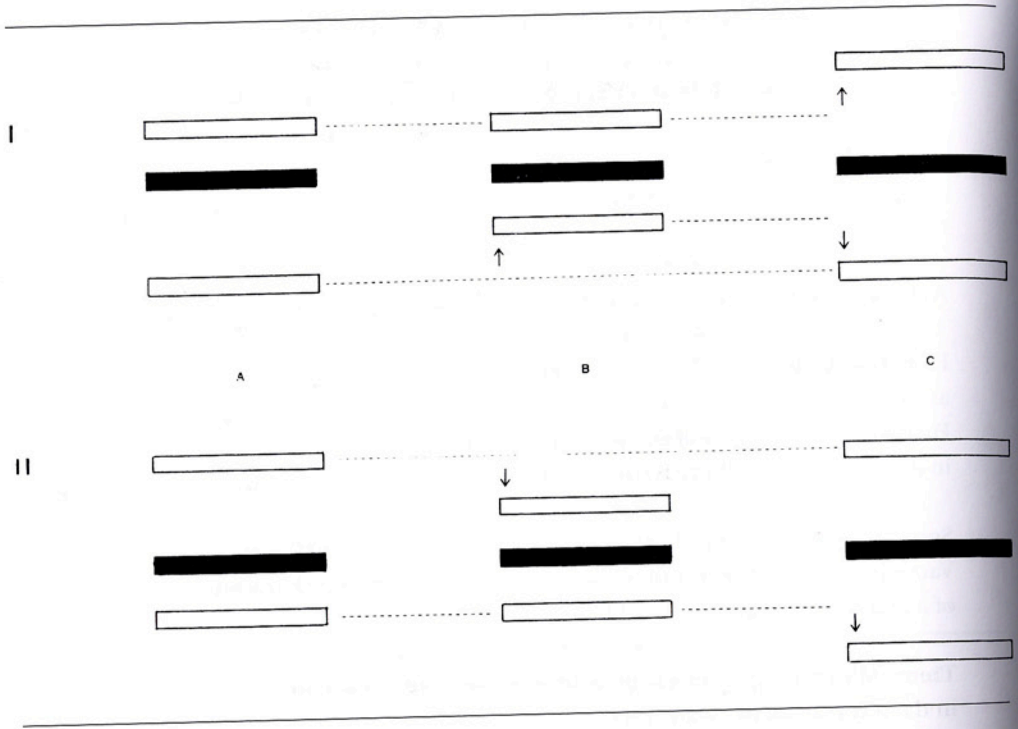
Third, when 1 color is read as appearing above or below another in the transparence studies, a third deception is recognized—space-illusion.

This leads to the next task:
To produce different illusionary mixtures which derive from 1 pair of parent colors. If the parents are again a blue and a yellow, some greens will be found with yellow dominance and others with blue dominance. With more mixing experience it will become apparent that the nearness of a mixture to one side (let us say yellow) necessitates distance from the opposite side (in this case blue).

After having found several mixtures of different pairs of parent colors, we then try to find the most significant and the most difficult mixture —the middle mixture. Topographically, this middle mixture demands precise placement, and therefore additional means of measure are necessary.

Since the middle mixture presupposes equidistance from the color parents, it therefore depends equally upon the absence of any predominance of the color parents.

Here, the following diagrams may be helpful:



Of the 3 bars in each diagram, the black bar represents an in-between color, the mixture in question; that is, the one to be "equidistant" from the accompanying white bars. The latter represent possible color parents for a color mixture. The upper bar represents a lighter (higher) color, and the lower bar represents a deeper (heavier) color.

In IA the mixture line is nearer to the upper line, and is therefore too light; in IIA the opposite happens. The middle color-to-be is nearer to the lower bar and consequently is too dark. For the necessary corrections in IA, we must look for a lower (darker) middle, and in IIA for a higher (lighter) middle.

Unfortunately, those higher and lower tones are often not available. In such cases, we should try to adjust the outer (upper or lower) colors —instead of the middle color—in order to exercise another way of correct placement.

Thus, in IB the lower bar is lifted from the dotted line, e.g. a lighter color is chosen; in IIB the upper bar is lowered. In C similar changes take place but in an opposite direction from B. Comparing groups B and C will demonstrate that correct arrangements may become closer to or more distant from the middle color.

Such efforts forth and back in our search for a middle color— to be specific, for a middle placement—provide through continued comparison a thorough visual training: "thinking in situations."

