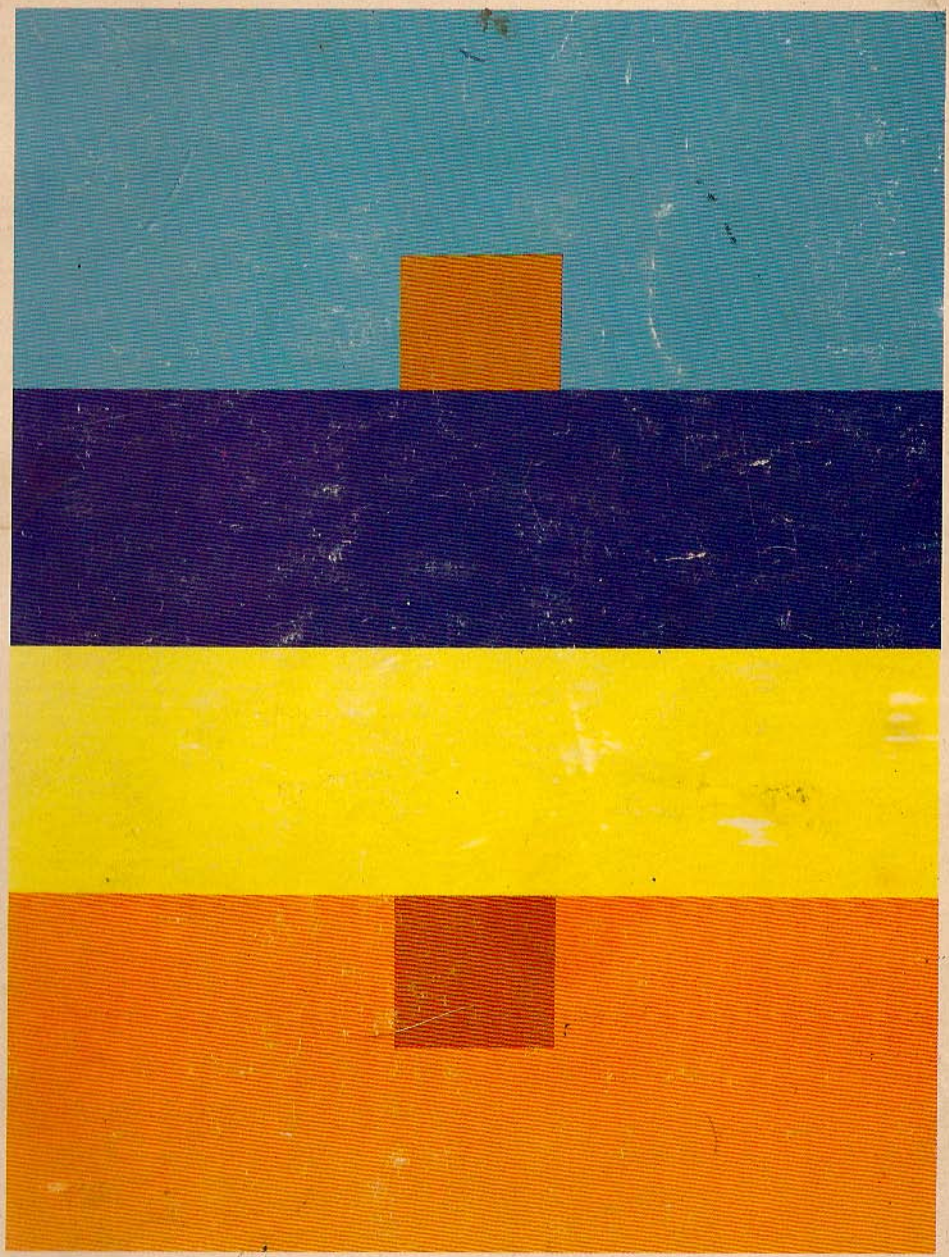
Interaction of Color

Josef Albers

Unabridged text and selected plates
Revised edition



Introduction

The book "Interaction of Color" is a record of an experimental way
of studying color and of teaching color.

In visual perception a color is almost never seen as it really is
-- as it physically is.
This fact makes color the most relative medium in art.

In order to use color effectively it is necessary to recognize
that color deceives continually.
To this end, the beginning is not a study of color systems.

First, it should be learned that one and the same color evokes
innumerable readings.
Instead of mechanically applying or merely implying laws and rules
of color harmony, distinct color effects are produced
-- through recognition of the interaction of color --
by making, for instance,
2 very different colors look alike, or nearly alike.

The aim of such study is to develop -- through experience
-- by trial and error -- an eye for color.
This means, specifically, seeing color action
as well as feeling color relatedness.

As a general training it means development of observation and articulation.

This book, therefore, does not follow an academic conception
of "theory and practice."
It reverses this order and places practice before theory,
which, after all, is the conclusion of practice.

Also, the book does not begin with optics and physiology of visual perception,
nor with any presentation of the physics of light and wave length.

Just as the knowledge of acoustics does not make one musical
-- neither on the productive nor on the appreciative side --
so no color system by itself can develop one's sensitivity for color.
This is parallel to the recognition that no theory of composition by itself
leads to the production of music, or of art.

Practical exercises demonstrate through color deception (illusion)
the relativity and instability of color.
And experience teaches that in visual perception there is a discrepancy
between physical fact and psychic effect.

What counts here -- first and last -- is not so-called knowledge
of so-called facts, but vision -- seeing.
Seeing here implies Schauen (as in Weltanschauung) and is coupled
with fantasy, with imagination.

This way of searching will lead from a visual realization
of the interaction between color and color
to an awareness of the interdependence of color with form and placement;
with quantity (which measures amount, respectively extension
and/or number, including recurrence);
with quality (intensity of light and/or hue);
and with pronouncement (by separating or connecting boundaries).

The table of contents shows the order
in which exercises usually lead our investigation.

Each exercise is explained and illustrated --
not to give a specific answer,
but to suggest a way of study.

I Color recollection -- visual memory

If one says "Red" (the name of a color)
and there are 50 people listening,
it can be expected that there will be 50 reds in their minds.
And one can be sure that all these reds will be very different.

Even when a certain color is specified which all listeners have seen
innumerable times -- such as the red of the Coca-Cola signs which is
the same red all over the country -- they will still think of
many different reds.

Even if all the listeners have hundreds of reds in front of them
from which to choose the Coca-Cola red, they will again select
quite different colors. And no one can be sure that he has found
the precise red shade.

And even
if that round red Coca-Cola sign with the white name in the middle
is actually shown so that everyone focuses on the same red,
each will receive the same projection on his retina,
but no one can be sure whether each has the same perception.

When we consider further the associations and reactions
which are experienced in connection with the color and the name,
probably everyone will diverge again in many different directions.

What does this show?

First, it is hard, if not impossible, to remember distinct colors.
This underscores the important fact that the visual memory is very poor
in comparison with our auditory memory. Often the latter is able
to repeat a melody heard only once or twice.

Visual memory poor

Second, the nomenclature of color is most inadequate.
Though there are innumerable colors -- shades and tones --
in daily vocabulary, there are only about 30 color names.

only 30 color names

II Color reading and contexture

The concept that "the simpler the form of a letter the simpler its reading" was an obsession of beginning constructivism. It became something like a dogma, and is still followed by "modernistic" typographers.

This notion has proved to be wrong, because in reading we do not read letters but words, words as a whole, as a "word picture."
This was discovered in psychology, particularly in Gestalt psychology.
Ophthalmology has disclosed that the more the letters are differentiated from each other, the easier is the reading.

