COLOR CONCEPTS FOR THE ART STUDENT

DISSERTATION

Presented to the Graduate Council of the North Texas State University in Partial Fulfillment of the Requirements

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by

Donna Finch Adams, B.F.A., M.F.A.

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The problem of this study is to determine the degree to which color concepts should be taught to the art student. There is a survey of the awareness of color through art history, the introduction of certain historical and recent information in the fields of physics, physiology, and psychology in relation to color and the art student, a review of the symbolic nature of color, an examination of the development of color notation or theories utilized by art students, and an attempt to integrate color more fully with the other art elements. Recommendations are made that for students pursuing color study there should be a cross-disciplinary approach to the study of color, that the study of color can follow a predetermined developmental path, and that the student have a logical construct from which to develop his own color theories.
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CHAPTER I

INTRODUCTION

Background of the Study

The art student who undertakes the study of color may find himself courting confusion. On the one hand courses dealing with color are not common, and the information available in the literature is so convoluted as to be almost impossible to untangle and to utilize effectively. On the other hand, the student must as an artist deal with his own conflicts about interfering with the creative process.

Certainly this anxiety is well-founded, for nothing of value can be achieved in art without intuition, creativity, and vision. Yet it is certainly possible to infuse this intuition with basic information about the nature of color so that a clearer understanding of its properties can contribute to the actualization of the images presented to the artist by his imagination. For while the study of color may be achieved scientifically, the application of that color must clearly be a matter of the fusion of the artist's acquired information, his experience, and his artistic insight. The artist has used color as a means of expressing emotion since the dawning of aesthetic awareness. It has always been an expression of the mood and tempo of life, exercising a powerful influence on man.
Yet the student searching for information about color faces a difficult task. The literature devoted to the study of color is vast to the point of being overwhelming. Within it are espoused many theories, charts, elaborate color notations, philosophical models, and illustrative histories of "isms" and artists. Such a plethora of material is not only confusing but discouraging to the beginning student.

In the past the structured texts which are formulated for beginning design courses as the standard support for teaching the elements of design in the modern student's laboratory work have devoted a single chapter to concentrated color study. A need for a comprehensively structured curriculum for the student electing to follow the path of extensive color study has only recently been reflected in the literature. It is the contention of this study that there is within the framework of the study of color a rich opportunity to expand the natural, intuitive approach of the artist. This research is an attempt to discover what could be taught as specialization in color study or included in the curriculum requirements in such fields as fine arts, advertising, illustration, fashion design, architecture, interior design, art education, or crafts with the information forming a pool, hopefully a broad resource base from which students, teachers and practicing artists may draw.
Statement of the Problem

The focus of this study was to determine the degree to which color concepts should be taught. Also within the scope of this work were examinations of the kinds of color study appropriate to the art student.

Purpose of the Study

The purposes of this study were (1) to briefly explore the role of color in art history, (2) to identify and explore the possibilities inherent in teaching the scientific aspects of color, and (3) to describe color theories taught in the past in order to draw conclusions about the extent to which they could be useful today.

Guideline Questions

The following questions were used as guidelines for the study.

1. What are the historical uses of color that might be presented to the student to help him to develop an appropriate overview?

2. What aspects of recent information in physics, physiology, and psychology might be integrated into a study of color?

3. What aspects of the symbolic nature of color might be germane to the art student?
4. What aspects of historical color notation and color theory might be included in a framework on which to solve problems in color within a logical construct?

Procedures

The following procedures specify the approach used in this study.

1. Works by authors on color usage and educators in the field of color studies were consulted to develop criteria for the judgments made in this study.

2. Theories from the fields of physics, psychology, and physiology were reviewed briefly to examine color as it is used by the artist and as it is perceived by the viewer.

3. Authors in color theory and symbology were surveyed to determine whether color theory and symbology should be taught.

4. Works on color as it is used in design were reviewed to determine if color should be taught as a course separate from the design courses where it is generally taught.

The problems addressed and the questions raised were heuristic in nature. Since this was a speculatively conceived study, it followed the configuration of the classical experimental paper only in relation to stating a conclusion and
making recommendations; its design was for a probity of its own.
CHAPTER II

ART HISTORICAL IMPLICATIONS IN COLOR

Introduction

The attempt to understand color and man's relationship to it is essential to any appreciation of the aesthetic history of mankind. Man's earliest artists, scientists, and theorists have recorded their impressions, thoughts, and musings about color and art, as have their successors. As a result, the historical chronicle of the use of color in art is as true a mirror of change as any more conventional historiographer's approach; the colors chosen and the color arrangements used by men and women of art reflect the social and political climate of their times.

Since art functions as a record of social evolution, integral to the civilization that produced it, the original purpose of that art may be forgotten as time passes. This in no way belittles the work itself, but rather it emphasizes that the art student today is not unique in his vision. The lessons of the past are part of the foundation the present art student may use to build the artistic future.

Prehistoric

Perhaps the first evidence of man's attraction to color concerns Ice-Age man's custom of burying his dead in red clay
soil or in painting the bones red (29). The Upper Paleolithic race or Cro-Magnon man painted the walls of caves in Northern Spain and in France utilizing the iron-rich clays of black, brown, red, and ochre to depict his concepts of animals.

An awareness of color might have first found its expression in decorations and in religious symbolism. Abstraction may have begun with body ornamentation and the use of colorful materials for jewelry (30). Thus the human body itself became the focal point for art. Pigments were applied directly to the body and later these colors were used to embellish fabrics (18). According to Pliny the Elder (49), among the barbarian tribes of his time (first century A.D.) the women used plants to stain their faces and the men tattooed their bodies.

Man in the Neolithic Age saw the world alive with spirits. The objects which he created, the masks, totems, and utensils were to him possessed by mysterious powers. These he decorated with the colors he knew (39).

There is little doubt that the controversies over the awareness of the eye's perception of color, the brain's manipulation of that information, the evolution of an abstract language to name colors, and the use of those colors is still being hotly debated. There is, however, ample evidence that early man was able to differentiate colors. Work done earlier this century by Rivers and reported by Parsons (44) indicates that although the primitive man may not have had a name for
each color, he could match yarn samples with ease in the standard Holgren Yarn Test. Parsons implies that the use of color in a society gives rise to color names. Such names are generally derived from the plants or minerals used for color production. Therefore, color names seem to appear when there is a need. If they are not needed, then they may not develop. Yet an awareness of the un-named colors will not be diminished (32, 44).

Luckiesh (34, p. 47), using Rivers' findings to establish a color awareness chronology, observes that those societies at the "lowest stage of development had names for red, white, and black; second stage, yellow and sometimes green; third stage, green and sometimes blue and fourth stage, blue."

Kuehni (32) concludes that linguistic development in most societies cite eleven basic color terms: white, black, red, green, yellow, blue, brown, purple or violet, pink, orange, and gray. He further indicates that the sequence of the terms appeared in virtually all languages of the world in the same order and that there is a high correlation between the number of basic color terms in a language and the technological or cultural complexity of its users.

Egyptian

According to Burge (9) there was a word in the Egyptian ideographic or hieroglyphic language expressing the abstract idea of color. The naming of this abstract concept separate
and apart from the depiction of nature or from replication is far more profound than the naming of individual colors. Kuehni (32) observes that ancient Egyptians used color to achieve aesthetic effects. They used pigment in abstract patterning, but light source or illumination was not considered.

Greek

Kuehni (32) supports his theories of color awareness by citing the terms in Homer and in other references, counting the number of times each color is mentioned in a specific work and investigating its roots. He thus draws conclusions regarding the development of human color awareness.

Many writers observe that the Greeks and other ancient cultures often cite the four basic colors as red, white, black, and yellow (3, 5, 7, 8, 13, 16, 18, 35, 53).

References to a palette restricted to four primary colors began in Greek literature in the metaphysical poetry of Empedocles and Democritus in the mid-fifth century. Pliny (49) remarks that Apelles and other artists who painted before 330 B.C. used only the above four colors in all their rich works. These four colors in ancient times seem to be related to the four elements of fire, air, water, and earth; the four seasons; the four directions in the heavens; and in Mesopotamian tradition, four of the planets (5, 6, 18, 30).
Yet Bruno (8), in commenting upon Pliny's four-color palette, notes that there was ample evidence among fragments that the ancient artist was indeed familiar with the handling of red, yellow, and blue to produce the intermediary hues of orange, green, and purple. In all of these traditions involving a system of four-color co-ordinates from antiquity, blue appears as an essential color, so that its omission from the list of primaries on the palettes of Ancient Greeks seems strange.

Burris-Mayer (10) finds that Pliny was wrong when he stated that early Greek painters used only black, white, red, and yellow. She theorizes that the lack of names for the colors blue and green among early people does not necessarily mean that they did not use them; such color names may not have been translatable.

The Greek Polychrome wall paintings and sculpture were limited not by variety of available pigment, but by a highly structured symbolism that designated appropriate color usage. This symbolic aspect of color may, in part, account for the seemingly contradictory color descriptions in ancient writings. Of course, these apparent contradictions may have arisen for a variety of reasons: faulty translation, incorrect transcription, or mistaken interpretations (5, 8, 10, 18, 32).
Medieval

The Israeli mosaics of the Byzantine Period are striking examples of Medieval color use. Kitzinger (28) explains that the color of such works was flat and bright, and that the colored tesserae (pieces of glazed ceramic tile) were applied in solid surfaces without any attempt at modeling; therefore, there was very little suggestion of three-dimensionality.

Other works typical of the Medieval awareness of color are the Irish illuminated manuscripts of the early sixth century. Sweeney (51) sees no attempt in these works to represent solidity, that the color was arbitrary with a passion for bright, primary colors. Thus for these—as for most works in the Medieval era—the main thrust of the primitive expression in color seems to have been bright, clear, strongly-designed patternings with color choices reflecting the preliterate symbolic message (8, 18, 28, 51, 53).

Medieval art researcher D. V. Thompson observes that

The prevailing fashion in much Medieval paintings was to use a palette of frank definite colours, in groups of comparable intensity, according to the work: the most vivid for book illustrations, a somewhat discrete range for panels, and for walls a well-assorted series of less intense but well-defined colours (53, p. 89).

Architects designed cathedrals so that the magnificent stained glass windows cast the images of saints in abstract patterns on the interiors. Most manuscript miniatures were colored outlines, some filled in. A glimpse into the Medieval artist's thought about color and palette choice is provided
by an unsigned work written by a monk in the late fourteenth century, found in the National Library of Naples and translated by Thompson and Hamilton (52). The monk concludes that the primaries according to the church and to scientific theory were black, white, and red, but, if one wanted to be a successful illuminator of manuscripts, he must add to this list yellow, blue, violet, rose, and green.

The later Middle Ages, known as the Gothic era, saw remarkable innovations in the creation of stained glass. These stained glass productions, created primarily for the purpose of instruction, admitted far more light than earlier attempts and took aesthetic advantage of the changing quality of natural light. Since sunlight moves across the spectrum from red to violet during the day, the red predominated in the windows of the east end of the cathedrals while violet predominated in the windows in the west (39).

Renaissance

Giotto rejected the rigid formulas (7), and the primitive intimacy of color discussed above and began the local color of the Renaissance. This period saw many attempts to codify and to assign fixed intervals to color (5, 43). Notations such as "natural friendships and hostilities" (13) among colors can be found in records of the time as can observations of the differences between natural and derived colors (11). Although Aristotle (3) had, long before, suggested the idea
of a color scale when he described rainbow color sequencing, no one actually published a color scale until the eighteenth century.

But from about 1400 it was light, more than color, that became important to the artist. The delight of pure color that the Medieval man loved was exchanged for the cool chiaroscuro, the volumes of space and form that preoccupied the minds of the Renaissance painter (4).

Much of Renaissance art was influenced by either the Florentine or Venetian schools. The painters of the former school largely denied the importance of color, seeing it primarily as a mere enhancement to the art of drawing (12). The Venetians, on the other hand, were delighted with rich, glowing color, fascinated with the subtleties of tone (39).

Yet association of bright colors with the taste of ignorant peasants was prevalent in the literature of the great period of Venetian art of the late fifteenth century. Despite the fact that pure, glaring colors were termed "beautiful colors" (a pejorative term) those painters who used them were thought to be pandering to the taste of the ignorant and were said to do it only to make money. Dolce, for example, observes that "a man of low taste, like Pope Sextus, is impressed by such colors which gorge the eyes" (4, p. 106). The Venetian school did not appear to have a word for the tones they used, but referred to them as "color
blending" and admired anyone who was skillful in color mixing (4).

Leonardo (13) writes of the environment of the represented subject. He speaks of the colors in reflected light. He feels that the only way an artist could keep from seeing and recording these reflected colors was to use black and white. His theory was that reflected colors mingled and produced colors that were not on the surface of the object or on the surround. He cautioned that colors were also "influenced by the colored rays that wander about in the atmosphere and slightly tinge the reflected lights with their own color." Theoretically, these reflections became a choice in aesthetic judgment and arrangement, not merely a representation of nature. Leonardo's awareness of color foreshadows the Impressionists' thought.

The concepts of light and color in Renaissance art theory were scientific, based on literary and symbolic traditions and on the practical workshop traditions. The philosophy, aesthetics, values, Medieval optics, occult astrological beliefs, specific schools, and even the stage of the development of the artist seemed to have solidified into the Renaissance awareness of light and of color (3, 4, 5, 10, 11, 12, 13, 31, 39, 43, 53). The Renaissance artist exploited his materials as best he could in the interest of the complete illusion of realism.
Faber Birren (7) gives a full account of the colors used by the masters of the Renaissance. Birren reproduces paintings by Renaissance artists in which they included their own self-portraits shown holding their own palettes. He shows color chips simulating these palettes, naming the roots of the ancient pigments used by each artist.

Doerner (16), Cennini (11), and Mayer (35) pursue methodology and exact binders used by artists of the era while Merrifield (36) provides insight into fresco painting techniques of the period.