Besides an explanation of the above diagrams on the blackboard, a physical demonstration in space may clarify this further. When discussing the first trial studies, exhibited on the floor with the students standing around them, 2 hands held horizontally 1 above the other may act as the 2 outer colors. And a third hand held between them may demonstrate various possibilities of color selection and placement, either by moving the hand indicating the middle color up or down, or by moving the outer hands up and / or down, singly or together.

With a more developed sensitivity for mixtures, it will be discovered that distance, nearness, and equidistance between colors can be recognized through the boundaries between the mixture and the mixture parents.

By exercising comparison and distinction of color boundaries, a new and important measure is gained for the reading of the plastic action of color, that is, for the spatial organization of color. Since softer boundaries disclose nearness implying connection, harder boundaries indicate distance, separation.

In both interpretations colors are placed above or below each other, or in front of or behind each other. They are read as here and there, as over, and beyond there, and therefore in space.

All this seems to change with colors producing middle mixtures. Sometimes they appear as if meeting within a 2-dimensional plane; at other times they can be read—interchangeably—as higher or lower than the mixture.

Thus, with a middle mixture all boundaries are equally soft or hard.
As a consequence, a middle mixture appears frontal, as a color by itself.
This is comparable to the reading of any symmetrical order
and the middle mixture will behave unspatially,
unless its own shape, or surrounding shapes, decides differently.
(See plates XI-1 and XI-3.)

Such a study, or a similar recognition, in my opinion, led Cézanne
to his unique and new articulation in painting. He was the first
to develop color areas which produce both distinct and indistinct endings
—areas connected and unconnected—areas with and without boundaries—
as means of plastic organization.

And, in order to prevent evenly painted areas from looking flat and frontal,
he used emphasized borders sparingly, mainly where he needed
a spatial separation from adjacent color areas.

XII Optical mixture—after-image revised

XIII The Bezold Effect

In contrast to after-image, so far the main concern of our studies, here
is another very different color illusion called "optical mixture."
Instead of 2 (or more) colors changing each other, "pulling" or "pushing"
each other into different appearances (toward both greater difference and greater
similarity), here 2 colors (or more), perceived simultaneously, are seen
combined and thus merged into 1 new color. In this process, the 2
original colors are first annulled and made invisible, and then replaced by
a substitute called optical mixture.

From the Impressionist painters we have learned that they never presented, let us say,
green by itself. Instead of using green paint mixed mechanically from yellow
and blue, they applied yellow and blue unmixed in small dots, so that they
became mixed only in our perception—as an impression. That the dots
mentioned were small indicates that this effect depends on size and on distance.

The discovery of the mixing of colors in our perception led in the last
century not only to the new painting technique of the Impressionists, and
particularly of the Pointillists, but also to the invention of new photomechanical
reproduction techniques, the 3- and 4-color process for paintings, and the
halftone process for black-and-white pictures. In the first case, 3 or 4
color plates subdivided into tiny printing dots mix to innumerable color
shades and tints. In the second case, a plate for black also subdivided by
a screen in tiny dots mixes with the white paper in just as innumerable
tones of white—grey—black.

There is a special kind of optical mixture, the Bezold Effect, named after its
discoverer, Wilhelm von Bezold (1837–1907). He recognized
this effect when searching for a method through which he could change the
color combinations of his rug designs entirely by adding or changing 1 color only.
Apparently, there is so far no clear recognition of the optical-
perceptual conditions involved. (See plates XIII-1, XIII-2, and XIII-3.)