Without going into comparisons and details, it should be realized that words consisting of only capital letters present the most difficult reading -- because of their equal height, equal volume, and, with most, their equal width.
When comparing serif letters with sans-serif, the latter provide an uneasy reading.
The fashionable preference for sans-serif in text shows neither historical nor practical competence.

First, sans-serifs were designed as letters not for texts but for captions, when pictorial reproductions were introduced with stone lithography.
Second, they produce poor "word pictures."

INTERACTION OF COLOR Interaction of Color

INTERACTION OF COLOR Interaction of Color

This illustrates that clear reading depends upon the recognition of context.

In musical compositions,
so long as we hear merely single tones, we do not hear music.
Hearing music depends on the recognition of the in-between of the tones, of their placing and of their spacing.

In writing, a knowledge of spelling has nothing to do with an understanding of poetry.

Equally, a factual identification of colors within a given painting
has nothing to do with a sensitive seeing
nor with an understanding of the color action within the painting.

Our study of color differs fundamentally from a study which anatomically dissects colorants (pigments) and physical qualities (wave length).

Our concern is the interaction of color; that is, seeing
what happens between colors.

We are able to hear a single tone.
But we almost never (that is, without special devices) see a single color unconnected and unrelated to other colors.
Colors present themselves in continuous flux, constantly related to changing neighbors and changing conditions.

As a consequence, this proves for the reading of color
what Kandinsky often demanded for the reading of art:
what counts is not the what but the how.

IV A color has many faces -- the relativity of color

Imagine in front of us 3 pots containing water, from left to right:

WARM LUKEWARM COLD

When the hands are dipped first into the outer containers,
one feels -- experiences -- perceives -- 2 different temperatures:

WARM (at left) (at right) COLD

Then dipping both hands
into the middle container,
one perceives again
2 different temperatures,
this time, however,
in reversed order

(at left) COLD -- WARM (at right)

though the water is neither of these temperatures, but of another, namely

LUKEWARM

Herewith one experiences
a discrepancy between physical fact and psychic effect called,
in this case, a haptic illusion. haptic as related to the sense of
touch -- the haptic sense.

In much the same way as haptic sensations deceive us, so
optical illusions deceive. They lead us to "see" and to "read"
other colors than those with which we are confronted physically.

To begin the study of how color deceives and how to make use of this,
the first exercise is
to make one and the same color look different.

On the blackboard and in our notebooks we write:
Color is the most relative medium in art.

Challenging examples of very surprising color changes are shown.
Then the class is invited to produce similar effects

but is not given reasons or favorable conditions.
It starts, therefore, on a trial-and-error basis.

Thus, continuing comparison -- observation -- "thinking in situations" --
is promoted, making the class aware that discovery and invention
are the criteria of creativeness.

As a practical study we ask that 2 small rectangles of the same color
and the same size be placed on large grounds of very different color.

Soon, these first trials are collected and separated into groups
of more and less promise.
The class will become aware that change is a result of influence.
The influencing color is distinguished from the influenced color.

It is discovered that certain colors are hard to change, and
that there are others more susceptible to change.

We try to find those colors which are more inclined to exert influence
and to distinguish them from those which will accept influence.

A second class exhibition of more advanced results should clarify
that there are 2 kinds of changing influences working in 2 directions,
light on the one side and hue on the other. And both occur simultaneously --
though in varying strength.

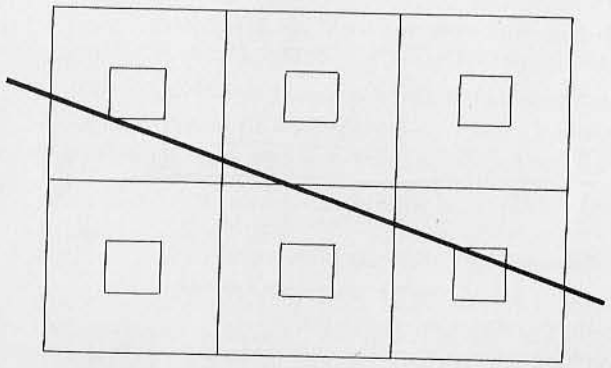
Since 2 pieces of the same paper, therefore of the same color,
are to appear different -- and, if possible, incredibly different --
we must compare them under equal conditions.
The only colors which are factually different are the large grounds,
though they are alike in size and shape.

Because of the laboratory character of these studies
there is no opportunity to decorate, to illustrate, to represent anything,
or to express something -- or one's self.

Here, successful studies present a demonstration. Since they cannot be
misread or misunderstood, they prove understanding both
of the principle involved and of the materials to be manipulated.

It should be clear that, with these exercises and all others to follow, whether or not we arrive at a pleasant or harmonious color combination is unimportant.

Precision and clean execution are required for all finished studies. To avoid destroying the desired effect, small pieces of paper on small grounds should not be used.
Arrangements such as the one shown below disguise the desired effect and lead to confusion:



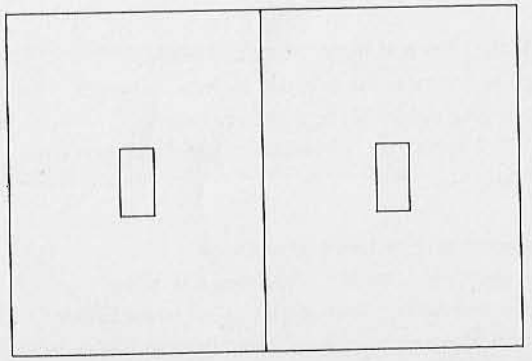
NO

Such studies shown separately in pairs may demonstrate clearly the desired effects. But interlocked in the tile pattern above, their illusional effects annul each other because of:

a) The simultaneous influence from too many directions -- from left and right, and above and below;

b) The unfavorable distribution of area between the influencing and the influenced color.

Consequently, such presentation lacks both sight and insight.



YES

V Lighter and/or darker -- light intensity, lightness

If one is not able to distinguish the difference between a higher tone and a lower tone, one probably should not make music.

If a parallel conclusion were to be applied to color, almost everyone would prove incompetent for its proper use. Very few are able to distinguish higher and lower light intensity (usually called higher and lower value) between different hues. This is true despite our daily reading of numerous black-and-white pictures.

Since the discovery of photography and particularly since the development of photomechanical reproduction processes, we are exposed -- more and more every day -- to pictures from all over the world, the world seen and unseen, visible and invisible.

These pictures, which are predominantly "black and white," are printed in only 1 black on a white ground. Visually, however, these pictures consist of grey shades of the finest gradations between the poles of black and white. These shades penetrate each other in varying degrees.

With the tremendous increase in pictorial information -- through newspapers, magazines, books -- we receive a training in the reading of lighter and darker tones of grey as has never before existed. With the growing interest in color photography and color reproduction, a parallel training in the reading of lighter and darker color is on the way.

However, it is still true that only a minority can distinguish the lighter from the darker within close intervals when obscured by contrasting hues or by different color intensities.

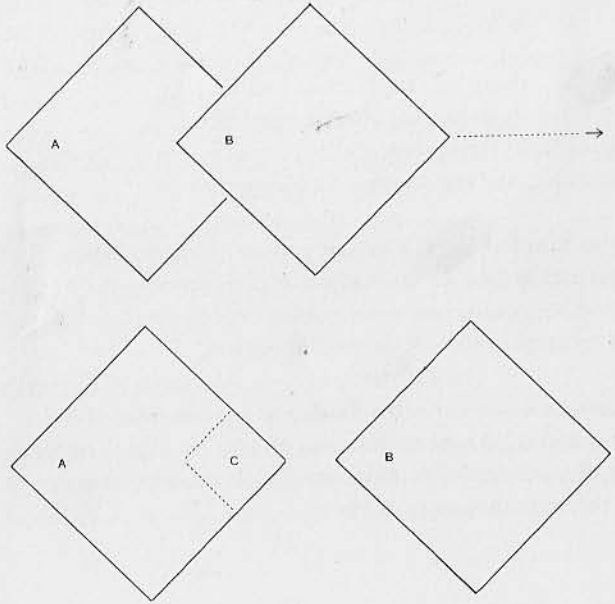
In order to correct a prejudice common among painters and designers -- that they belong to that minority -- we have the students test themselves. We confront them with several pairs of color, from which they are to select and to record which color in a pair is the darker.