Lomazzo of the Milanese school in the late sixteenth century had a theory of art unusual for its time (7, 21). With the philosophical knowledge available concerning color Lomazzo felt that color was the property of the object and could be described as both pigment on the surface of the painting and pigment used symbolically. Before that time the placement, thrust, or movement of the bodies in the paintings seemed to describe the emotions.

In general, the Dutch school took a more classical, more naturalistic approach to color (22). But a study of black-and-white reproductions of Vermeer's small jewel-like canvases will reveal his Renaissance obsession with light. His values were beautifully controlled. His placement of the local color was precisely ordered to obtain inner radiance, thus intuitively anticipating today's scientific knowledge (5).
Rembrandt's concentration on light was, as Raphael (45) observes, evidence that "his whole development as an artist is marked by his effort to absorb color into this mystical light," resulting in color that "blazes up determinate from a general indeterminateness" (45, p. 84).

El Greco departed from the idealized drawing of the Renaissance and used color as a medium for eliciting emotional responses. He was one of the first of his period in history to deal with color by violating the rules of perspective and geometry, forcing figures, by means of his limited palette, to advance and to recede (4, 7, 39).

Early Renaissance art encompassed objective or naturalistic color usage, but it still relied on gray to define shadow areas (4, 13, 43). In order of importance the artists seemed to place design first, then proportion, and finally color. Moholy-Nagy, in describing the later Renaissance, remarks that the essential thing the Renaissance artist wished to bring to life in his picture was not the fact that color and contour, surface and line, their values of direction and position were capable of releasing a nexus of sensation peculiar to these elements alone, but rather that the artist's canvas was a story to be narrated in color, a truthful copy of the world comprehensible through the relation of material objects (37, p. 64).

Mannerism

At the end of the Renaissance and the beginning of Mannerism came Titian who, in his later period, was using color in a more spiritual and emotive manner (39, 43). Color
was still naturalistic but was becoming abstract patterns which dissolved in the form and at the same time described it. El Greco handled color in this arbitrary and expressionistic way.

**Baroque**

Color in the Baroque period was sensuous, dynamic, emotive (39); it was used to infinitely extend spatial qualities (41) incorporating Hausee's theory of the cinematic (improvisation) which mirrored the society's anti-classical impulse toward the unrestrained.

**Neo-Classical**

The Classical revival of the nineteenth century was inspired by the work of the German archaeologist, Johann Winckelmann. Classical painting valued line above color; for line was accountable to mathematics, color only to the uncertainties of direct observation (12). Both Ingres and his teacher David used tight, muted cold colors to define volumes in the Greco-Roman manner (7).

**Romanticism**

While the Neo-Classical period might be characterized as an era of observation and of order, the Romantic era might be described as a period of greater chromatic harmony and freedom. Although color was used in an expressive way in fantasy landscapes and in escapism (41), the laws of contrast in color juxtaposition were felt and were understood.
The writings of Turner (7, 19) and Delacroix (42) clearly state their interest in all ordered bodies of knowledge concerning color available in their day. Delacroix’s discoveries pertaining to the use of color were so great that he once claimed that he could make the skin of Venus out of the mud of the street if he could choose the colors to surround it, thus reflecting a very thorough understanding of the interaction of color (2, 7).

Realism

With the advent of the work of Courbet, painting shifted from Romanticism to Realism and its dark and soupy colors (7). While Courbet was insulting the critics and carrying the philosophy of Realism to extremes, the philosophy of color was being more gently advanced by a group of landscape painters known as the Barbizonists and the new problems of value, depth, and relief as expressible by color (12).

Impressionism

Primarily, Impressionism was a philosophy of realism with the only law being to copy nature (12) by dropping the Renaissance browns for the new-found color intensity that was to change entirely the direction of painting (39). Monet, the only life-long Impressionist, did not adhere to the Renaissance idea of chiaroscuro in terms of light and dark areas. He deleted blacks, white, and browns from his
palette and relied on the white canvas and opaque primary colors thickly applied like color shining and reflecting in his landscapes (7).

An awareness of color or color used as the primary carrier of the concept in art was only suggested in Impressionism (21). The incorporation of color theory and the idea of color's being mixed in the eye were used as analogies for light which the Impressionists portrayed as reflecting into, bouncing, and penetrating into every quadrant of their canvas.

Post-Impressionism

Most Post-Impressionists reacting from what Hauser terms as upheavals in social structures brought on not only by politics but by the changes in thought initiated at the onset of the Industrial Revolution felt that Impressionist art, in its search for the momentary and evanescent light quality, had neglected both the compositional structure on the canvas, and the solidity of the figure. But had it not been for Impressionism's clean, sparkling colors applied directly to the surface, the new Post-Impressionist art would not have been possible (39).

It was a period of a swing toward scientific theories in light and in color. Seurat (46) and Cezanne (33) led the more intellectual faction in color experimentation with Van Gough, Gauguin, and Matisse moving toward the more intuitive and emotive color uses of Fauvism and Expressionism (41, 48, 50).
The modeling of the figure in broad color planes derived from Cezanne, the powerful linear outlines and flat color areas from Gauguin, the alteration of color areas for aesthetic rather than naturalistic effect, the shallow space, and the powerful color contrasts ushered in the era of the Fauves under Matisse (39). Fauvism explored the dynamic possibilities of full-strength color as an essence of form and of color sensation in a given experience rendered in abstract terms (39). Therefore, Matisse's work does not use the Renaissance idea of local or naturalistic color, but solved through the use of color the same problems of form, light, space, and expression that were so differently addressed in the earlier period (15).

Conversely, the work of Gauguin began the Post-Impressionistic Symbolists' and the Expressionists' concern with the problem of giving visual form through color to spiritual ideas (38). Gauguin's distortion of color and of shape serve a double purpose in that they enable the artist to create his form, pattern, or rhythmic effect to subordinate figures to the general aesthetic idea, and they permit a certain emotional expressiveness necessary for the symbolic and the mystical purpose of the artist (23, 25, 40).

At that point the Symbolists could represent abstract and general ideas such as love, hate, fear in a form that could be apprehended by the senses, using the primitive, archaic, or exotic. At the same time in Germany, as a result
of the revolt against the authoritative atmosphere, the emotional, mystical, romantic work of the Expressionist developed. The expressive inner truths were sought by the artist by distortion or destruction of form, color, and space (24, 38, 39, 40).

The Neo-Impressionist grew out of the Impressionist's thought on color with its awareness of the complementary relationships of color and the need for dividing colors into their components so that the eye would be able, even forced, to bring them together into a more or less pure light (38, 39, 40).

Cubism reduced color to a minimum, using at times only the gray scale. Elderfield (17) suggests that Cezanne, when he consciously manipulated the light sources, initiated the analytical Cubistic thought of creating color as a tool for coding planar areas in a thin space. Kandinsky and Marc note that

it was the deliberate intention [of Cubism] to restore again to painting the knowledge of measure, volume, and weight instead of Impressionistic illusion of space based on perspective in atmosphere and in naturalism of colors. Cubism renders simple, abstract forms in defined relationships and proportions to one another (27, p. 105).

The Orphists felt that in Cubism there was no exploration of color, so with Delaunay (14) as their leader they proceeded to "liberate" Cubism, and return to the symbolic use of color (41).
The development of psychiatry contributed to the subconscious mechanism of the dream-like or the subconscious world which grew into the Surrealistic color thought (39). The Surrealists defined their aim as pure psychic automatism (26) and it stimulated several novel technics for exploiting chance effects. In dealing with the illusion of three-dimensionality on a two-dimensional surface Dali and Magritte used color conceptually and imaginatively while Kandinsky's non-representational Expressionism and the chance effect of the Surrealists joined in the color expression of Pollock under the name of Action Painting or Abstract Expressionism (26, 39). This emotional impact of color united with the intellectual aspects in the work of artist-teacher Josef Albers (2), making this non-objective or arbitrary use of color a continuing force world-wide in the art field. Since there are no recognizable objects involved in the works of artists like Rothko and the other Color Field painters, color is the form, the line, and the texture; color is used for its own sake (41).

Optical art (47)—a whole cluster of related trends begun in the mid-fifties—was named because of its concern with optics or the physical and psychological process of vision (26) and seems more akin to the scientific and not the emotional, yet it is in agreement with the modern idea of man's mind as a computer constantly analyzing visual
sensations. Pop artists, for instance, looked to their environment picking the garish colors of modern American advertising to govern their color choices. Practitioners of such diversified art fields as interior design and architecture utilized the scientific aspects of color more than their colleagues in the fine arts, the modern painters.

The development of color awareness, the work of the second half of this century, might not have been conceived without the "isms" of the first half. With the advent of air travel the world shrank, information became instantaneous. The quick procession of history of the two World Wars, shuffling populations, and the entry of the mass information age created a fertile ground for the rapid changes in art in America. In seeking to embrace all, the artist looked inward for ways of expressing this plentitude of influences; as a result, his work became highly personal, manifested symbolically, often through color alone (20). In the last twenty years the emphasis on color selections, materials, and elements has revolved around the artist's concepts; the New Realists, for example, depicting the coolness of the modern photographer's image, or in an effort to contain broad expanses of color some artists have chosen enormous canvases so that the color experiences are physically bigger than the viewer. Goosen (21) claims that paintings the size of their content make whatever happens in terms of color or light a function of the painting's size. Adams (1) observes that
these works are attempts to make art once again a part of man's life, as, when in ancient times, the walls of caves were covered with images.

Summary

In surveying briefly several different eras in the history of color in art the student has the opportunity to judge their respective merits and perhaps to develop a coeval personal theory and a store of workable information, granting the power of acceptance or rejection of ideas in color. Color was shown to be at times of minor importance to the artist. For centuries the artist's handbooks mentioned only the mixing of pigments (11, 16). Color emerged in the latter half of the nineteenth century as one of the essential elements of artistic expression, a highly personal conceptual statement. Although the vocabulary and the intent of artists have changed from ancient to modern times, the accomplishments of each age may be examined either as mental constructs or as classroom exercises with color choices shown to be related to the concepts, e.g., socioeconomic, symbolic, religious, psychological, of the given periods in time.
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CHAPTER III

ART-RELATED ASPECTS OF COLOR IN PHYSICS

Introduction

Einstein obviously understood the interdependence of art and science, for he claimed that inspiration and intuition were essential components of the latter (4). The twentieth-century scientist differs from his predecessors primarily in his realization that he is part and parcel of the phenomenon he studies. The modern artist differs from his predecessors in much the same fashion, realizing that he is an integral part of what he observes (2). When the nature of color is examined then by either the artist or the physicist, the matter becomes not merely a question of what one of them sees, but also a problem of how (both objectively and subjectively) he sees it (9).

Since it is not the intent of this study to deal systematically with the finer points of physics, the use of a lay vocabulary predominates. This step is taken to emphasize the introductory nature of this explanation of color, an explanation which is intended to be useful to the art student.
Light

To begin the study of light, it must be understood that its nature is many-sided. In a literal sense, without light nothing can be seen by the human eye (5, 16, 35, 40). For the normally-sighted person in a completely darkened room, no lines, no form, no colors are perceived. Colored objects reflect only the color or colors of the light shining on them.

Thus an object is visible if it either reflects or emits an amount of light that differs from that of its surroundings. This difference defines the border of an object (26, 32). Light passes without resistance through space as electromagnetic waves until it strikes an object and is converted. The visible spectrum reacts with the human eye, and objects are seen because of the effect that they have on the light before it reaches the eye (14, 27).

Human eyes are sensitive to a continuous spectrum of color, beginning with a deep red and ending with an intense violet (12, 37). This spectrum is produced by individual and unique wavelengths of light that correspond to the various hue names: red, orange, yellow, green, blue, and violet (see Figure 1). When all the wavelengths of light are joined and transmitted, the eye sees white, pure white light.

When the white light is passed through a glass prism, all the colors are again separated by the prism and fall into the familiar spectrum: a discovery made by Newton when he
Fig. 1--Visible Spectrum
A student. Newton (30) thought that light consisted of small particles emanating from a source, particles which he believed traveled in straight lines, unless disturbed. He chose to name seven colors for his spectrum: red, orange, yellow, green, blue, indigo, and violet. It is interesting to speculate why he chose seven colors; perhaps he was influenced by the ancient belief in the magical powers of the number seven (8, 14, 17).

Since the discoveries of Newton there has been a controversy over the naming and the ordering of colors in the spectrum. Newton systematized the colors of the spectrum by separating the brightest, or what he called "simple" colors from compound or intermediate ones. He used what he called "brightness" as his gauge. Understandably, since each color melts into the next in the spectrum, Newton's pronouncements on this question are not universally accepted. Another difficulty arises from the fact that different names may be applied to the same color under different circumstances because of various cultural traditions (7, 18). Properly speaking, according to Orna (31), physics orders the colors in terms of increasing wavelengths: red, orange, yellow, green, blue, and violet with the eye most responsive to the yellow-green region diminishing to the violet at one end and the red at the other.

Light travels in long and in short waves (14, 26). If light is approached in terms of the relative amounts of energy
which it contains in the various frequency ranges of its spectrum rather than in terms of its visual color, many otherwise difficult concepts become easily apparent. A wavelength is simply a unit of length, but those of light are so small that it is necessary to refer to them in terms of "a billionth of a meter or a nanometer" (31, p. 189) with blue light having a wavelength of about one seventy thousandth, while the wavelength of red light is about one forty thousandth nanometer (14, p. 20).

When an object absorbs a particular wavelength of light, the human eye receives the impression of a particular color. Each color is measured and classified according to a certain wavelength (26). Orange light is measured at around 600nm, yellow around 580nm, green around 500nm, blue around 480nm, and violet around 400nm (12, 14, 21, 24, 26, 36). Even though these numbers are virtually meaningless to most people, they are valuable to the scientist and colorist in describing specific colors, for while each person might have a different concept of the color red, the measurement 632nm would universally describe a specific red. The international color measurement organization on colorometry, more fully explored in later chapters, has adopted these standards and has related them to the revised Munsell Color Notation System which is well-known to artists and teachers.