A color has many faces—the relativity of color

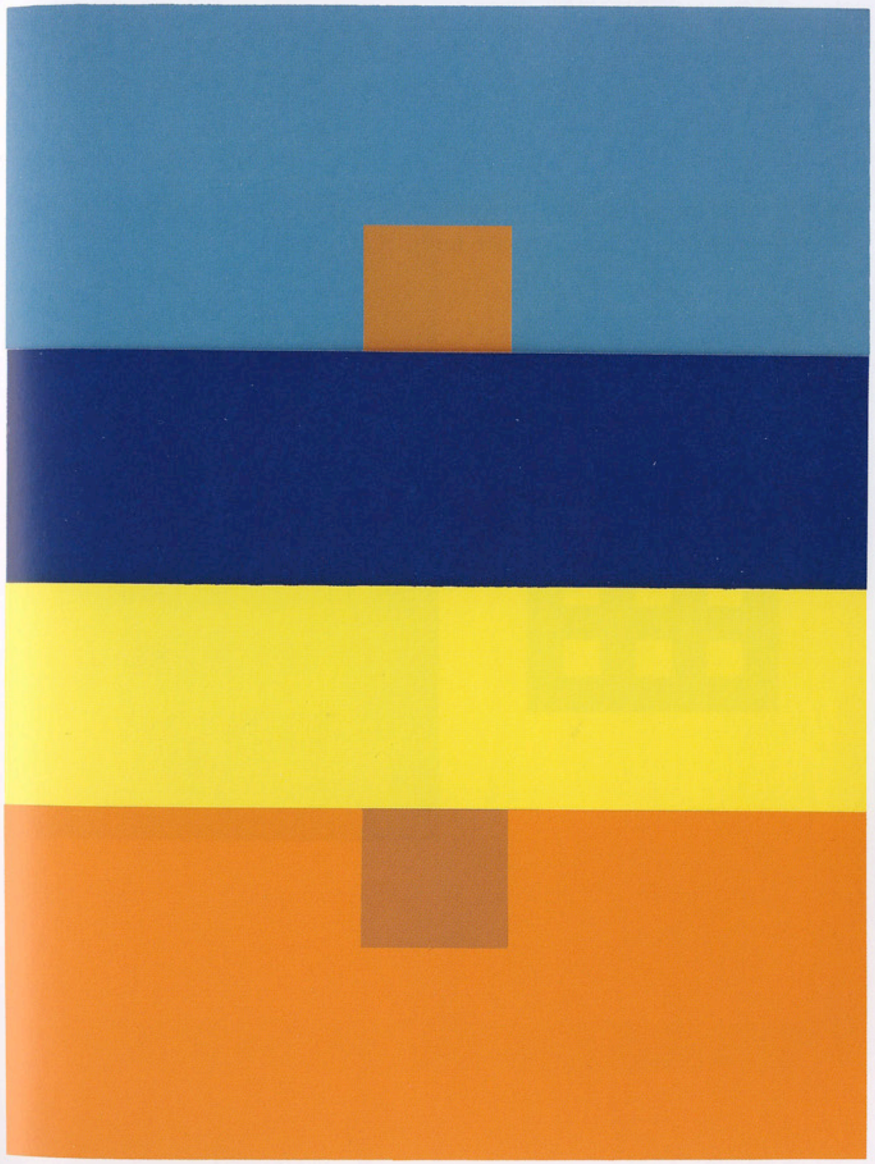
CHAPTER IV

IV-1 A color has many faces, and 1 color can be made to appear as 2 different colors. In the original design for the study IV-1, horizontal dark blue and yellow stripes were on a flap which could be lifted to show that a vertical stripe of ochre is the same color at the top as at the bottom.

Here it is almost unbelievable that the upper small and the lower small squares are part of the same paper strip and therefore are the same color.

And no normal human eye is able to see both squares—alike.

Note: Plate numbers correspond to Folder numbers in the original edition.