The darker one, it is explained, is visually the heavier one, or the one containing more black, or less white. It should be mentioned that the students are encouraged to abstain from making a judgment in any case of doubt. It may also demonstrate that not voting can have a positive meaning.

Though there have always been advanced painting students in the basic color class, the result of this test has remained constant for a number of years: 60% of the answers are wrong and only 40% are right, not counting the undecided cases.

By this experience we are led to the next task: To find colors about which we cannot say immediately which is the lighter or darker. These colors are collected and pasted in pairs, and observed again and again until their light-dark relationship is clearly recognized.

In cases where a decision seems impossible, an after-image effect may be helpful. 2 color sheets are put on top of each other in this way:



Focus longer than the eye wants to on the covering corner (B) of the upper paper and then quickly remove this upper sheet. If area (C) now appears lighter than area (A), then the upper paper is the darker -- and vice versa. After this, repeat the experiment with the papers in reverse order. Frequently only 1 of the 2 reversed comparisons reveals the true relationship.

The usual results (60% wrong) are disillusioning as well as revealing. Voting for the wrong color often needs cover or compensation; also, the disappointment of wrong answers encourages doubts. The doubts often are directed, not against one's own judgment, but against the competence of the teacher: are his answers the right ones?

As the test is to prove whether one has a trained eye or not, the pairs of color presented for discrimination are not easy to decipher. Within the pairs there is no equal light intensity because the conclusive question to be expected from a class is: are there equal light values within these couples? The answer is No.

Another unavoidable question is: will a photograph of these colors reveal their true relationship and thus give the final proof? The answer again is No.

This answer will remain true for black-and-white as well as color photographs, because the sensitivity and consequently the registration of the retina of an eye is different from the sensitivity and registration of a photographic film.

Normally, black-and-white photography registers all lights lighter and all darks darker than the more adjustable eye perceives them. The eye also distinguishes better the so-called middle greys, which in photography often are flattened if not lost.

As an example we showed our class 2 different reproductions of the same Ensor painting, "Masks Confronting Death," of 1888. The first appeared in the catalogue of an Ensor exhibition, the other in a newspaper report on the same exhibition.

The first, the larger and more official reproduction, in very fine screen on coated paper, presumably would be considered more representative than the second, smaller reproduction in a coarser screen and on the cheapest paper.

But the latter was not only much more correct in its whole tonality; it also showed clearly 1 more mask, face, or head which the more expensive, so-called high-key reproduction blotted out entirely -- a small but complete frontal face, lighter than all the others and separated from them, near the left picture edge.

This shows what a higher key in light can lose in photography.

The greatest advantage the eye has over photography is its scotopic seeing in addition to its photopic seeing. The former means, briefly, the retinal adjustment to lower light conditions.

Color photography deviates still more from eye vision than black-and-white photography. Blue and red are overemphasized to such an extent that their brightness is exaggerated. Though this may flatter public taste, the result is a loss in finer nuances and in delicate relationships. Whites rarely appear white but usually look greenish. This makes color slides of Mondrian paintings unbearable.

For practical reasons, certain groups of our color reproductions in the original edition are done in 4-color process which presents subdivided, optically intermixing transparent colors instead of the opaque colors which are characteristic of most of our studies.

Gradation studies -- new presentations

With the experience that often we are unsure and thus unable to distinguish between lighter and darker in color, it appears appropriate, even necessary, to develop a more discriminating sensitivity. To this end,

we study gradation by producing so-called grey steps, grey scales, grey ladders. These demonstrate a gradual stepping up or down between white and black, between lighter and darker.

For such exercises, we first collect as many greys in paper as possible, and preferably independent of commercial grey sets, which usually offer a too limited choice, or, worse, unequal steps. Rich sources for many paper greys are black-and-white reproductions from popular magazines.

Selecting from them smaller and larger areas of as many greys as possible, we will be taught first that photography registers and measures light and dark differently from our eyes. That it turns darks darker and lights lighter means, besides a generalization toward the polar contrasts, a loss of the visually more interesting middle greys. Thus, such reproductions confront us with a dominance of very heavy and very light greys, and a consequent scarcity of middle greys.

These cutouts are to be arranged in gradations as described. The softer the steps appear, and the more equal the steps are, the more valuable and convincing the study. As any lines or empty spaces between the steps interfere with a direct comparison, such separating in-betweens prove nonsensical. We also reject the still-recommended but misleading stepping-up of thin layers of water colors or India ink, as explained in Chapter XX. In order to avoid such mistakes, and also any mechanical repetition of the too-familiar illustrations of color books, we aim at a more creative, more challenging, more instructive presentation. Thus we subdivide and mount our grey scales to show new interactions, particularly between graduating and non-graduating greys, and vice versa.

Color intensity -- brightness

After the study of "Lighter or Darker" and with some training in gradation studies, one can expect to come to an agreement on different light intensities.

However, when it comes to color intensity (brightness), occasionally one may find agreement among a few people but hardly within a large group such as a class.

As "gentlemen prefer blondes," so everyone has preference for certain colors and prejudices against others. This applies to color combinations as well. It seems good that we are of different tastes. As it is with people in our daily life, so it is with color. We change, correct, or reverse our opinions about colors, and this change of opinion may shift forth and back.

Therefore, we try to recognize our preferences and our aversions -- what colors dominate in our work; what colors, on the other hand, are rejected, disliked, or of no appeal. Usually a special effort in using disliked colors ends with our falling in love with them.

The exercise in color intensity consists of sorting all possible shades and tints within a hue. From these is chosen the most typical hue (the bluest blue, the greenest green, etc.) and it is placed within the group accordingly.

VI 1 color appears as 2 -- looking like the reversed grounds

Having presented, in the previous problem, a very detailed explanation of a step-by-step method of teaching and learning, the following problem permits a briefer description.

With the first exercise in color interaction we make
1 color look like 2, or, what means the same,
3 colors look like 4. The next step is to make
3 colors look like 2, or, describing it as in the previous task,
1 color is to show 2 faces which refer to the 2 colors
of the reversed grounds,
or, the changed color is to echo the 2 changing ones.

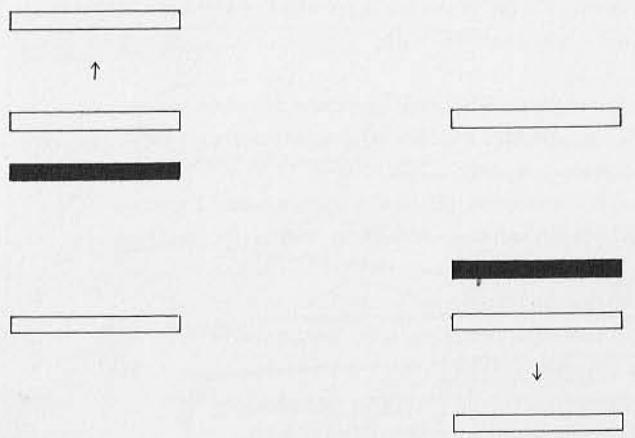
After showing a few examples, the task of producing similar effects is introduced with the question:
Which color will play simultaneously the roles
of the 2 colors of the 2 reciprocal grounds?