A spectroscope is used to measure light (the nanometer being a standard measurement used throughout the world).
Spectrophotometry determines the measurement of the total energy in light by dividing it into the frequencies that it contains. It measures the intensities and expresses the results so that they can be understood and manipulated. The physicist can exactly measure any color while the eye averages the same information and the brain translates the information to acquired knowledge called red, blue, green, and so on (22). Obviously the color names used in the narrow band of human visual perception are only meaningful to humans.

If a spectrophotometer is used to match the lightwaves reflected by two pigments which are used to make artists' pigments, the readings can be translated into numbers which are concise enough to allow artists and scientists to talk about specific colors and to reproduce these colors. This precision accounts for the great strides which have been made in quality control of paint mixing which enables the artist and the student to be confident that he will get consistency in the tube paint he buys.

There seems to be no theory to completely explain the entire nature of light. Plato (8, 14, 26) thought vision was due to particles shot out of the eye, spraying surrounding objects. Newton, as mentioned above, felt that light traveled in straight lines in small particles from a source. Some theorists today, according to Krishnan (22), think light travels in electromagnetic waves as small packets of energy called quanta.
Each wave has alternating, identical crests and troughs. A wavelength is the distance between the mid-point of any one crest in the wave and the mid-point of the next crest (see Figure 2). The height of the wave is called the amplitude. All electromagnetic waves travel at the same speed, roughly 186,300 miles per second (in a vacuum), but they differ greatly in wavelength and in frequency (11, 14, 26).

The electromagnetic energy system extends far beyond the visual spectrum (11, 14, 26, 36). The violet melts into ultra-violet radiation, x-rays, cosmic rays, and into the unknown while the invisible red goes into infrared, microwaves, radio, television, radar, and so on.

Additive Mixtures

Mixtures of colored light are called additive mixtures. When two groups of wavelengths, giving the sensation of two different colors, are added together, the result is the sensation of a third color. Physicists, according to Krishnan, call this phenomenon "color averaging." It is a judgment which takes place in the human eye and is interpreted by the brain. The additive mixture can be visualized as circles representing the primary colors of light or the additive primaries of red, blue, and green (see Figure 3). The diagram shown in Figure 3 must be thought of as circles of colored light projected on a white surface with three spotlights: one red, one blue, and one green. These are the
Fig. 2--Wavelength Chart
Fig. 3—Additive Primaries
three colors of light that scientists have determined cannot be produced by mixing any other colors of light, but which can produce all but the black-bearing colors when mixed in various proportions (12, 17, 19, 26).

Just as the three primary colors of light are said to be red, blue, and green, the secondary colors are said to be magenta, cyan, and yellow (14, 25, 26, 32). As shown in Figure 3, if the red spotlight and the blue spotlight, being equal, are overlapped, the result is a violet-red called magenta. A mixture of blue and green produces a blue-green combination called cyan. Red and green light when overlapped produce yellow. When red, green, and blue are overlapped, white light is the result. One property of a secondary color of light is that when "mixed" with its opposite primary white is produced. For instance when yellow and blue light are mixed, the result is white; therefore, yellow and blue are said to be complementary colors in light, as are magenta and green, cyan and red.

Color applied to the visual spectrum is not the same as color mixing with pigments (compare Figure 3 and Figure 7). The visual perception of light functions additively, while the artist mixes his pigments through the subtractive process. If a blue and a yellow pigment are mixed, green is the result. If a blue and a yellow spotlight are overlapped, white is seen.
Effects of Light

There are thought to be five main sources of light: the sun, thermal luminescence, thermal incandescence, electrical luminescence, and electrical incandescence (5, 12, 26, 36). The sun is an obvious source of full-spectrum lighting. The moon would be an example of thermal luminescence. Thermal incandescence could be a candle’s light. Electrical luminescent sources are widely used today as fluorescent tubes while electrical incandescence is seen familiarly as the tungsten bulb. Considering the widely-held theory that energy cannot be destroyed, only changed from one form to another, and considering the physiological composition and functions of the eye, it can be understood that light is transformed from electrical energy to radiant electromagnetic energy with a light source, traveling in high-speed, high-frequency wave form, and that it is changed upon contact with the receptors of the eye into electrochemical impulses which are translated by the brain as light or as color (12, 14, 19, 26, 27, 32, 37).

As has been observed earlier, objects seem to have color because they absorb only selected wavelength ranges of white light. Alternate light sources sometimes give different sensations of colors. For example, two dyed surfaces might give an identical match in daylight or full-spectrum and be quite different under artificial lighting. Artificial light does not emit the same range of wavelengths as are present
in the daylight full-spectrum of sunlight (12). The tungsten bulb, as an example, lacks the short waves which form blue. It operates at about 3200 degrees centigrade and has a yellow appearance to the eye. Thus, blue cloth might appear black in artificial tungsten light since it can only absorb or reflect the wavelengths which fall on it (25).

Seagers (35, p. 38) says that "whether materials are transparent, translucent, or opaque, they never transmit or absorb all of the light which strikes them." Evans (17) found that there is no white as white as pure spectrum light and no black as black as the complete absence of light. As a result, the art student who must work in a middle range often is not fully aware that he may push the contrast as far as his materials will allow.

The study and application of the science of color is rendered very complex because the appearance of a color is so modified by its environment (5, 6, 10, 12, 13, 26, 39, 40). The hue, value, and saturation of the choices of color made under one type of light will therefore not produce the same response nor harmony under another light source (3, 8).

Color, then, is not a property that is a physical part of viewed objects; it is the effect of light waves bouncing off of or penetrating various surfaces. The color of a given object is determined by several things: the characteristics of the light under which it is viewed, the way the
object absorbs, transmits, or reflects the light waves striking it, the effects of surroundings on the mind of the viewer, and the condition of the viewer's eyes.

History of Light Use in Art

Light has been an important element in art since pre-historic times. The stained glass windows in Gothic cathedrals filled the interiors with color as the sun illuminated them, eliciting emotional responses from those who saw them, caused by the direction, quantity, and intensity of their color.

In 1791, when he published his "Optical Contributions," Goethe maintained that Newton's development of a theory of light was a mistake. Instead of forming a hypothesis about the nature of light, Goethe wanted a complete history of its effect on man's mind. His friend, Schopenhauer, quotes him as saying, "Colors are the acts of light—its activities and passivities. In that sense we can expect from them information about light" (38, p. 83). Goethe did feel that light must be studied in connection with nature as a whole, "for it is nature as a whole which thus reveals itself to the sense of the eye." Goethe sent Schopenhauer several of his experiments and asked that an essay be written. It was published at Easter, 1816, and titled, "On Vision and Colours." It takes what Schopenhauer calls a physiological or subjective attitude, assumes that colors are in the eye, while light is
an external agent, supplying primary stimuli to which color is the response of the eye.

Hegel, like Goethe, reflected on the totality of light, color, and the eye. He concluded that light was a bond between the material and the spiritual. He built a careful relationship between what he calls the physical element of painting (meaning light) to construct illusions, which are, in turn spiritual (20, p. 131).

The architect, Alberti (1) was the first author to make light per se an object of investigation. He discussed light as one of the central problems involved in art. Neither Alberti nor Cennini (15) saw light as having an aesthetic value of its own, only a functional one. Alberti, according to Birren (8), drew conclusions from Leonardo's Treatise, which related color to light. The Renaissance method of depicting light, chiaroscuro, was developed by Leonardo (3, 8) and was amplified by Rembrandt (29) who narrowed the visual sensation to "shafts" of light to illuminate areas. The Mannerists (17) heightened the drama of using chiaroscuro when they realized that a candle fills a room with a yellow glow, thereby changing the color relationships in the entire painting. Turner, in the early nineteenth century, showed that he was aware of the scientific advancements in the physics of light and was able to apply the union of light and of pigment to his work (33). Later, the Impressionist's chief aim was to record the play of light (8, 12, 17, 29, 33).
Some modern artists are using light not only as a method of studying value or of creating distortions, but as the medium for the creation of art. Lucie-Smith (23) notes that the ancestry of the modern light-show can be traced back to the 1920's and the Bauhaus where light environments and light theaters were planned, but never executed. According to Schechter (34) the decade of the sixties was a time of light shows displaying psychedelic explosions of colors in light. The wide-spread use of light as an art form will be discussed further later in this study.

**Summary**

Morman (28, p. 48) comments that "if color as pigment has tantalized, color as light has obsessed artists." The science of optics seems to have begun to develop quite rapidly in the late eighteenth and early nineteenth centuries with the artist using these advances to synthesize his response to his culture.

Scientists say they are mixing colors by means of light-waves. Artists who are working with paint are mixing by means of pigments. The words "additive" and "subtractive" are used to describe, respectively, the two different kinds of mixing. Physics deals with the measurement of light without the prejudices of a human observer. Lightwaves can be measured, mathematically manipulated, and calibrated. Scientific
techniques are not dealing in how the eye sees nor how the brain perceives when they are measuring lightwaves.

Since it is the psychological factor which governs what color the viewer names (as he views a color), scientific investigations in physiology have long been hampered because of an inability to exert strict scientific controls on color perception experiments. What the observer perceives is controlled by personality, philosophy, and conditions (6, 12, 19, 24), which are points difficult to deal with in a scientifically controlled environment. It might be said that lightwaves which are the cause of the color sensation can be measured precisely by spectrophotometers, but measurement of the effect of color sensation, that with which the artist deals, seems to be psychological. Mackinnon (26) observes that color is an example of a subjective observation.

It is not easy to understand that the colors seen are not innate, but are merely perceived as colors because the objects seen have the property of absorbing some lightwaves while reflecting others. Since light and color are essentially one, an investigation of the physical aspects of light is important to the student who would understand not only the psycho-physiological and symbolic impact of color, but the nature of its physical components as well.
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CHAPTER IV

PHYSIOLOGICAL ASPECTS OF COLOR IN ART

Introduction

Light and color and the problems of visual perception have always fascinated man. But, unfortunately there seems to be no simple means of describing color vision. Color depends not only on the stimulus wavelength and intensities as described in the preceding chapter, but also on the differences of intensity between regions, and the acceptability of the patterns. This involves high-level processes in the brain. Gerald Jacobs (9, p. 160) suggests that man developed color vision "to promote the perception of contrasts." He theorizes that man used color for object detection, object recognition, and for its signaling properties (i.e., symbol recognition). Color seems to be the most efficient dimension of discrimination.

The Eye

Scientists say that the eye is an outgrowth of the brain (3, 5, 12, 23). According to theory (3, 5, 12, 23), light, on entering the eye through the cornea, is finely focused by the lens through the action of the ciliary muscles, is projected on to the fovea and the rods and the cones of the
retina (see Figure 4), is translated into chemical energy, and finally travels through nerve endings into the brain for analysis, identification, association, and perception.

The cornea is transparent tissue that bends light, as does the aqueous humor, but it is the iris, acting like the shutter diaphragm on a camera, that governs the amount of light admitted to the lens (5). Scientific research points to the theory that not only light triggers the diaphragmatic action on the iris, but emotional response to the object viewed may influence it as well, as when the iris widens in an adult viewing a baby (2, 13).

The pupil is actually a hole into the inner eye that lets in light through the action of the iris (5, 14). The lens, which is directly behind the pupil, is held in place under tension by the zonula. Tiny ciliary muscles attached to the zonula relax to allow the lens to become long and thin for distance viewing and contract to make it short and fat or convex for close vision.

Unfortunately, the lens continues to grow throughout life adding new cells on the outside (23). This decreases the food supply to the inner area causing it to become less pliable. The result is a need for reading glasses as most people get older (13).

The retina lies like a screen at the back of the eye receiving the information projected on it by the lens (26).
Fig. 4--The Eye
The eye is constantly pulsating, saccading, and moving smoothly on its muscles in order to focus the fovea, the tiny area of "detailed sight" which is less than one-sixteenth of an inch (5). The fovea is the area of the retina which contains the highest concentration of cones, the color receptors. The rods are also light receptors but are not involved in color vision. The rods and the cones in the retina are behind several retinal layers facing the back of the head where they receive a rich and constant supply of nutrients through a webbing of blood vessels and through diffusion from the vitreous humor (5, 13, 23, 26).

The rods and cones augment each other since the cones deal mainly with daytime or photopic vision, and the rods deal principally with low-light or scotopic vision. Rods which can detect movement give general, all-over pictures of the field, with no fine detail resolution. Objects which appear to be brightly colored in daylight when seen by the color-sensitive cones, appear only as colorless forms by moonlight when only the rods are stimulated.

There seems to be a variation shift in the perceived brightness of colors at these different levels of illumination. The central fovea is weak in responding to blue, strongest in red. In low-light (scotopic) the blues appear to be brighter than the reds, but in full-light (photopic), the reds appear to be brighter than the blues. This
phenomenon was discovered and recorded by Johannes Purkinji in early 1800.

Add to one complicated structure another exactly like it, and stereo-optic vision is gained. Cotman and McGough (3, p. 439) state that while the "primary visual cortex exacts information about the configuration of edges from the two-dimensional retinal images, the secondary visual cortex puts the two eyes' separate images together into a three-dimensional picture of the visual scene." The brain uses every clue in viewing an object: size, shape, movement, color.

The word "image" is used for both the optical pattern thrown on the retina by an object and the mental experience of seeing the object. Most images consist of surfaces, at various angles and in various relationships to each other (19). Most of the surfaces have some kind of texture, such as a tree trunk or a woven fabric. These textures structure the light reaching the eye in a way that carries vital information about the layout of the images.

The apparent size of an object is determined by information from the entire incoming light pattern (5, 14, 26). Those movements, pulsations, and saccades are constantly making new retinal images which, in turn, fade rapidly. They are necessary because the area of sharply-defined vision available to the stationary eye is so limited. For high visual acuity, the head is always moving to look directly at
the object. The visual world seems to be somehow constructed on the basis of the information taken in during these many fixations.