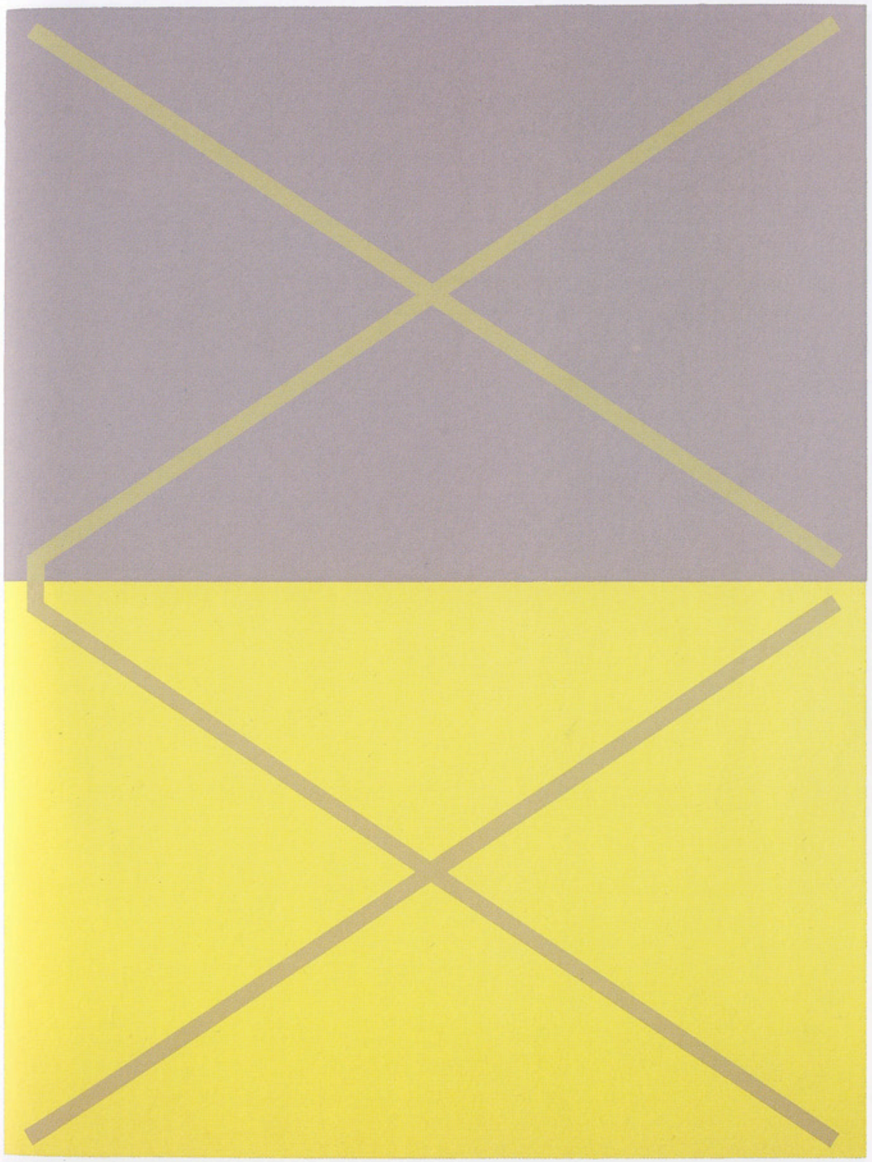
Reversed grounds

CHAPTER VI

VI-3 1 color looks like 2—or: 3 colors appear as 2. In plate VI-3 when you hold the yellow ground at the left, the X-form on it appears violetish and the X-form on the violet ground looks yellowish.

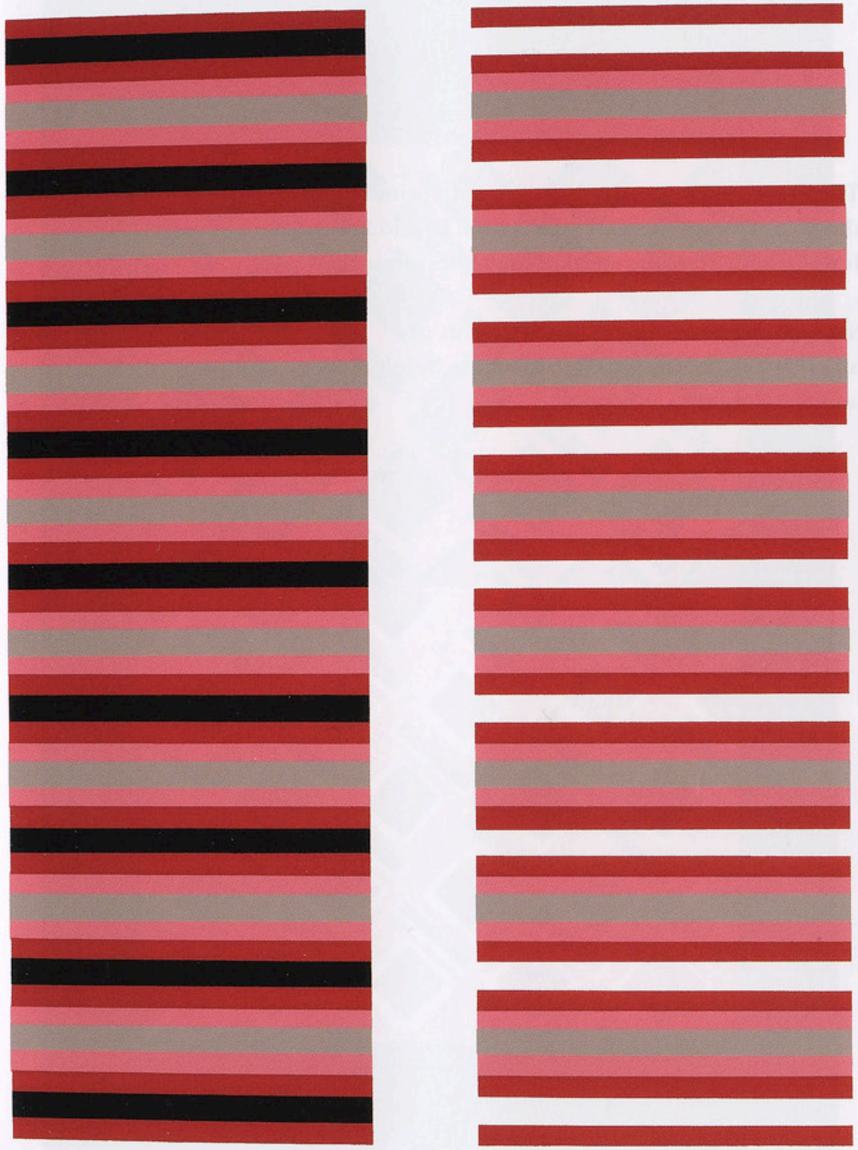
To show that both X's are the same color, see where they meet in the middle at the top.