The first class exhibition of preliminary solutions shows that most of the trial colors selected appear closer to one ground than to the other.

However, when one tries to find a color that is equally close or equally distant from both grounds, one will discover that even a large collection of color paper (even that of the entire class) may not provide the fitting tone.

Then, instead of pushing the in-between color to one or the other side, we must consider changing 1 or both of the grounds, either moving closer to or more distant from the in-between color. (See diagram.)

After repeated trials it must be concluded that the only fitting color is the one which is topologically in the middle of the colors of the 2 grounds.



The task is to find this middle color.

This is relatively easy when the 2 grounds are of the same hue, as with a lighter and a darker green ground, or with a lighter and a darker violet ground.

It is a more challenging task to find the middle color between 2 different hues but it is particularly interesting when the 2 grounds are of opposing (complementary) colors.

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.

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.

First: 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.

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 two 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.

Suddenly, one shifts the focus to the center of the white circle. Then 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.

Second: On the left are yellow circles of equal size which touch each other and which fill out a white square.
On the right is an empty white square of the same size.
Each is on a black ground.

After staring for half a minute at the left square,
one shifts the focus suddenly to the right square. Here one experiences
a very different after-image. Instead of seeing
the complement of the yellow circles (blue), diamond shapes
are seen -- the leftover shapes of the circles -- in yellow.
This illusion is a double and thus reversed after-image,
sometimes called contrast reversal.

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.

XXII Vibrating boundaries -- enforced contours

As a deception, this effect is related to our earlier experience
in which 2 colors appeared as 3 or 4 colors.

However, the additional illusionary colors
often are hard to define as to their hue.

They often appear as shadow on one side of the boundary
and as light reflected on the other side.

Or sometimes this vibration presents just a duplication
or triplication of the boundary line.

The conditions for these varying effects occur between colors
which are contrasting in their hues but also close or similar
in light intensity.

Though this effect refers to the after-image,
its physio-psychological function apparently
seems not to have been clarified.

Often, under the same conditions, it is perceived by some people
and not by others.

It is visible and not visible with or without glasses;
or, similarly, with interchanging of near and far focus.

This initially exciting effect also feels aggressive
and often even uncomfortable to our eyes.
One finds it rarely used except for a screaming effect
in advertising, and as a result it is unpleasant, disliked, and avoided.

XXIII Equal light intensity -- vanishing boundaries

Though rarely perceived, it is a fact that articulate boundaries
between colors can be made nearly unrecognizable, or made practically
invisible -- through the choice of color alone.

This very surprising and most exciting of all color phenomena depends,
like all other effects, on specific conditions.

The effect is the opposite of the aforementioned vibrating boundaries,
and it is not possible between very contrasting hues.
It is confined to adjacent, neighboring colors and depends most decisively
on equal "light intensity." Only real equality in lightness
or an equivalent real equality in darkness produces the effect here aimed at
and searched for.

Now, since the term "equal value" has unfortunately been misused too often
for colors lacking just this quality, incompetent judgment has distorted
this term to a falsified measure. In this way, "equal values"
are more spoken about than realized -- than actually seen.

Thus, we can safely state that very few people -- including many colorists
and painters -- have ever seen 2 adjacent colors
of true equal light value -- that is, of exact equality in light,
of the same level of light, or, in a sense, the same altitude of light.

This will indicate that equal light intensity presents,
besides a most challenging exercise, a most difficult task
demanding most of all -- patience.

Because several of our color classes were not able to present
even 1 convincing color couple of equal light intensity,
this makes it an exercise for teachers willing to demonstrate
that in all teaching the personal example is the strongest incentive.

Earlier, right after the test "Which is the lighter and/or darker?"
we had the opportunity to prepare for this difficult exercise,
which usually is the last exercise of our course.

When we were collecting pairs of colors hard to distinguish as lighter or darker
we were often tempted to
consider some of them to be of "equal value."

At that time we learned that in cases difficult to decide upon,
which we named "near-equal light intensities," or "almost-equals,"
the after-image test can be a helpful measure. (See diagram, page 13.)

Though sometimes it may appear hopeless to find equal light intensities in paint
and painting, in color papers, or in our surroundings, we have found that
nature occasionally provides an opportunity to see them on cumulus clouds
against blue sky.

When these clouds, often lined up in horizontal groups,
appear gleaming white in their upper part in full sunlight,
separated from and rising against a distant deep blue,
then underneath they show grey tones as shaded white.
These shades merge, or even hinge, with the same
but here very close blue. Why very close? This grey is
of the same light intensity as the neighboring blue below.
Thus, the boundaries between grey and blue vanish,
and we do not see where clouds end and where sky begins.
With such clouds, this is best observed with the sun at our backs.

In order to produce this provocative color effect -- but also the most
delicate one -- all disturbing effects of paper (such as different surfaces)
and of montage (visible edges or paste marks) must be carefully avoided.

Therefore, the 2 papers of equal light intensity must be mounted as
inlay (known also as "intarsia").

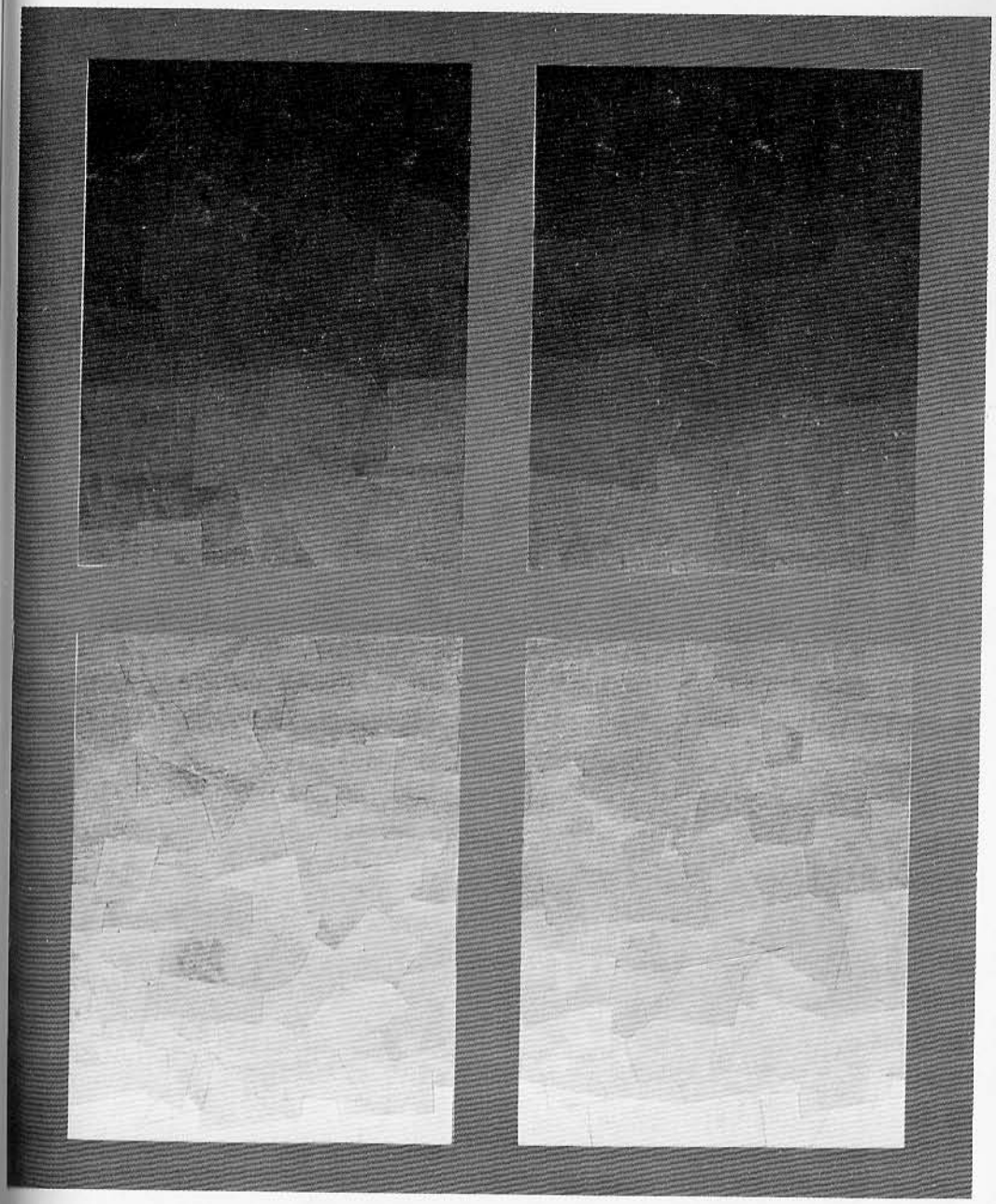
In this process the papers are placed within each other, instead of on top of
each other. Thus the thickness of the paper does not show, and, more important,
its very disturbing shadows are eliminated -- provided the papers are of
equal thickness.