Color Vision

Newton (15) felt that the eye had an infinite number of particles with each particle capable of reacting only to a single color. It was not until early 1800 that Thomas Young (27) theorized that there were only three color receptors in the cones. Helmholtz (6) experimented with Young's theory and by the 1850's came to the conclusion that all three receptors reacted to all colors, but in varying degrees, and that the total reception the brain received determined the colors actually seen.

His theory was challenged by Ewald Herring (7) who formulated an entirely different approach working through psychological processes. He said that the retina's receptors were absorbers of light and that the sorting process was further along the optical system. According to Herring, one system would send the code for red or for green and the other system for blue or for yellow. A yellow signal could be sent, according to his theory, only when the blue receptor was shut off. He felt that the perception of brightness or darkness of color was tied to how "irritable" the coders were, that the manner in which a light mixture was received in the brain depended upon the viewer's mood.
The latest theory in color vision seems to combine both the Herring and the Helmholtz ideas. Jameson and Huvich (10) found that the three receptors do not give sensations directly, but in a complex fashion; they feed into a set of nerve cells that work by the opponent process. That would mean that when only yellow is seen, the opponent blue is less active.

Scientists can now measure under different light sources the energy transmitted by the cones and can analyze by computer to see if indeed a message is being sent to the brain. Results have shown that while the cones do not send a message directly to the brain, there does seem to be a coding mechanism as Herring theorized.

The Brain and Sight

The orderly, layered arrangement of neurons in the retina and within the brain itself suggests that information processing is carried out in hierarchically arranged levels, proceeding from one functionally-related group of cells to the next (12). In this manner, the eye seems to act as an out-post for the brain. It collects information, analyzes it, and sends it on for further processing by the brain through a well-defined track, the optic nerve. Kuffier and Nicholls (12) observe that the right side of each retina projects to the right cerebral hemisphere and the left side of each retina receives the image of the visual world on the left side (see Figure 5).
Fig. 5—Brain-Eye Pathways
Ornstein (17) declares that physiology has now provided, through right and left hemisphere research, the explanation of the two modes of consciousness, rational and intuitive. He says that the left hemisphere is largely involved in analytic thinking, speech, and logic, and the sequential processing of information while the right hemisphere specializes in spatial orientation, artistic ability, body awareness, facial recognition, and integrating material in a holistic, creative, and simultaneous manner.

Cells in specific areas of the brain, it seems, process the signals associated with individual colors (11). Groups of cells set thresholds that define the brightness or the darkness of a color. Some respond to color only when it is framed by a particular shape or in a certain pattern (18). The mature eye is not equally sensitive to the energy of all colors. With adequate illumination, the greatest response seems to be yellow-green, near the middle of the visible spectrum with the sensitivity falling off toward each end of the spectrum (5). As discussed in the preceding chapter, most eyes are not sensitive to the ultraviolet or to the infrared wavelengths which lie at opposite ends of the visual spectrum. Scientists speculate that the yellow tint within the eye prevents passage of the ultraviolet. As the eye ages, the slight yellow tint becomes more pronounced so that the result is, in some eyes, that the blues, purples, and violets are absorbed (22).
Neurobiologist Rollie Schafer (21) says that current eye-brain research tends to point to even more specialization and segmentation of components of the visual image than was previously suspected. Scientists, he says, have known for a long time that the brain interprets edge, contrast, orientation, and color to identify objects, but now they have discovered that there are minute networks of cells responding only to very specific stimuli such as frontal face or profile. Visual information is broadly assimilated by the retina, broken down to specifics during initial processing in the retina and the brain, and reassembled at the highest levels of the visual system in the brain to provide exact perception of visual stimuli.

Perception

Sensing, selecting, and perceiving seem to be simultaneous; only the totality rises to awareness. In reality, they are not the same (11, 19, 26). The eyes and the nervous system could be said to do the sensing and the brain the perceiving; a perceiving that seems to be related to accumulated experiences. Thus seeing clearly appears to be the result of accurate sensing and correct perceiving. Any improvement in the power of sensing and that of perceiving should produce improved vision.

There are four factors involved in sight: light, contrast, size, and the time the object is presented to view (1,
13, 14). However, there is support for a fifth factor: color (5, 19, 25). It is related to both light and to contrast. Without light or brightness, as mentioned earlier, no visual image is possible, for the object must contrast with its immediate background to be discernable to the human eye. The more noticeable the contrast, the more detail is distinguished, as a drawing done in silverpoint on white paper in contrast to a drawing done in black ink on the same white background.

The size of an object is a factor in seeing and in recognition, affecting the judgment of what is perceived as increased illumination makes small details visible (20). There seems to be a relationship between brightness, contrast, and size so that the altering of any one can radically affect visibility. Time is of equal importance since the eye does not process information instantly (19, 26). If objects and their details are to be seen quickly, relatively high levels of light are necessary; conversely, if there is plenty of time even small details can be seen under rather low or mesotopic lighting.

Color seems to operate concurrently with all of the above factors. If an apple is red, on a gray background, in low light, shown quickly, it will probably still be "read" as an apple since its shape and color are perception clues and instantly retrievable. Many times artwork disturbs this
easy linking by distorting color, size, and contrast so that the viewer is confused momentarily into a more careful study of the work.

Research has been done into the field of visual scanning by many physiologists and psychologists. In viewing art, according to Brandt (2) the preferred entry into a two-dimensional piece of work would be the lower half, the right side, and the outside edges. It was found additionally, that the actual movements of the eye contribute their share to the satisfaction accompanying the observation of the artwork (16, 24). If an imbalance is seen, the eye spends more time out of the objects or the positive space. The impact of this type of research is of immediate value to the art student. This information may be used to intensify what is a natural, pleasurable visual patterning, or to produce the opposite effect, e.g., tension, frustration, and discomfort.

It is physiologically and psychologically disquieting when the natural order of color appears to have been violated. A study of modern artists' work will show that they have explored the concept of warm-cool and near-far separateness by juxtapositioning such colors as red and blue (8). These colors are reflected differently in the eye and consequently affect focus in different ways. When the longest wavelength enters the eye, it arouses the sensation of blue, which tends to be retiring or receding while the short wavelength called red is aggressive or advancing (5). The red wavelengths are
bent only slightly by the lens; they focus at a point beyond the retina. To focus a red object sharply on the retina, the lens bulges or becomes more convex; just as it does to focus on a closer object. This pulls the red object nearer the eye, and it is perceived to be closer than it actually is. The short blue wavelengths are bent more and focus at a point in the front part of the retina. To focus more clearly the lens flattens and pushes the blue back to the retina so that the blue object is perceived to be further away than the red object. As a result, rooms painted red appear to be smaller than rooms of the same size painted blue. Other psychological factors such as the blueness of the sky or of distance and the disquieting aspects of red could be further involved.

This usage of red and blue to affect depth perception and to evoke a particular psychological response enters into the work of such artists as Mondrain, who used these colors in combination with black and white to eloquently play up this interference. Response to such color changes could both visually and psychologically exhaust the viewer. The human eye, it seems, simply screens out irrelevant color changes for its own protection, but at the same time it tunes in those deemed uncommon (1, 11, 26).

Fatigue

The psychophysical process that results in the brain's perception of color is two-fold. Color originates in the
eyes as a sensation and returns as acquired knowledge about the object which gave rise to the sensation. This dual process results in the indiscriminate use of the word "color" to describe the content of these two aspects of this phenomenon.

Subjectively, color is a relative term such that the nature of awareness of color at any moment is dependent upon the degree of fatigue existing at the time and upon the surround (26). Anyone who stares at a circle of red, for example, on a white surface will experience an after-image of blue-green when he looks quickly at a blank piece of white paper. The fatigue of the red receptors that results from having stared at the red circle has not affected the blue or the green receptors. As soon as the balance of color receptors is restored, the blue-green after-image fades and equilibrium is restored (1, 5, 9, 13).

If the eye stares persistently at one color, the resulting fatigue can confuse the color sense and complicate the sensations sent to the brain. But, since the eyes are never still, since they saccade, pulsate, move smoothly on muscles, and utilize head movements, they move from one point to another examining different sections of objects. Thus color receptors or cones do not become fatigued normally because they do not concentrate on one color for any length of time. It takes considerable conscious effort to stare intently at one area for over about five seconds. It can be assumed that
this difficulty is a built-in protective mechanism to save
the eye from fatigue.

Large contemporary works employing broad areas of color
utilize chromatic aberration, or the inability to focus
different colors at the same time. The distress the eye
feels in trying to focus on a near and a far object at the
same time is similar to the tension involved in trying to
look at, for example, a yellow and a violet at the same time.
The eye attempts to shift to accommodate and to ease its dis-
comfort (1, 5, 16, 20). If a red line on a green or a blue
surround is viewed, there is a feeling of unrest such that
the eye appears to reject the presentation and both colors
tend to be averaged. This effect, this overlapping of after-
images which is caused by involuntary eye movements, this
shifting must of course alter the appearance of a painting
or a drawing. Color averaging naturally can result in a
"lost edge," an effect that skillful painters through the
ages have used to their advantage.

Two adjacent areas can so profoundly mutually influence
one another that they each might appear different in hue,
saturation, and value (1, 8, 13, 14, 26). When these
influences are considered physiologically and psychologically,
and when the nature of these phenomena are considered in
tandem with the intensity and spectral character of the
illuminant, it becomes evident that no pigment has any
definite and fixed appearance once it is out of the tube.
Highlight reflectance and aggressively intense illumination usually produce too much glare, and, as a result, the eyes become fatigued. Aside from lowering the receptivity of the eye, this strain also occasionally manifests itself in discomfort in other parts of the body—headaches, tension, backaches, or a general tired feeling (1, 13, 26).

Summary

The eyes are one of the most active of the sensing organs, continually moving as they scan and inspect the details of the visual field. Since these fragmented movements play an important part in visual perception, gestaltists might suggest that these "mosaics" unite into objects and are identified only when they are assimilated as wholes.

It would seem that the eye's structure has a built-in demand for an equilibrium of color sensation which must be accommodated if temporary impairment of color vision acuity is not to occur. An understanding of the effect of one color on another in relation to their relative size, their proximity, the time viewed, and the lighting conditions under which they are viewed is stressed by scientists in the field.

Thus the discipline of psychophysics attempts to combine the study of the behavior of lightwaves and the investigation of the human eye and the brain and to seek rules by evaluating a stimulus against the resulting action of the visual system.
Scientists working in this visual field codify the information from which the general rules and knowledge utilized by many artists emerge.
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CHAPTER V

PSYCHOLOGICAL EFFECTS OF COLOR IN ART

Introduction

One reason that the study of color can be confusing is that the word "color" can have so many distinct meanings. First, in its most general sense, it refers to a quality which all objects have in common. Next, it is used to refer to the physical (i.e., visual) sensation stimulated by this quality. In addition, it is used to describe the individual stimuli which we recognize as blue, green, red, and so on. When the nature of color is examined from a scientific point of view, definitions become even more diverse: in physics, color is radiant energy; in physiology, color is the response of the human retina to physical stimuli; in psychology, color is a visual sensation, existing only in a temporary mental consciousness.

It is this psychological aspect of color which occupies the imagination of so many artists. It is generally recognized that color is capable of producing an emotional response, and that such responses are largely in the relationship of one color to another. Most artists readily admit that their effects are experiences of creative intuition. As a result, many artists rely on experiential awarenesses to
provide color choices which will evoke desired psychological responses. Some, however, who desire greater conscious control of their art, may appreciate a brief inquiry into the identification of some formal relationships in color.

Associations

Color designation and color nomenclature are so vague it is often difficult to discuss color with any degree of accuracy. Because there is no unique name for each of the thousands of color sensations, it is a formidable task to try to talk about color and its associations. To complicate matters, not only are names too few, but they are so distressingly inexact that all people do not give the same name to the same color.

The color associations called "harmonies" appear to be a social concept. Van Doren (35) theorizes that color preferences change with the moods of a society. Economic factors, for instance can influence their use. "During the depression years they [colors] veer sharply toward somber hues of black and gray, then returning prosperity brings brighter hues" (35, p. 316). Other determinants also may affect color fashions. "Many factors contributed to the color revival after World War I: increased prosperity, greater leisure, and more active competition" (35, p. 318).

Pure hues of the primary colors of red, yellow, and blue and the secondary colors of orange, green, and violet
tend to jar the senses of those with highly-developed aesthetic taste, but they seem to have strong appeal for the majority (4, 37). Although delicate tints appeal to those with a more cultivated sense of aesthetics, they seem to have little effect on many people (11, 18, 36). Colors that are seen only occasionally possess the emotionally stimulating elements of surprise and newness (5, 15). Common colors, like common surroundings, are monotonous. They become tiresome and the eye seems to look for new stimulants. Thus, since color is one of the most easily modified of any of the elements of normal surroundings, it becomes a key factor when artificial environments are created to suit personal tastes.

Faulkner and Ziefeld (15) feel that "not many people have strong likes or dislikes regarding form and texture, but everyone has definite color preferences" (15, p. 320). Most people think themselves objective and analytical, but numerous psychological tests have shown that the bulk of human action is emotionally motivated (22, 28, 30). Colors are emotional factors which bring forth emotional responses. As Hicks has observed, "Color is in the mind of the beholder" (18, p. 12).

Barbara Brown (18) says that color affects and alters brainwaves, supporting the theory that colors induce emotional states which are specific to different hues. Her thesis is supported by such artwork as Franz Marc's "Three Red Horses" in which Marc made the horses red because he
wanted to depict, through color, the mental expression or sensation of an excitable temperament.

Gerstner (16) asks, "what is this red sensation?" Further, how could anyone perceive the color red if he did not have the concept for it available, or, if the concept was not extant, would he perceive the color at all? Color perception and with it the emotional associations any viewer feels are a cultural achievement.