The question that this study presents: What color is able to play such complementary roles in one show?



XIII-2 The change of 1 color alters both light and weight of the original, and, one can say, its speed and age as well.

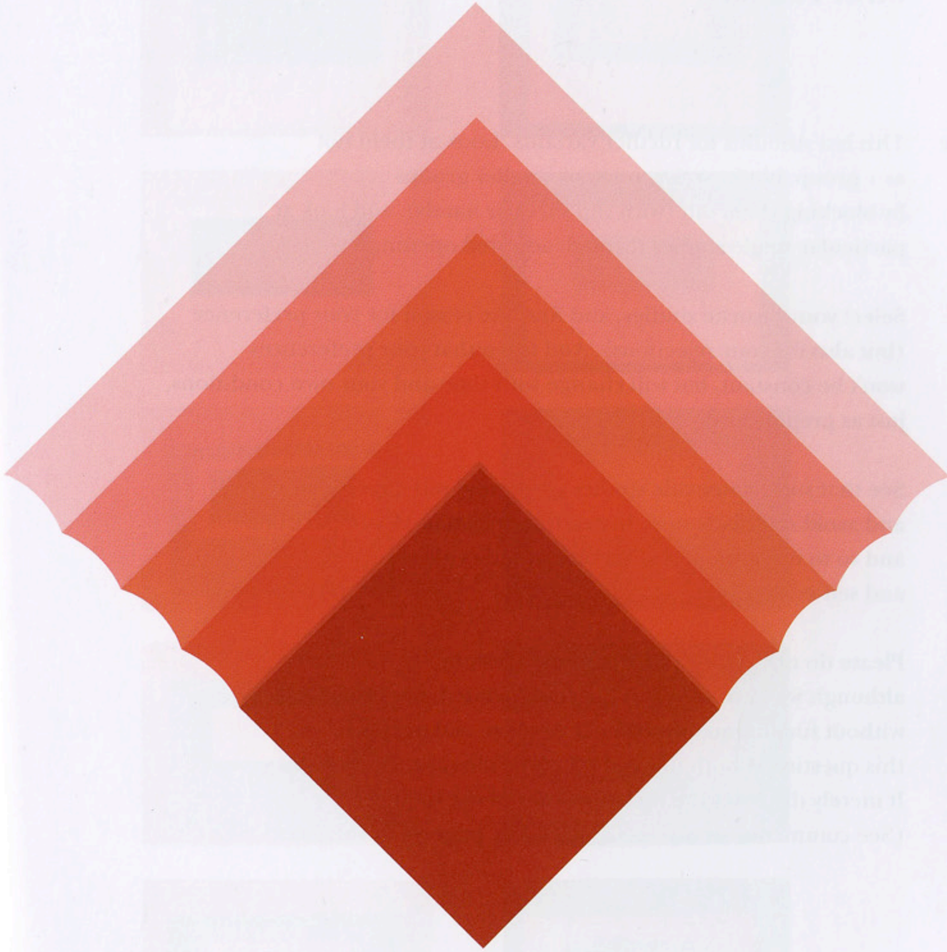
Another reading: besides the Bezold Effect, its opposite appears here—an after-image effect—when the dark red flanking the black is compared with the same red accompanying the white. Define this change.



Intersection
CHAPTER XV

XV-2 To achieve a new sculptural illusion of intersecting colors, note that the separating boundaries of a middle mixture look elevated, or raised from the ground, which causes a "fluting" effect known from the channelings of a Doric column.

Here is a "blown up" view of the fluting effect: Consider the dark red rectangle as a ground plan, and read the channelings as 2 side elevations.



Film and volume color

CHAPTER XVII

XVII-1 An illusion of film color indicating a sheet of almost clear acetate covering 4 colors, and at right covering even twice. But remember that the original study is done not in transparent material but in opaque paper, which, of course, demands a very precise color selection.