For precision fitting, so that the joints will not show, the papers to be
inlaid are formed simultaneously in a single cutting.

The finer the knife (best, the thinnest razor blade), the thinner the paper,
and the harder the ground to cut on (preferably glass), the better the
fitting will be and the less the joints will show. It is also essential that no glue
seep in to mark the joints.

As the selection of the papers here demands patience, so their presentation
demands skill and cleanliness.

PLATES



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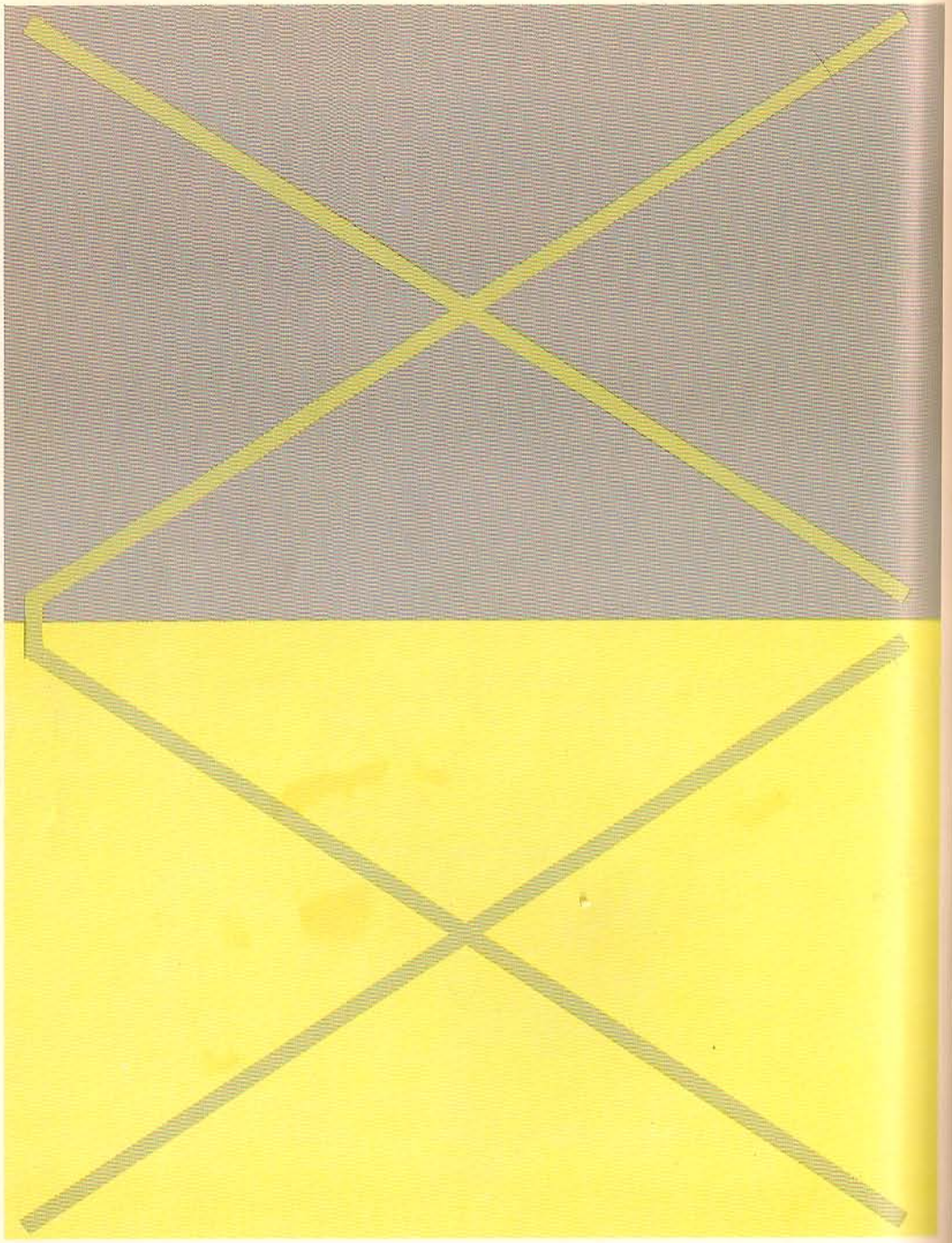