According to Bornstein and Marks (6), regardless of the generality of the terms used to describe the perceptions of color, all people appear to perceive the divisions in the spectrum in about the same way. Essentially the same emotional, imaginative, and intellectual responses are stimulated by color in most people. The artist who can control his work to evoke these responses finds himself working toward uniqueness of color expression. Bradley (7) found that this striving for unique color expression is a characteristic which has received attention among psychologists and others who study the nature of human behavior. Creative people, he found, have the ability to see multiple possibilities in solving problems relating to color experiences.

Weintraub (36) has investigated the viewer's awareness of color associations as stimuli in subtle works of art. He found that some viewers, because they lack comparable past experiences or because they are not fully focusing their
attention on what they see, may not respond as fully to the subconscious stimuli as would more sophisticated or more attentive viewers. The huge paintings by Rothko in the Chapel at Saint Thomas University in Houston, or one of Ad Reinhardt's black canvases require that the viewer exert every effort to see and to become aware of the subtleties. While the study of these subconscious perceptive associations is a valid pursuit in the field of art, an effective use of them may also arise from the artist's intuitive sense of just the "right" hues.

Keeping in mind that perception of color might be culturally motivated and that it very often appeals to the subconscious, there have been numerous arguments in the past thirty years about the validity of the Luscher Color Test (25) copyrighted in 1949. Some feel that it is useful within the context of the time-frame in which it originated, but to say that it would be valid for all time is a mistake. In a later book (1977) Luscher (26) answers this by claiming that the test will remain as effective as the day it was written, and that further, it holds true cross-culturally.

From his research, Luscher simplified to primaries and applied the four psychological colors (see Figure 6) to the personality. His original test had four basic colors (dark blue, blue-green, orange-red, bright yellow) and four auxiliary colors (violet, brown, black, neutral gray). The
Psychological Primaries

- Yellow
- Green
- Red
- Blue
Physiological Primaries
Light Primaries
Theoretical Pigment Primaries

Fig. 6—Psychological, Physiological, Light or Subtractive, and Pigment Primaries.
lengthy test has seventy-three color patches consisting of twenty-five different hues, tints, and shades and requiring forty-three different selections. The test is comprehensive and requires training and considerable psychological insight to administer and to interpret. It is still being successfully used by physicians, psychologists, and employers to test personality traits world-wide.

Luscher (26), in his later book, tends to be more philosophical than clinical, trying to place his theories in an historical perspective. He sees red as associated with fire, blue with water, yellow as air, and green as earth. These he sees corresponding to the four temperaments of choleric as red, phlegmatic as blue, sanguine as yellow, and melancholy as green. This kind of a relationship between color's psychological impact and its use in art has traditionally been recognized and utilized by the highly intuitive artist (16).

Since color has a strong emotional effect upon people, everyone who can see color reacts to its use, with some registering this reaction more consciously or more acutely than others (5, 16). The inherent association of ideas with color causes emotional responses: for example, red might be exciting because it brings to mind fire, danger, blood. These associations can be tested by means of scientific instruments which measure the body's physical responses.
Scientists say that yellow, red, green, and blue are psychologically unique and are not mixtures of other colors (5, 28, 36). Further, purple or violet seem to be mixtures of red and blue; orange appears to be a mixture of red and yellow. From a comparison of the primary charts (see Figure 6) the similarities of color sequencing may be noted. The light and eye primary system which is called "additive" and the pigment system of primaries which is called "subtractive" produce different results when each is mixed within its own system (see Figures 3 and 7). Consequently, a firm understanding of the parallels and divergencies of these systems would seem worthwhile for the interested artist or theoretician.

Pure complementaries, according to Birren (5), are psychologically overwhelming, even in small doses. If we consider the emotional intensification possible with super-saturated color, sound amplification, strobe lights, lasers, polarized slides, and so on, the bombardment of the senses could well create an altered-reality.

Color Consciousness

Since color cannot be specifically measured without scientific equipment, then hue, saturation, and value are thought to be mental constructs. Normal color vision is therefore subjective (2, 5, 16, 19, 25). When shown several values of blue, a viewer can only say which is "lighter"
Mixture of Pigment (Theoretical) Subtractive Primaries

Yellow

Orange

Green

Black

Red

Violet

Blue

Fig. 7—Subtractive Primaries
and which is "darker." In all probability he cannot state how much these blues differ one from the other. After-images, color shadows, lighting, and background influences, alternate and simultaneous contrasts, color theories, and Mach bands are a few of the tools available to aid in the development of a comprehension of which blue one is seeing, or of the subjective influence that blue has on the individual viewer.

Color consciousness could be grouped into three main responses: response due to unconscious motivation, response due to a conscious reaction, and (emotional) response due to a chain of thought.

This psychological impact in relation to color can be most clearly illustrated in advertising (4, 18, 20, 36). Advertisers have long been aware of the three above-mentioned stages: drawing a customer to a product (response to unconscious stimulus), reaching for the product to examine it (response of a conscious nature), and buying that product (response to a chain of thought). Crewdson (11, p. 183) speculates that "all of the great distributors' advertising is based on some human buying motive rather than on price appeal, and color has played a great part in its success." People, he theorizes, seem to buy or refuse to buy products according to their feelings, and those feelings seem to be largely governed by color. There seems to be a color memory range carried around mentally governing the acceptability of
products. For example, fresh meat must be a specific red and tomatoes must be another. Products are often judged on the basis of color, value, and saturation. An interesting study was made by Judd who claims that packages of merchandise must show the background and trademark colors to which the buying public is educated; if the colors of the package are too pale they suggest to the customer that the package has been on the shelf so long that the colorants have had time to fade; and the contents to spoil. Package colors too dark and grayish indicate dirt from excessive handling and suggest that other customers have found something wrong with this particular package or brand, causing them to put it back on the shelf. Color that is the wrong hue is the worst of all. The customer may not even recognize the package at first as the brand and may get the impression of carelessness on the part of the maker. If the maker cannot take enough care to put the right color on the package, he probably misses out on contents too, and the customer will not take the next package even if it's correctly colored but will switch to another brand (20, p. 31).

Despite the importance of color distinction and identification, color memory is apparently restricted to a type of idea-related memory which may identify certain colors under certain circumstances as mentioned in the above example, and there seem to be very few people who have accurate color memory (4, 11, 23, 35). The subtle properties of something which could be called perfect color memory or pitch seems much more elusive than its musical counterpart. Color may, in some instances, be described as solely a psychological phenomenon in which certain functions of light are affected by an object's ability to absorb some part of that light, plus the momentary conditions within the retina of the eye
as interpreted by the brain. Lighting, personality differences, and perception problems (i.e., color blindness) are all factors which influence the development of a perfect color sense.

Additionally, color preferences do not seem to coincide with color retention. Color sensations at times do not easily rise to consciousness. Yellow generally has a low preference rating yet it is easily recalled while the modified red-orange called peach, which is a favorite color with many people, is difficult to remember (5, 11, 36). The questions involved in color associations and their rise to consciousness seem to be ones of considerable complexity, and certainly dogmatic assertions in this field should be accepted with considerable reserve.

As mentioned in earlier chapters, certain personality traits and socioeconomic conditions seem to influence color preferences in their rise to consciousness (5, 9, 18, 20, 23). Researchers feel that ordinarily, green is one of the universally preferred colors. Vigorous people are said to like red, while many intellectually inclined people tend toward the blues. Purple seems to attract the aesthetically-minded, while yellow is preferred by the egotist or the self-centered person. In large numbers of people questioned, the range of color preference was found to be surprisingly limited (25). Their preferences were for colors that were
simple, clear, and pure. The eye seems to respond quickly to whites that are bright and to blacks which are intense and opaque. Most people tend to like tints (color plus white) that are clean and shades (color plus black) that are intense. What seems to be most disliked generally are the in-between colors—the indefinite tones (color plus black plus white, see Figure 8) which are almost impossible to classify in ordinary language.

Kandinsky (21), concerned with psychological and emotional responses to color, writes, "Passivity is the striking feature of absolute green; yellow tends so greatly toward lightness, that there can be no such thing as a very dark yellow" (21, p. 27). The yellows seem to dissolve into brightness while the dark blues seem to dissolve into darkness. Where stronger saturated colors are involved, warm colors tend to advance and cool colors to recede. As Goethe (17) has observed, "We like to follow an object that flees from us, and, similarly, we like to look at blue, not because it presses in on us but because it pulls us after it" (17, p. 14).

This phenomenon comes into play in atmospheric perspective (also called Arial Perspective) as the artist tries to convince the viewer that he is experiencing the sensation of three-dimensionality on a two-dimensional surface. Physics relates how haze scatters light, and as the light is scattered,
Fig. 8—Birren Diagram
colors become desaturated, less pure than they would otherwise appear. The artist translates this as a change in the saturation of colors, a change in the color itself, a loss of detail causing a blurring of lines, and the cooling and loss of definition of colors.

In another vein, the Optical artists of this century have used psychological color effects to their advantage. Bridget Riley suggests the work of scientist Ernst Mach (27) in her paintings. Her work illustrates Mach's theory that a pattern of black and white lines will, in a sense, flicker before the eyes, creating an illusion of desaturated colors between the black and the white. Scientific experiments conducted with the Benham Top (10) also bear out this theory. A history and an analysis of hue production by flicker may be found in an article by Cohen and Gordon (10) where many illustrations of black-and-white circular designs suitable for producing chromatic responses are presented.

In still further experiments in color by Robert Gerard (31), a California clinical psychologist, colors were found to influence blood pressure, respiratory movements, eye-blink frequency, and skin conductance. His experiments indicated that certain pinks seem to act as a sedative and can even relax muscles. He found that a chain reaction of hormonal secretions, set off by different colors, apparently affects the adrenals to slow their secretions, which in turn
slows down the heart muscle. Therefore, a person determined to express anger cannot do so effectively if in a pink room; the heart muscle will not go fast enough. But, prolonged exposure to pink (about fifteen minutes) could lead, he found, to a condition called malillumination, which results in an imbalance in the endocrine system. Gerard's work led in turn to the widely publicized work of Alexander Schauss, director of the American Institute for Biosocial Research in Tacoma, Washington, who did primary research in using "pink conditioning" (a bright pink called Baker-Miller pink) in jail cells to calm violent prisoners.

Temperature

It can be proven that different lightwaves produce different temperatures so that the red end of the spectrum is hotter than the blue end. In this regard the emotional and the physical properties of color may be found to go hand in hand. Red, which may bring to mind fire, etc., is actually hotter than the green which is associated with cooling imagery and feels cooler to the touch.

Consider the progression of a ceramic kiln as it is fired. As the heat rises, it turns a dull red inside, then a bright red, then orange, yellow, and white. As the temperature rises, the cavity tends to look larger. Therefore, white appears to be larger than black and the warmer colors
appear to advance while the cooler colors appear to recede. In other words, light colors (yellow and orange-red) tend to move outward and dark colors (dark blue and dark green) tend to move inward upon themselves. This may be, psychologically, one of the reasons people contend that light colors are active and warm, while dark colors are passive or cool.

As mentioned earlier, color sensations sometimes do not rise to consciousness. It has often been reported by researchers and analysts that rooms painted with cool colors were "felt" to be cold by the people living and working in them. After the walls were repainted a warmer color, people reported that they were more comfortable even though there had been absolutely no change in the temperature registered by the thermostat.

Music

The psychological effects of both color and of music and the relationship between the two has been of interest to philosophers for centuries, appearing in the writings of both Aristotle and of Newton. Modern artists have also appreciated the power of this relationship. The color organ built by Louis Bernard Castel in 1924 produced color via sound in logical progressions. This union of music and of light is also evident in rock concerts that use computers and lasers and in discos where this evidence of the color-music theory is most intense.
Kandinsky laid great importance on music when he began his own philosophical research into the relationship of sound to visual symbol. Kandinsky "saw" colors in terms of musical sound, and compositions in terms of musical structures. It was so natural for him idiomatically that he related the function of "no-color" to the pauses in music (1) and wrote that white is the symbol of a world from which all color attributes have disappeared. White he felt acts upon our psyche as a great, absolute silence like the pauses in music that temporarily break the melody. This "no-color" function is well understood by contemporary painters who often leave large areas of their canvases blank, or allow the raw canvas to remain in the finished pieces.

Color Without Light

Color can be experienced without light (5, 13). Multiple studies indicate that a pressure on the eyeball, stroke, drugs, and even sounds can produce color sensations when the eyes are closed. Pressing lightly on the eyeball at the outside edge of the eye produces a fantasy of color effects. Some people experience vivid color dreams, and some have utilized hallucinogenic drugs for dramatic color sensations. Ehrenzweig (13) observes that the experience of color stimulates deeper levels of the mind than does form. He demonstrates this by experiments with mescaline, under the influence of which the precise outlines of objects become uncertain and
ready to intermingle freely while color becomes "greatly enhanced, tends to detach itself from the solid objects and assumes an independent existence of its own" (13, p. 155). These sensations are perceived in the absence of sight.

Light

Since most color sensations are produced under the influence of light, the nature of lighting has a definite effect upon the appearance of the surroundings. The human eye does not seem to see as well under artificial light as it does under sunlight or light that imitates sunlight (34, 37). This is because sunlight contains all colors; thus all colors may be seen in its glow. There is a strong psychological preference for viewing the world in either a yellowish-tinged light or in full-spectrum lighting (5, 14, 20).

Conversely, in some cases color suggestions in naturalistic artwork are so strong that they virtually over-ride the visual response and tend to remain no matter what lighting is used to show a work (14). The mind adapts and corrects the visual response. It should be noted that consideration must be given to light source distortion when a piece of work hinges on a delicate color harmony or when the subject matter is non-objective. Compensations may be made for the color of the illumination; the perception of the surface color may be influenced if the subject matter is imprinted information
stored in the brain. This observation comes closer to the recent scientific theories of social color adaptation and the minute imprint information processing theories mentioned in an earlier chapter.