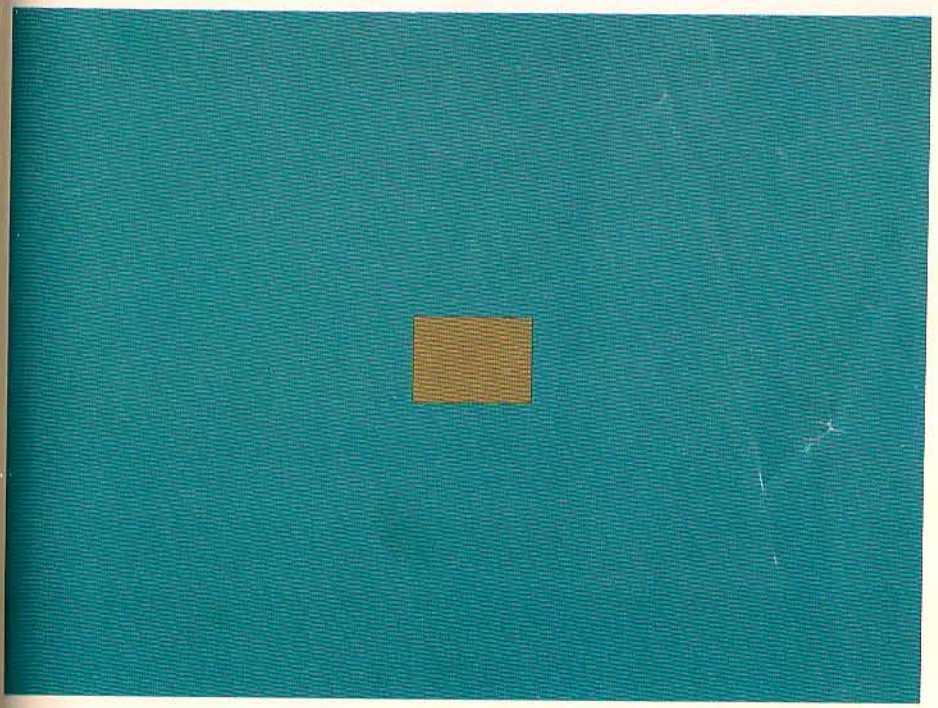

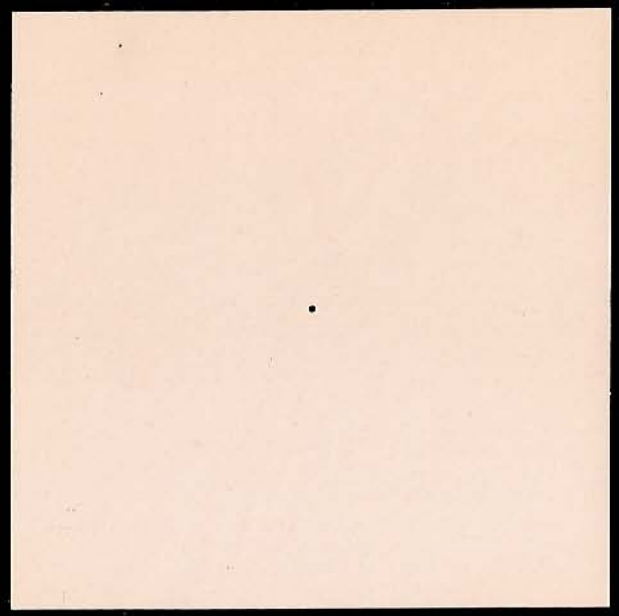

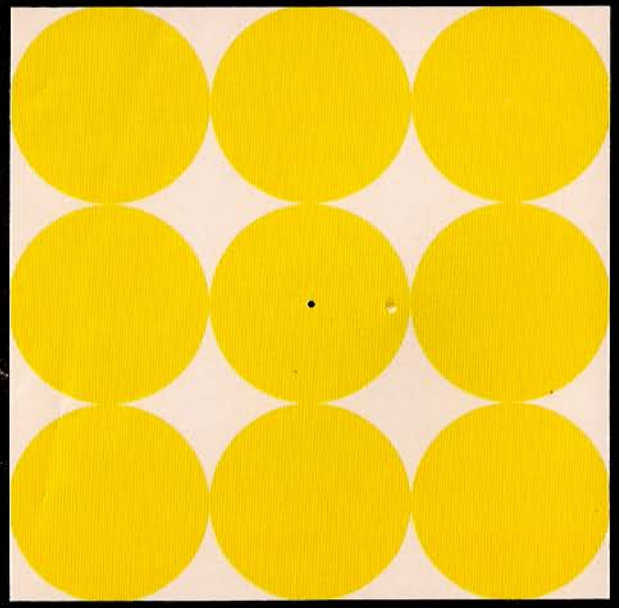

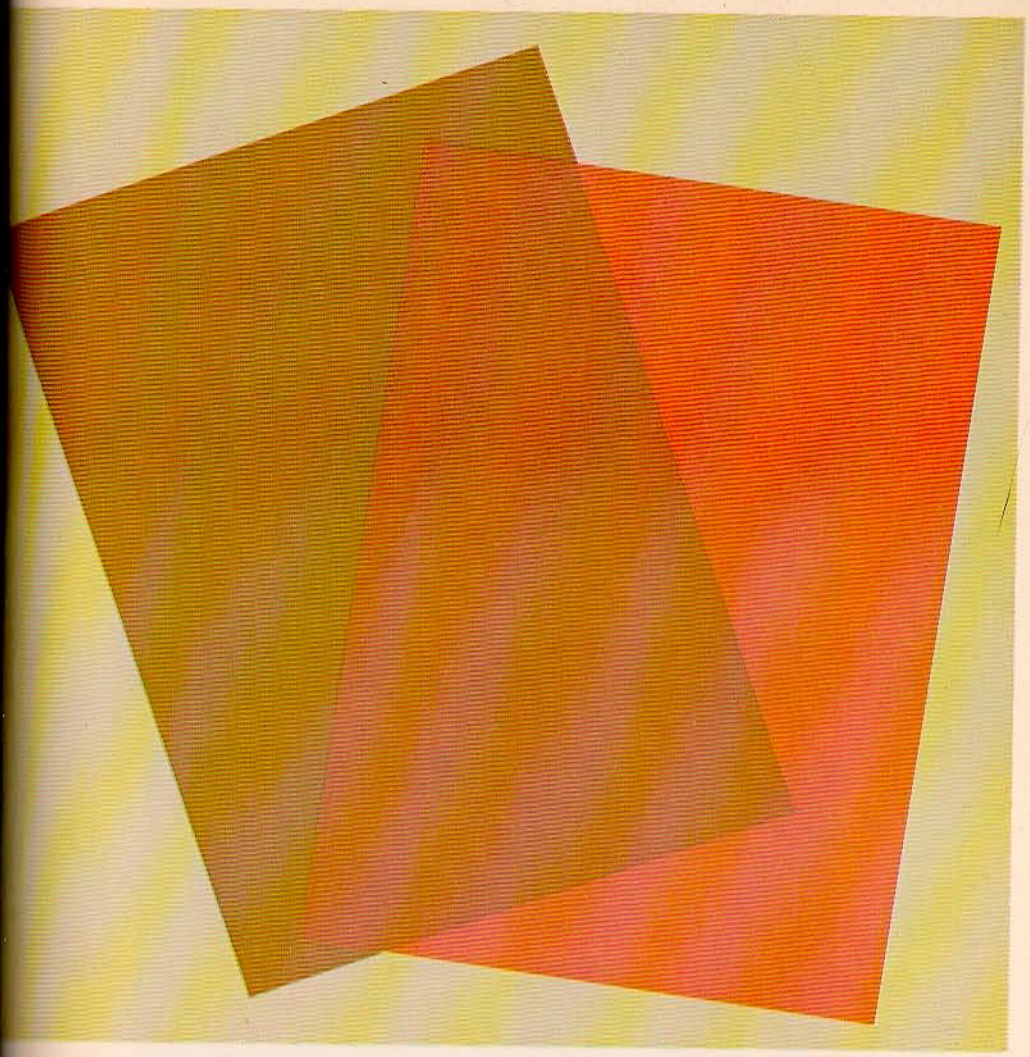

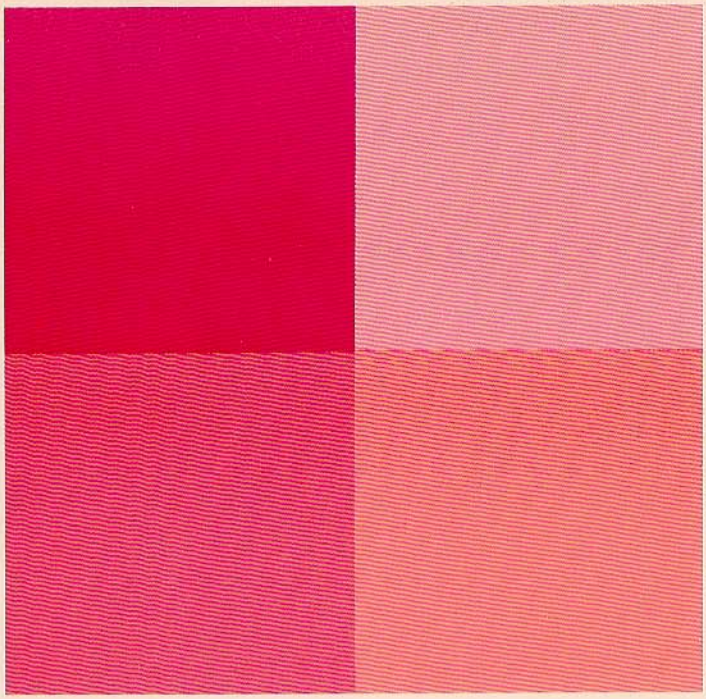

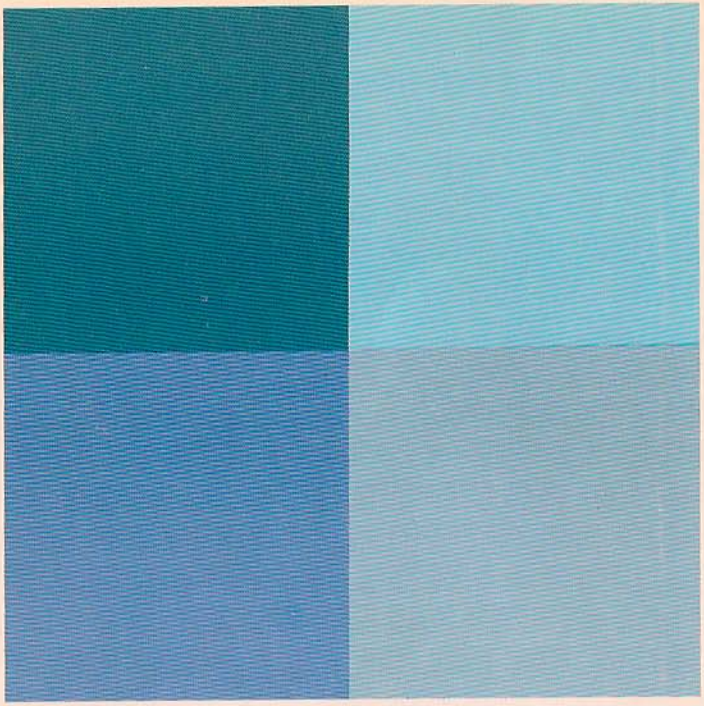

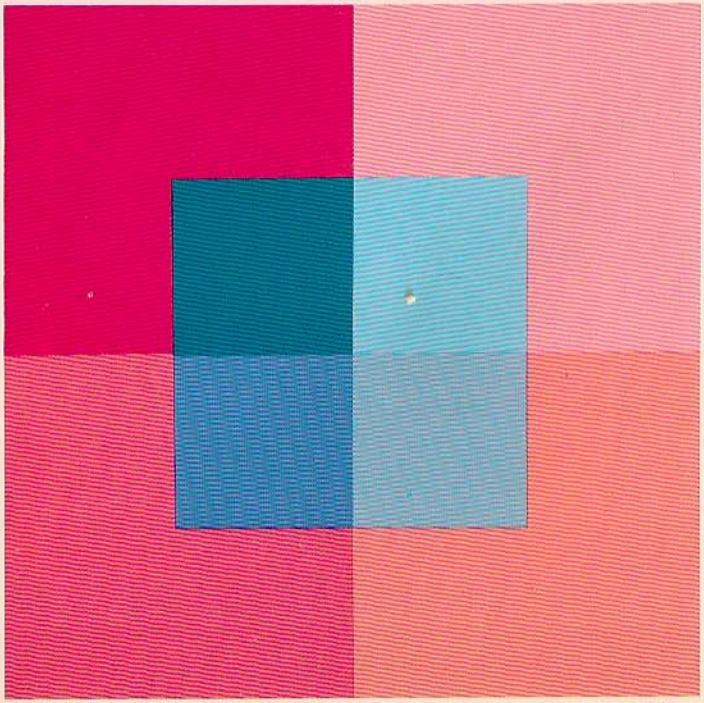

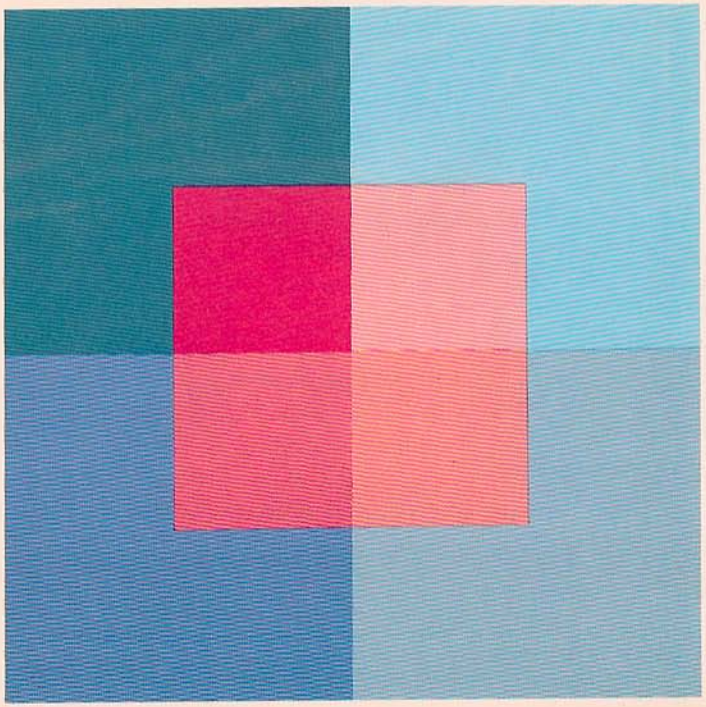

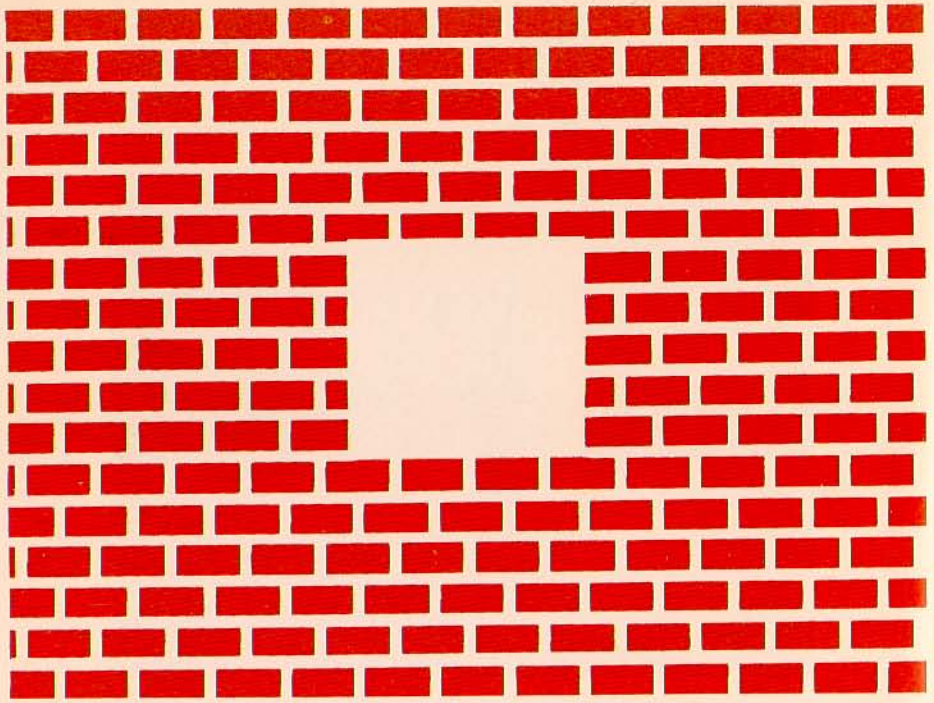

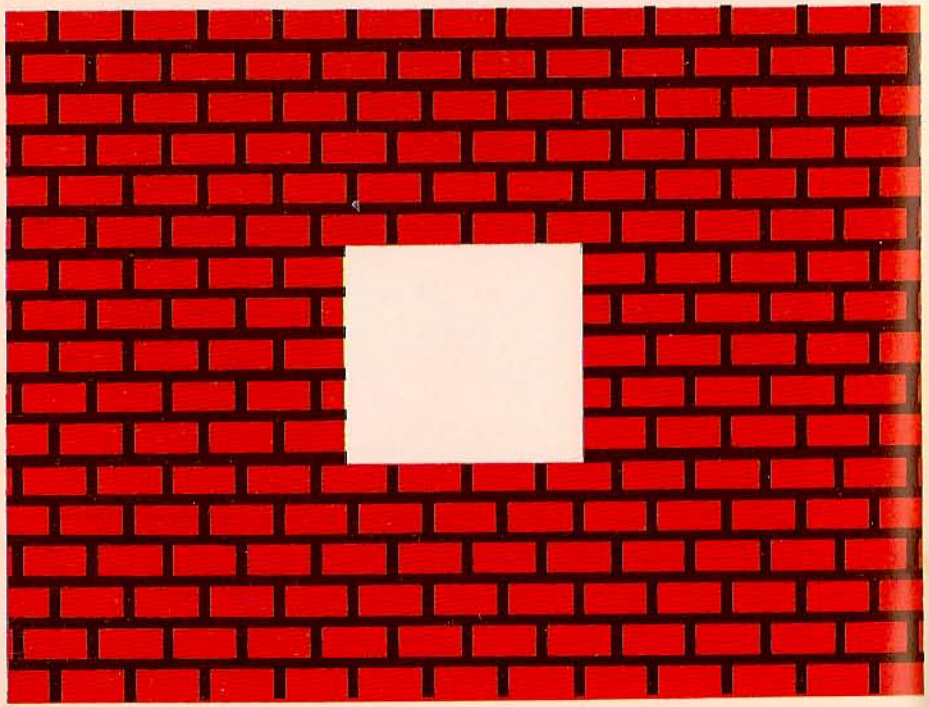

XIII-1

Explanation of plates

A color has many faces -- the relativity of color; Chapter IV

A color has many faces, and 1 color can be made to appear as 2 different colors. In the original design for the study now on the front cover (plate IV-1 in the unabridged edition), horizontal dark blue and yellow stripes were on a flap which could be lifted to show that a vertical stripe of ocher 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.

Gradation studies; Chapter V

The gradation in plate V-1 is a collage of small snippets of grays carefully collected from magazine illustrations, which should come from the same publications to ensure the same hue of the black.

They are arranged downward in the softest possible transition from deep black to clear white, and then mounted as 4 equal-sized rectangles on a cardboard sheet of a correct middle gray so that they appear as in a window frame with a central cross, of which all parts are the same width.

This combination of decreasing blacks into clear whites within an unchanging framework results in the following interaction: the 3 verticals of the frame appear increasingly lighter toward the top, and similarly darker toward the base.

Of the 3 horizontals within that frame the upper appears lighter, and the lowest one darker. And the middle horizontal almost vanishes from merging with its neighboring middle-gray snippets.

Although such study depends very much on precision and patience, similar studies should be encouraged. It should be mentioned that samples of a real middle gray are hardest to find.

Reversed grounds; Chapter VI

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?

Subtraction of color; Chapter VII

Hold plate VII-4 with the deep green ground on the left, and the light gray ground on the right.

Below them are 2 contiguous horizontal stripes, the upper one a brownish-green on top of a thin ocherous yellow.

The small rectangles in the centers of the large rectangles seem to be alike.

For the best simultaneous comparison do not look from one center to the other but focus firmly on a point in the middle between them, which will be within the boundary of the grounds.

This is a courageous example of making 2 very different colors look alike. It proves that its author understood the meaning of "subtraction of color." In other words, how to get rid of too much dark or light in a color, or too much hue, as the green or yellow.

After-image; Chapter VIII

For a clear understanding of interaction of color caused by interdependence of color we should experience what "after-image" means. Before going on to study plate VIII-2 we need to do the following.

Cut out of brilliant light red and clear white papers 2 precise circles, each at least 8 inches in diameter and with a black dot marking their centers. Then paste them -- horizontally related, the red circle to the left and the white one to the right -- on a blackboard or a piece of black paper or black cardboard, about 12 inches high and 20 inches wide, with equal amounts of black before, between, and after the 2 circles.

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, sickle-moon shapes appear, moving along the circle's periphery. In spite of this, one must continue to focus on the center point of the red circle 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 voices of astonishment, because now 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.

Now look at plate VIII-2 shown horizontally. On the left are yellow circles of equal diameter which touch each other and fill out a white square. There is a black dot in its center. On the right is an empty white square, also with a centered black dot. Each is on a black ground. After staring for half a minute at the left square, shift the focus suddenly to the right square.

Here one experiences a very different after-image. Instead of seeing the complement of the yellow circles (blue), diamond shapes are seen -- the leftover shapes of the circles -- in yellow. This illusion is a double and thus reversed after-image, sometimes called contrast reversal.

Color mixture in paper; Chapter IX

In painting it is easy to mix pigments by pouring them together and stirring them, which achieves an in-between color as a mixture. Since this is not possible with paper, we must imagine a possible "in-between color." In plate IX-1 we superimpose part of a brown rectangle on a rosy-red rectangle. First we pass our eyes from left to right several times across the overlapping area, in which the mixture should appear.

After several passages back and forth we see that the red appears to come through the brown at the left, and the brown seems to come through the red at the right border of the overlap. This is proof that we have a true mixture.

It is easy to see that the right edge of the brown rectangle has a heavier boundary than the left edge of the red. Therefore this mixture contains more brown than red. Thus, the brown is on top; in other words, the brown is dominant in the mixture.