Saturation in color is the function of available illumination (14, 24). Since the eye is constantly adapting to different light sources, this difference in perception is a very difficult concept to quantify. Because theoretically daylight possesses all wavelengths with no one being dominant, it is considered ideal for the comparison of color, but daylight is somewhat variable, its color changing throughout the day. The Impressionists were so sensitive to these changes in daylight that they changed canvases virtually hourly to catch the same scene under these different conditions. They found that a color will appear much warmer when viewed in direct sunlight than in the north light of a studio and that specific color matching is dependent upon the consistency of lighting conditions (29).

Obviously, then, a color arrangement achieved under an incandescent or a fluorescent source might not be harmonious in a daylight situation. From Leonardo it is known that it is important during drawing or painting to mask the color arrangement (maybe a model or a still-life) from other colors since color surround always affects the resulting work. It is well-known that light plus color surround causes reflections which change perceptions of objects.
Furthermore, colored lighting seems to change human reactions to environmental conditions (2, 32, 37). The carnival atmosphere is stimulating because of the gaudy, rapidly moving lights. A cathedral is restful because of the light streaming through the stained glass windows. Medieval and Renaissance churchmen, cognizant of this effect, would lay the sick in the area below the colored glass windows where benches were placed around the walls of the old cathedrals. The light bathed the ill in color which was thought to have special curative powers. Babbitt (2), in the last century, researched color for use as a therapeutic agent and in recent years Ott (32) has studied color and light and their effects on plants, animals, and humans.

R. J. Reiter, University of Texas Health Science Center scientist, notes that a series of studies is under way to find out how light affects behavior. He says that in optimal situations places of work should have one sort of light bulb whereas recreational places like gyms should have an entirely different sort, as should hospitals. According to the same study, light in homes might vary from room to room, depending upon the effect desired (12).

Summary

Scientifically, color can be codified, measured, and controlled, but the unpredictable effect of color as sensation can vary radically from person to person. It is the
effect of color on human thought and behavior that is the
province of the psychologist. It is no coincidence that the
evolution of psychiatry as a viable scientific study parallels
(and contributes to) the dream-like quality of the Surre-
alists' color theory (29), for it is the effect of color--
rather than merely its causes--that is the primary concern of
the artist.

The source of colors is physical, the materials out of
which they are produced are generally chemical, and the
receptors are physiological, but the major effect of color is
psychological. Although individuals often express strong
opinions about color, ordinarily color sensations are
unconscious so that people are not often aware that color has
such a tremendous influence upon them. Colors are powerful
factors in determining mood, temperament, and behavior
although viewers frequently seem oblivious to their color
environment.

Colors seem to be divided into two distinct psychologi-
cal groups: The cool colors which are predominantly the
blues and greens and the warm colors which are predominantly
the yellows and reds. Cool colors have a sedative or a
calming effect on highly nervous people to the degree that
some persons actually become depressed in surroundings of
cool colors. People feel cold, for instance, in a blue room
and warm in a red one, yet may not realize that color is
responsible for the sensation. In most cases, people surround themselves with diluted colors (shades, tints, or tones) derived from both cool and warm colors, unconsciously seeking a balance (5, 9, 11, 20, 23).

Color is, after all, an abstract concept, unconsciously assimilated into impressions when the eyes supply the brain with color information. This information is added automatically to all other imprinted information in the brain.

Possibly, of all the elements in art, color has the strongest effect (9). Since the psychological impact of color is ordinarily unconscious, people often do not try to analyze the reasons for associating color with response. Luckiesh (5) observed that our final interest in the use of color, as in any other activities, is largely concerned with psychological effects. In other words, according to Biederman (3), the ultimate object of color in the various arts lies in their influence upon human response.
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CHAPTER VI

SYMBOLISM IN COLOR

Introduction

Symbolic color associations are a powerful factor in artwork. The tendency for beginning students is to try to reproduce exactly the natural or native colors of the object. In this respect, the chosen colors are symbolic of the object and are governed by association. But on a more profound level, the relationship between emotion and color represents the most primitive haptic color experience. Lowenfeld (23) relates repetition of color to color's power as a symbol. He feels that the more complex haptic color experiences become, the greater the tendency to abstain from color symbols of general validity; therefore, color expression becomes highly subjective.

Since color symbolism has been deemed highly subjective, it is difficult to attach definite meanings to each color. Sperber (29) theorizes that colors are not paired with their interpretations in a code structure. They must be instead interpreted. This interpretation or response to color is therefore deep, and is as Birren (6, p. 145) suggests "entwined in life processes." Bernado (5, p. 8) supports this notion when he says that "almost any color evokes strong
symbolic images, which we cannot ignore." As artist Edvard Munch (28) has observed, "art is the crystallization of ideas through images."

Langer (21) reinforces this train of thought when she states that the basic symbols of human thought are images and that this expressive activity (art) whereby impressions are formed and elaborated and made amenable to intuition is the very process of elementary symbol-making. This means that the past impressions and the future ones exemplify the same response evocation. Modern man, according to Mundt (27), is not accustomed to the color implications or symbolism in Medieval man's art, but he feels that perhaps anthropologists may discover someday that what is felt about color today derives meaning from the distant past.

Historically

The whole of ancient color symbolism was founded in mystery, but Birren (7) feels that in each society it speaks a language common to all men. The mystery of these early works derived its reinterpretative powers from the magic of the "presence" of a divinity in the society's icons (11). These icons could only transmit the magical message when the viewer could successfully decode the symbolic message (10). In great art, according to Gowan (16), the symbols free themselves from the iconic mode of private symbols and become part of an external public world. In this interpretation
the color symbolism of primitive man, if it is art, will elicit a response from modern man.

In Egypt, Greece, and Rome, color was looked upon in terms of mysticism and symbolism (8). The ancient painter adhered to prescribed color use and practices and did not give reign to personal choices in the mixture of paint; his expression was formal and impersonal to perpetuate the cultural message.

In Pompeii and Byzantium there were brief moments during which symbolism was neglected for a lavish and sensuous use of color apart from meaning (7) but more often color has been used didactically. This type of symbolism rose in the early period of Christianity when the stories of the Bible were told to an illiterate populace by word of mouth and were illustrated by the paintings or decorations in churches and other meeting places. Specific colors stood for certain virtues, vices, and emotions and these colors were used in the painting of robes and halos in scenes illustrating the various stories. As a result, one saint appearing again and again in a series of illustrations of the scenes of his life and martyrdom might wear halos and robes of varying colors in varying panels, indicating variations in emotions, social standings, and even age.

Mundt (27) notes that the moods of a period are expressed in their color choices. The emotion of the Early Renaissance
is shown in the cool grayed palettes. The Baroque period expressed its mood symbolically by warming paintings with rich oranges. The Rococo expressed itself in the cool, subtle, and fragile whites.

The rich and brilliant color of the more modern work reaches back in history, expressing primitive emotional and spiritual relationships (15). These pictorially stated moods are expressed in such a way that the symbolic vagueness appears to multiply its possible meanings. The Fauves' effort to return to this symbolic simplicity induced them to reduce their methods of communication to one, that of color, and to employ it directly and strongly.

The visual artist in recent years, according to Ashton (2), has not spoken of specific myths, but has "returned to grand cosmogonic themes that myths encompass: the primordial wildernesses, astral spaces, cavernous places where life was legendarily spawned, subterranean depths that give birth to myths, the symbolic center" (2, p. 76).

Collingwood (13) talks of the sterilizing of the senses that can result from ignoring the emotional charge of color. He feels that this approach is a common characteristic of the adult educated man, less in women and in artists. He concludes that "To study the so-called symbolism of the Middle Ages is to see into a world where, even among the adult and the educated the sterilizing of the color-sensa has not taken place." His term, color-sensa, refers to a special awareness
in anyone who is "conscious of seeing a color and is simultaneously conscious of feeling a corresponding emotion" (13, p. 162).

Specific Symbols

While such things as the mixing of the pigments and their behavior once they are mixed appear to be essentially the same in all cultures, the assignment of certain colors to symbolic representation must necessarily vary from society to society. Since the connotations of colors change within different civilizations, no attempt is made in this study to trace the symbolic meanings of all colors through all societies. Only certain points are noted as being relevant because of their long associational aspects.

It seems that partly because of their direct emotional effect upon man and partly because of their associations with various experiences, most colors have acquired symbolic or mystic significance. Therefore, color use in older societies and their art may have had a greater cultural impact than the pure color relationships do today. It seems that almost every color has had both bad and good connotations at different times and in different places.

Yellow

In India it is the marriage color, in China it means royalty, but to the Egyptians, a grayed or greenish-yellow meant disease (7). In Greece it was the color of age (12)
while at different times in Russia and in Italy it has been the color associated with prostitutes (27). In Western Europe, particularly in England, it was in fashion during the decade of 1890-1900 when Oscar Wilde popularized it. Artist Aubrey Beardsley wore lemon-yellow gloves and even had his entire studio on Warwick Square painted a deep rich yellow with black wood trim (7). It is the university insigna for the field of science (3). Kandinsky (19) associated yellow with the shape of a triangle.

**Green**

In different cultures green has been associated with nature and water. The green olive branch is the symbol of peace and the laurel wreath of immortality. Green was the color of the horse of knowledge that the Hindu god Om rode (7). It is the color of the activity of youth, and conversely, of rest. In art, green is associated with the hexagon (9), and in the university it is the color of the field of medicine (3).

**Blue**

In Mexico blue is the color of mourning because of its peaceful associations. In our society it is sometimes a sad color related to blues singers and to blue Mondays. Yet blue is also considered a symbol of power for males, particularly in the corporate world (5). The term blue-blooded denotes
aristocracy, and the term true-blue signifies fidelity (27). The Greeks wore blue garments as a sign of truth and integrity (7), but to the Cherokee Indian it meant defeat (12). First prize ribbons are blue. In universities blue symbolizes the school of philosophy (3). Kandinsky (19) and Albers (1) feel that blue suggests the circle or sphere.

Purple

The imperial color of Rome was purple and it remains today a symbol of royalty (27). It is the color chosen to represent the overall prize winner in competitions. It is a traditional Easter color (12). In university insignias purple is the color representing law (3). In art purple suggests the form of the oval (1, 19).

White

Probably the most varied interpretations belong to white: the white flag of truce, the white dove of peace, purity, innocence, virtue, the moon, riding a white horse, wearing a white hat (12). In Egypt a white tiara decorated the head of Osiris (20) while the Greek word for white carries a suggestion of happiness and gaiety (27). Ghosts and pallor are the negative suggestions of white in modern times, perhaps harking back to early African beliefs where it stood for death and the supernatural (27). It is identified in higher education with the arts and letters (3), and in prize competitions it is the fourth award.
Black

In Greece black was thought to be the mother of all things, for they believed that all things came out of darkness. In other societies it has many evil connotations: black magic, the occult, death, powers of darkness, mourning (12). Yet it represents solid basic or structural strength and deep restful quiet (27). Occasionally the cultural color symbolism can change dramatically. According to Bernardo (5) the dress designer Coco Chanel dressed in black to honor a dead lover, creating collections of dresses which for several generations have set standards for the "little black dress" proper for all celebrations. Whereas before it had indicated mourning, it is now the symbol for the cocktail party.

Red

Among the primitive tribes of Italy red was the favorite taboo color; demons fled from it, and for this reason sacred stones, trees, and the bodies of people were painted red for protection (27). Red is the color of blood and is associated with action, vigor, war, bravery, self-sacrifice, fire, heat, and carnal passion. It is symbolic of the devil, danger, and anger (27). Other associations of red come to this society from China (royalty's signing of all important documents) in the form of red seals of state and red pencils for grading (24). Red is the color which symbolizes the crown of Lower Egypt (20). In Japan sick children's red bibs are tied
around the necks of stone Buddhas as prayers for recovery (6). Today red marks the branch of the study of theology—music is pink (4). Red is associated with the Fourth of July, Christmas, and St. Valentine's Day. It is the color denoting the second place in prize ribbons. Kandinsky (19) suggests that it is associated in art with the square or the cube.

It seems that color symbolism has assumed importance in all societies. For example, castes in ancient Gaul wore certain colors; heraldry prescribed color regulations; flags and banners in national colors have inspired patriotism (27). In India the four original castes were associated with colors or varnas, "varnas" meaning "color" in the Sanskrit language (6). Each educational institution has its own colors while there are military ribbons, academic gowns, prize ribbons, church colors, primitive symbolic colors, colors of paper money, safety colors, and electrical wire colors. But it is to be remembered that while these colors may have been chosen originally for their emotional impact, they might also have been chosen for their visibility in some instances.

Among advanced cultures, each group within each culture seems compelled to rename some color to denote a particular shade, tint, or tone in a terminology known only to the immediate group. Balinkin cites this compulsion.

Even in the sixteenth century the desperate need for color names caused the word artist to create rat-color or widow's joy or chimney sweep. In the eighteenth
century French women wore colors of such extraordinary designations as Rash Tears, Paris Mint, Stifled Sight and similar inspirations. In the twentieth century we can hardly be considered outdone with such colors as Basketball, Wireless, Elephant's Breath, Cocktailgreen or Swingtime (3, p. 42).

Currently, Carole Jackson (18) attempts to advise people as to the colors they should wear according to their skin, hair, and eye color. The problem is precisely what color is icy green, bright burgundy, watermelon, clear salmon, or medium warm bronze? Her obscurity is particularly frustrating since there is a system (C.I.E.) she could have used which is approved internationally, a system that defines, describes, and places all color accurately within its framework by the use of numbers and letters (described elsewhere in this study).

Burchett (9) observes that symbolic color became scientific color in a move to resolve the duplicity of color meaning found jointly in the definition of its origin and the description of its enjoyment. This duplicity is confusing, hinders clear thinking in relation to color description, and further, impedes the movement toward a fuller appreciation of the possibilities in teaching color.