Now try to find a mixture in which the red is on top and therefore dominant.

Read Chapter XI and find some color mixture in paper that produces various space illusions.

Color intervals and transformation; Chapter XIV

A "transformation" of 4 reds to 4 blues of a slightly lower key seems comparable to a transformation of a tetrachord in music from one instrument to another. Therefore we are also in color concerned with "intervals." But such rearrangement is far more complicated with colors than with musical notes.

Upstairs in plate XIV-1 we have 4 red squares at the left, making one square, and 4 blue squares at the right, also making a square. Each has its darkest squares on the left. In the top row of each the strongest contrast exists between the left and right squares, and they are separated by the hardest boundaries.

To demonstrate whether they provide the same "intervals," downstairs we transfer the blue square arrangement to the center of the reds, and vice versa. After this transformation, if the intervals are correct, the hardest boundary in the top pairs of squares is repeated in the

upper halves of the vertical axis, and the lower pairs show the evenly softer boundaries.

In order to train your eyes, compare the corresponding boundaries upstairs and downstairs, from left to right. Then you will see that in all four cases the left vertical halves are heavier and that the right

vertical halves are foggy. Read Chapter XIV and look at the 6 drawings that illustrate it.

Optical mixture -- the Bezold Effect; Chapter XIII

The French Impressionists (after 1870) aimed at an optical mixture effect. Instead of mixing their colors on their palettes, they applied them in small dabs on the canvas so that the colors were mixed, at a distance, in our eyes.

A similar effect is named after Wilhelm von Bezold (1837-1907), a meteorologist in Berlin, who discovered that certain strong colors, when evenly distributed, changed entirely the effect of his rug designs, which were his avocation.*

One of my color students, following Bezold's example, showed in plate VIII-1 light red bricks laid up with very white mortar, and then showed the same bricks laid up with pure black mortar. The red with the white looks much lighter than the red with the black, particularly at a distance.

**The Theory of Color and Its Relation to Art and Art Industry,* trans., Boston, Prang, 1876.

Free studies; Chapter XVIII

The study on the back cover done with pressed autumn leaves shows again that color interaction is a result of good color instrumentation.

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