Light and Technology

What is the symbolic function of light and color? It is diversified, changing from one period to another, from one school to another, one painter to another, and sometimes, from one painting to another. The concepts of light are, it
seems, determined by the general thought of art prevailing in a given century, the accepted value scale, and the cultural background of the artist.

One school might feel that light is to illuminate objects so that they are visible and representable, that shadows are a way to produce a convincing illusion of relief or textures. Such a school would feel that color is a quality of surface and usable only to manifest form (4, 26) so that both color and light would be subdued. In this respect color might be a method of symbolizing material, solid objects, an approach which would allow a more functional concept of light and of color.

Another school of thought might focus on the expressive element in light and in color. It was not until the sixteenth century that light itself came to be seen as a subject matter of painting apart from the items it illuminated (4, p. 82). The distribution of shadow and of light on the surface of the picture came to be seen as an artistic value in its own right so that man was able to write about the power of color to stir emotions in relation to light.

In speaking of the contemporary use of light as expression, Andy Warhol once remarked that "television is the new everything," meaning that it was a new field of perception exploration (11). Artist Nam June Paik, by manipulations of the television set explodes abstract patterns of light or
runs a spectrum of flowing colored ribbons across the screen. As McLuhan might say, process level analysis of the art experience is concerned with art as the process of perception, a way of experiencing how one sees rather than what one sees.

To the artist trying to draw or to paint naturalistically, the distribution of light on a work has a great influence upon the expression of the piece (24). In writing on this problem early in this century, Luckiesh showed that measurements in the range of relative brightness in a landscape often are as high as 500 to 0. This means that the brightest area in the sky is several hundred times brighter than the darkest shadow. Since artists' pigment cannot record this intensity accurately enough to symbolize this scene (a white paper is no more than fifty times brighter than a so-called black paper), alternate means of symbolizing the intensity of the scene must be discovered to compensate for the inadequacy of the materials.

**Theater**

Early theater leaned heavily upon the symbolism of the religious color referencing to denote emotions and to identify the players (6, 17). Modern theater still carries the vestiges of color significance. In some instances it is possible to know a character's age, personality, and part in the play before the actor or actress has spoken. The theater has utilized the dramatic intensity and the emotional symbolism of color through lighting as well as costuming. Consider the
double impact of a fine player when symbolic color referencing is used: gray for old age, brown to symbolize melancholy, black to forecast doom, red for energy, yellow for warmth and joy, green for calmness, blue for spirituality. Note the grouping of gray, black, brown, blue, and purple for tragedy; and red, orange, and yellow carrying the symbolism for comedy. For the most part, the audience does not seem fully to realize the extent to which it relies upon color delineations in costuming and in staging for its understanding of the play (17, 18, 25). Throughout art history this type of "staging" with color sets the scene for the mood and the emotional impact of paintings.

Summary

The symbolic use of color is at the very core of civilization. Researchers feel that the response to the symbolism of color is a deep and universal one, but one which may vary for different people at different times. Color symbolism is extremely differentiated and can probably be explained in terms of surroundings and in the prevailing religious value system (20). Symbolism in religious ceremonies might in itself constitute a full history of mankind. The assumption that must be drawn from these opinions is that there is a certain basic symbolism in color innate to all man, but tempered by the time in history from which the samples are
taken (5, 14, 25). The books of Faber Birren form a fascinating history for further pursuit of the subject.

In modern art there appears to be a chance to return to the purely personal symbolic nature of color, devoid of the extra baggage of colloquialisms in name (2). Collier (12) feels that when the prime effect of color is to arouse feelings such as happiness, sadness, elation, depression, anxiety, or serenity, that color is fundamentally a symbolic expression. When a color or an arrangement of colors moves the viewer subjectively to ideas which are not based on rational associations or relationships, he says "we must grant that color works as a symbol" (12, p. 163). If specific feelings are recognized because color has touched some intangible response, then color has symbolic power.

As the level of complexity of the society rises, the power of the work will be compelled to rise accordingly to maintain importance as an expression of the society. Our culture deals in theory, and theories require abstract thinking capabilities. As Leepa (22) notes, "Today colors have different meanings. Color is used to express the artist's feelings and moods regardless, often, of what the color of an object actually is" (22, p. 149). The student of the present who will be the producing artist or teacher might find difficulty integrating into a highly-theoretical society without an awareness of the possibilities of the symbolic use
of color. To this end, the archaic, symbolic nature of color and the abstract, highly technical and theoretical nature of a modern society might be joined through the artist's works, assuming an understanding of the implications of each.
CHAPTER BIBLIOGRAPHY


CHAPTER VII

COLOR THEORY IN ART

Introduction

Delacroix expresses the frustration of the color theorist when he observes,

The elements of color theory have been neither analyzed nor taught in our schools of art, because in France it is considered superfluous to study the laws of color, according to the saying "Draftsmen may be made, but colorists are born." Secrets of color theory? Why call those principles secrets which all artists must know and all should have been taught (17, p. 8).

Burchette, in his dissertation, describes what he perceives to be the difficulty the study encounters when first taking a painting course, for the student can draw, but knows nothing about colors. He falls back on drawing skills and

often views color in painting as a frightening prospect. As a result, beginning painters are virtually set adrift in a sea of confusion regarding color; and they spend the better part of their early painting experience not learning how to paint, but trying to somehow integrate the previously neglected and formerly unclear, possibly invalid, and essentially impractical knowledge about color into their work (5, p. 183).

He concludes that it seems more logical to have a color course be a prerequisite of a painting course.

There are a great many theories as to color (37), but color schemes and systems are only guides. "They are tools,
not rules!" notes Faulkner (12, p. 40). It is good, he observes, that color mixtures do call for experimentation, for in the teaching of color there should not be too heavy a reliance on rules since the thought of domination by strict standard is not consistent with the creative intent.

Within this context a solid color sensitivity can bridge the gap between color theory and the theme or emotional meaning. As Burroughs remarks, "You can put sets of colors guaranteed to go together without clashing, but that is not all there is to the relation between colors: Very dull and insensitive results can be had" (7, p. 8).

Historically

Color organization diagram theories are at least as old as the thirteenth century, with the seven-color circle possibly the oldest found. The four-color was next in the fourteenth to fifteenth centuries. The red, yellow, and blue circle (the most recent) was done in the eighteenth century (31). Although no evidence shows a circular patterning before 1611, some may be inferred from existant scientific texts and reconstructions (31). Parkhurst and Feller, in addition, include copies of the original sketches of some of the systems, plus a very full and useful bibliography. The three components of color--hue, value, and saturation--are combined in different color systems to establish various harmonious or contrasting effects. Ostwald notes eight basic
hues in his color harmony system, Newton seven, Goethe and Schopenhauer six, and Munsell ten with one of the earliest traceable charts (that of Harris in England) dividing the spectrum generally into yellow, red, and blue.

As mentioned earlier, the seven-color scheme of Newton (yellow, red, orange, blue, green, violet, and indigo) was thought to be derived from the planets and the four-color patterning of red, yellow, blue, and green from the four elements, but these systems were devised to describe color or natural elements as opposed to pigments used in painting. These seem to predate Aristotle to a time when ideas belonged to the common cultural heritage as opposed to ideas being restricted to the educated.

In about 1737, DuFay describes how by mixing two or more of the primaries of red, yellow, and blue that any color could be obtained by dyeing yarns. He chose these three colors because he felt that these were elements that when placed equidistant around a circle formed the points of an equilateral triangle (10).

Goethe observes that

Nature perhaps exhibits no general phenomenon where scale is in complete combination. The mode, however, in which the entire series is connected in a circle, is rendered most intelligible by tints on paper, till after much experience and practice aided by the susceptibility of the organ, we become penetrated with the idea of this harmony, and feel it present in our minds (5, p. 320).
In Figure 9 it is seen that the original thought of the Newtonian and Goethian spectrum is bent from the rainbow shape into that of the circle. The three primary expectations seem firmly established: a sequencing which would be maneuverable, a system that could be memorized, and a system from which relationships might be drawn.

The three so-called secondaries of orange, violet, and green form another triangle within the circle (see Figure 10). It is theorized that when yellow and orange pigments are mixed the sum will be yellow-orange, when orange and red are mixed red-orange will result, when red and violet are mixed that the sum will be red-violet, when violet and blue are mixed it will produce a blue-violet, when blue and green are mixed the result will be a blue-green, and when green and yellow are mixed there will be a yellow-green produced. These double-named colors are called tertiaries.

Within the past few years there has been a resurgence in the field of research into the roots of color systems following the advent of the scholarly contemporary artists and teachers. Gerritsen (13) discusses the development of value, hue, and saturation from 600 A.D. to the present. He acknowledges that the history of color research spans many fields, granting philosophers, artists, psychologists, physicists, physiologists, and technicians all shares in its development. Jacobsen (19) and Hickethier (15) note scientists
Fig. 9—Pigment Complements
Fig. 10—Color Arrangements
and artists who have enlarged upon the subject of color. Faber Birren (5) provides a chapter on color systems.

Goethe's thoughts (14) tie together the scientific and the aesthetic approaches. He presents his ideas regarding the connection between color and philosophical ideas, color harmony and aesthetics. Judd (20) suggests that Goethe's theories have been too quickly dismissed by the scientific community. He points to the still-unanswered question of why full spectrum can be seen in refraction when only certain waves are used for illumination. He suggests, as did Goethe over 160 years ago, that subjective phenomenon might be the answer. In this century Goethe's thoughts are pursued by theorists like Land (23).

Chevreul

Art theorist, J. F. A. Taylor (36) found that in medieval times, in the nineteenth century, and in the works of masters such as Giotto and Goya important creative color effects were derived from an effective use of simultaneous contrast. Regardless of whether earlier artists were intellectually aware of the phenomenon, they had to anticipate or otherwise handle the color effects. One of the first to explain the sensation of simultaneous contrast for the art field was Chevreul, a French dye-master. His influence was felt most immediately in French art, for his greatest impact was on the color-consciousness of the nineteenth-century painter.
Although his work has been modified over the years, the basic laws and principles are the same. His "Law of Simultaneous Contrast" is an objective theory. Chevreul observed that two different values of the same color affect the intensity of each other and that two different colors of the same value seem to combine optically. His system did not discount the subjectivity of the eye's perception, but it did give concrete evidence to the fact that color has a life of its own and is not a mere accessory. In Chevreul's words,

If we look simultaneously upon two stripes of different tones of the same colour, or upon two stripes of the same tone of different colours placed side by side, if the stripes are not too wide, the eye perceives certain modifications which in the first place influence the intensity of colour, and in the second, the optical composition of the two juxtaposed colours respectively. Now as these modifications make the stripes appear different from what they really are, I give to them the name of simultaneous contrast of colours; and I call contrast of tone the modification in intensity of colour, and contrast of colour that which affects the optical composition of each juxtaposed colour (8, p. 4).

Chevreul's discovery may be understood as a double-sided phenomenon: "In the case where the eye sees at the same time two continuous colours, they will appear as dissimilar as possible, both in their optical composition and in the height of their tone" (3, p. 38). Successive contrast he saw as an optical sensation such that a "complementary color halo appears gradually to surround an intense hue seen on a white or neutral ground" (3, p. 38). He explained the reasons for this optical effect and arrived at a system by which it could be measured, anticipated, and deliberately utilized. Chevreul used an
early color wheel as the basis for his work, naming red, yellow, and blue as primaries, and green, orange, and violet secondaries. He pointed out that areas of color perceived simultaneously by the eye and fused in the mind look different from areas of color perceived separately.

This premise formed the basis of Chevreul's principle of harmony and contrast which he applied to both value and to color juxtapositioning. He showed that the farther apart two colors were on the color wheel, the more effective was their contrast, and he recommended the juxtaposing of those colors which appeared 180 degrees apart on the color wheel (complements, see Figure 9) to achieve the most intense effects.

Specifically, complementary colors are those described as lying opposite each other on a color wheel (see Figures 9, 10, and 11) which tend to enhance each other in relation to their surface, lighting, value, and saturation. For instance, when placed next to the same hue of full saturation a delicate tint is almost indefinable, while next to its complement, the tint takes on a rich quality. A delicate pink that looks almost white by itself takes on a distinctively pink character when placed next to a green. In some cases each color is felt to be tinted slightly with its neighbor's complement.

Whites and grays appear to be tinted by surrounding colors when there are large areas of color and small areas of
Primary:
- red, yellow, blue
Secondary:
- orange, green, violet
Tertiary:
- yellow-orange, red-orange
- red-violet, blue-violet
- blue-green, yellow-green

Fig. 11—Pigment Primary, Secondary and Tertiary Colors
white or gray. Simultaneous contrast seems to visually make strong colors stronger and weak colors weaker. If two colors of the same hue, but of different saturations are placed side by side, there is a strong tendency for the complementary hue to appear in the area of lower saturation. If both saturations are moderately light, the effect is to accentuate the saturation difference. Colors influence and change each other continuously, interacting with the viewer's perception. With experience, the artist adjusts colors until they "look" right, sometimes without an explicit understanding of the effects of simultaneous contrast.

Although Chevreul's law is a fact of vision that can be effectively utilized, the effect of simultaneous contrast is not easily grasped. It should not, for instance, be confused with the effect called after-image. After-image can be seen only after staring fixedly for many seconds at a colored area. Simultaneous contrast, on the other hand, is immediately apparent and is equally apparent to a roving gaze as it is to a fixed stare. After-images and simultaneous contrasts are a psycho-physiological phenomenon. Lee (23) feels that no normal eye, not even the most trained one, is fool-proof against color deception. He remarked that "he who claims to see colors independent of their illusionary changes fools only himself and no one else" (23, p. 103).
Ostwald

The single purpose of a color scale is to systematize. If the color system devised is a workable one, then, within reason, any primary hues deemed as the basic ones by the designer of the system may be fitted within the context and, consequently, manipulated. If the Newtonian order for spectral colors were followed and the system forced (from perceptable violet to perceptable red) into a circle, making a color named "purple" when the two overlapped, then, that configuration would be satisfactory for color theory exploration.

Ostwald took exception to this spectral theory when he expresses the opinion that any rational color system must regard black as a positive sensation, not as a mere negative experience resulting from the absence of light. He notes that all surface colors seen under natural conditions contain black as one of the constituents, although sometimes only in a small amount. Ostwald proves his point when he observes that (1) duller colors of brown and olive-green which figure so strongly in our surroundings cannot be obtained from any mixture of spectral colors, (2) crimson and magenta are not to be found in the spectrum; and (3) monochromatic colors are artificial colors, quite different in quality from the natural color of ordinary surfaces excited by rays with wide ranges of wavelength (35). Ostwald's color system is used today and seems to be very close to man's psychological concept of color.
Ostwald arranged removable color chips, lettered, in triangles, and described them in terms of purity, whiteness, and blackness. The system forms a fan-like double cone in three-dimensions. All pure hues are located at the girdle of the double cone-fan in the same relationship to each other.

Munsell

The color system originated by Munsell (28) in early 1900 is probably the most widely used color notation today. The color theorist Rood (33) met with Munsell twice (in 1900 and in 1901) and the two corresponded for many years. As a result, Munsell felt he had solved the problem that Rood had worked on: a decimal system for color. Rood mentions many times in his writings his affiliation with Munsell and the color measurements that they used which they credited to the scientist, James Clerk Maxwell.

In his color theory Munsell defined three variables of color: hue, value, and chroma. He constructed from these a three-dimensional color solid having a vertical "near black" and "near white" axis. Around this he arranged the colors in artificially distributed equal spaces and defined chroma as the distance from the axis at any particular level. His Atlas (28) contains colored paper chips arranged according to the various sections throughout this solid. The specification of color consisted of a set of numbers showing the color position on the scale of the solid. If visualized as a giant
wheel, the black-and-white or value scale would be a cylinder through the center of the wheel, starting down from zero or near-black and going upward to nine or near-white. The ten hues or colors he placed around the girdle as spokes. He concluded that each color was different and would have a unique placement. His figure when produced as a solid, would appear quite uneven when compared to Ostwald's leaves.

In listing the advantages of his system Munsell states that

1. Loose and unrelated color terms are replaced by a definite notation.
2. Each color names itself by its degree of hue, value, and chroma.
3. Each color can be recorded and transmitted by a code.
4. Color contracts can be drawn, and proved by physical tests.
5. Color grading of agricultural and industrial products can be accomplished in terms of hue, value, and chroma.
6. New colors in no way disturb the orderly classifications, as a place is already awaiting them.
7. Fading can be defined and plotted at certain intervals, showing its progress in terms of hue, value, and chroma (29, p. 57).

Despite Munsell's clear delineations, it has frequently been noted that while standardization has arrived in practically all other fields, there is still dissension in the color field. Most early work in standardization seems to have been done in relation to fields of study other than art, i.e., mineralogy, textile manufacture, horticulture, dye manufacture, stamp collections, etc., ad infinitum. This lack has been discussed in books and in technical journals.
Colors have been named for flowers or plants, for fruits, for places, and for people (25). The inadequacy of such terms is evident. Munsell (29) expresses the thought aptly: "Can we imagine musical tones called lark, canary, cockatoo, crow, cat, dog, or mouse because they bear some distant resemblances to the cries of these animals?" (29, p. 13).

C.I.E. and ISCC-NBS

The Commission International de l'Eclairage or the International Commission of Illumination met in Paris in 1931 to try to devise a unified international color system. That system is called the C.I.E. System (16). It measures, designates, and matches color whether those colors are emitted, transmitted, or reflected. The information is read on a spectrophotometer using the three primary colors (see Figure 3) of light to plot a graph. This makes the system the most accurate to date and could be called a combination of all of the color systems since it combines the information in each.

The Inter-Society Color Council-National Bureau of Standards (18) in the United States, the ISCC-NBS, has standardized names for describing the colors of commercial paint. Each matches a color chip of the reorganized Munsell scale. Only hue names are used, plus modifiers such as light, medium dark, deep, grayish, moderate, pale, strong, vivid, and brilliant. The beauty of the Munsell System and
the reason it may have endured is that it is an open-ended, viable system. The revised book, although expensive, is a valuable teaching aid owned by most colleges and universities.

Tints and Shades

The addition of varying amounts of white to a color or hue produce different tints of the color. The addition of varying amounts of black produce the shades of a color. Tints have an entirely different symbology than do shades or pure color: tints suggest delicacy, whereas deep shades symbolize strength, and pure colors seem to denote richness. The term "tint" appeared in about the fifteenth century as "tinture," a synonym for the word color. It was only in the nineteenth century that it came to mean a light color. The term "shade" emerged also in the nineteenth century as meaning "lowered brightness."

Tones are seen within their proper context as a mixture of any color and black and white (see Figure 8). To read this figure imagine the large circles as of primary importance. Color plus white equals tint; white plus black equals gray; color plus black equals shade. Any straight-line mixture through the middle equals tone.

Hue Scale Contrasts

Hue is the quality or characteristic by which one color may be distinguished from another, a red from a yellow or a green from a violet. Hue specifies the position of a color
in the color system. Hues which are closer together share a common color and are therefore similar and generally prove harmonious in combination. They are called analogous. Hues that are farther apart provide more contrast with complementary colors providing the greatest. They tend to intensify each other as, for example, an intense red and a strong blue-green will appear to glow and to pulsate.

If a hue called red and one called yellow are placed next to each other, the yellow will appear slightly greener than if it were by itself, and the red will appear cooler and a little purple. The same hue or color will seem much stronger alone on a white, black, or a neutral gray background. Hues, in their scales, do not follow the same geometrical progression as do grays as proven earlier in this century by the work of Munsell. Different colors reach their maximum pureness at different levels; for instance, a full red has a higher saturation than a full green.

Between the warm and the cool sides of the color wheel (Figure 12) lie the colors yellow-green and red-violet. They occupy a unique space in the dichotomy, since they each may be made warm or cool by the influence of surrounding colors (17, 26).

Gerritson (13) observes that since a lightness contrast between two colors is visually more important than a much larger contrast in hue or saturation, it is necessary to be
Fig. 12—Warm-Cool Dichotomy
aware of the inherent lightness of individual spectral colors, and he asks, "which are the relatively light and which are the relatively dark spectrum colors to the human eye?" (13, p. 35). Many attempts have been made to devise a mathematical rule of balance, but since colors vary with their position, size, and surround, there does not seem to be a suitable formula. If the problem was one of warm-cool balance, the problem could be solved by adjusting intensities or area (1, 17).

Primary Mixes (Subtractive)

Although it is generally held in theory that the pigment primaries are red, yellow, and blue, throughout history there have been four, five, seven, and even twelve-color primary systems. Yet the three-color primary system remains the most widely accepted. Within the three-primary system theory there are the secondaries of orange, violet, and green and the tertiaries of yellow-orange, orange-red, red-violet, blue-violet, blue-green, and yellow-green. They all fit logically once the three primaries are put into order within their triangle. Using this system, the three primaries and three secondaries at full purity are called hues. Complementaries are directly across the color wheel (see Figures 9, 10, and 11). To split the complement one can go across the wheel to the complement and pick up the double-named tertiary on each side of that complement. The shape of this combination would
be an isosceles triangle. A double-split would return to the original color to pick up the double-named tertiary on each side of it. To clarify, yellow might be the original choice, violet would prove to be the complement, red-violet and blue-violet would be the split complement, and the double-split would add yellow-orange and yellow-green. This would form a rectangle within the circle that is called a tetrad (see Figures 10 and 11) while a color combination of the original color and its complement would be only a dyad. Another possible combination is the triadic which consists of any three colors which form the points of an equalateral triangle within the circle as in the primaries of red, yellow, and blue.

Analogous color harmonies are colors on a wheel lying next to each other. Some feel that analogous harmonies should contain colors incorporating a common color only. Five colors seem to be the most colors which should be included within this category, three the least. Again, using yellow as the central choice, three color analogous harmony would be yellow, yellow-green, and yellow-orange. The wider aspect of this arrangement would add orange and green to the above three-color combination. It is Raphael's (32) opinion that when colors follow one another in the same order as in the spectrum, their interplay acquires a dynamically continuous character; otherwise they would have a discontinuous, abrupt character.
Kuppers (21) suggests a color system consisting of the three additive primaries and their couplements: yellow, red, green, cyan, blue-violet, and magenta, plus black and white to be used in the above theory. Ellen Marx (26) and Enid Verity (38), modern color authors, suggest yellow, cyan, and magenta as primaries for pigment mixing. The question as to which pigments are chosen for successful primaries in mixing and theory presents a significant problem.

As the subject of color becomes better understood, there will be a refinement of the primary controversy. Modern research methods might lead to more scientific inquiry which will assign generic color names, letters, and numbers, more firm definitions of terms, and a more practical theory study and a primary palette.

Albers (1) and Smith (34) were the proponents of the thought that students should first learn to manipulate pigments as visual sensations before actually working with them. They used colored papers to teach, but Smith recommends using the Maxwell disc-type for testing color mixtures. Ideally, red, blue, and yellow, if they are indeed true primaries, will produce a true mid-gray to black when spun. If there is a bluish or a greenish cast, then theoretically the colors are in the wrong proportions or they have not been proven to be the basic primaries.
Pigments

Pigment is a substance which has the unique capacity to select and to reflect a limited band of the spectrum and at the same time to cancel or to destroy the vibrations which it cannot reflect. Although the pigment might be used to produce the color seen as colored light, the pigment itself is a physical substance different from light, and its behavior in mixture might be expected to differ from the behavior of light. A mixture of colored light is the sum, or simple addition, of the light vibrations involved. A mixture of pigment is the remainder after the pigments have exerted their subtractive force upon each other.

Pigments are able to split up a ray of light as it falls on them, to absorb certain wavelengths, and to reflect others. Thus when these pigments are viewed the human eye receives the sensation of a definite color determined by the wavelengths reflected. If the pigment reflects only the red wavelengths, the pigment looks red; if it reflects only blue wavelengths, the color is said to be blue.

Naturally the quality of the light in which the pigment is viewed affects the wavelengths received by the eye. Except in the type of rare instances mentioned in Chapter IV, there is no perception of color without some type of light, so in absolute darkness, pigments will be black.

Orna (30) confronts the problems the artists face in buying prepared tube pigments. Most manufacturers use
different base chemicals in mixing pigments which are then called by the same name. Further, most artists' pigment manufacturers seem unwilling to list ingredients on the tubes along with exact notation about the colors. Orna says that "the coloring matter in a tube of 'cerulean blue' may be barium manganate, copper phthalocyanine, or oxides of cobalt and chromium, depending on the manufacturer; on the other hand, three different manufacturers may label copper phthalocyanine 'thalo' blue, 'cerulean' blue, or 'intense' blue" (30, p. 192). The problem is further complicated by the naming of compounds by another set of names and numbers unknown to the layperson except with the availability of a Color Index (9).

There are inherent problems in producing three basic pigment primaries. First, they must be the exact hue that will correspond to the secondary colors of light. Second, the pigments have different specific gravities and have to be balanced in strength on a weight basis so they can be used in a system for color mixing. Third, the colors must be stable.

Scientists have developed and are still developing pigments which are stable synthetic colors which fit into a system which is clear, standardized, and organized. The field of color measurement called Colorimetry has one set of standards which are definitive and the arts have another system which still accepts tube names as poorly differentiated as "flesh" and "brilliant blue."
Summary

Fixing the dimensions of color and offering a notation for relating them which is both verbal and visual offers a means for thinking about color in a structured manner. If a well-conceived color system does have validity, it should add to information, comprehension, and make relationships logical and consistent. Luke (24) remarks that there "will probably never be a completely accurate three-dimensional color solid" (24, p. 178), although some solids might be of historical value in teaching or in use as an illustrative tool.

In color there are three things to think about: the pigment, the light, and the color sensation which results from the action of the light on the eye. To speak color language successfully is to know the nature of color itself, to use it in terms which express its qualities. It will continue to be difficult to speak that language, however, until the terms and the theories which control its use are expressed in a precise and a codified vernacular. All technical fields have their own nomenclature; color theory, to be properly constructed, requires its own terminology as well. The use of descriptive names for colors has so often resulted in that confusion of mental images caused by multiple connotations. To complicate the matter, the fragments of a nomenclature which do exist are not precise in meaning: hue, shade,
tint, value, tone, saturation are all ambiguous terms clouded by their meanings outside the art field.

The modifications in simultaneous contrast by Chevreul in the last century have proven to be beneficial to the modern artists and students. Painter Camille Pissarro, in reflecting upon his study of color theory, remarks,

But surely it is clear that we could not pursue our studies of light with much assurance if we did not have as a guide the discoveries of Chevreul and other scientists. I would not have distinguished between local color and light if science had not given us the hint; the same holds true for complementary colors, contrasting colors, etc. (4, p. 261).

In dealing with color, there are theoretical arrangements which fit into a color wheel format and which may be manipulated, i.e., the dyad, triad, tetrad, split-complement, and analogous. These arrangements form the basis for a theory of color study. Some artists and teachers feel that more study would result in a clearer understanding of color and its possibilities. Burchette observes that "as new possibilities for the organization and use of color were discovered, color manipulation and expression gained scientific dimensions; the search for a personal aesthetic in color became also a quest for natural law" (6, p. 10).


11. Drever, James, "In What Sense Can We Speak of Primary Colours," The British Journal of Psychology, 21 (April, 1931), 360-367.


CHAPTER VIII

INTERPRETING COLOR THROUGH DESIGN

Introduction

The designing of the color relationships in a piece of work is not only an intuitive but it is an analytical and a technical process. Structuring, controlling, and mastering the interrelationships of the parts give completeness to the work. It is, after all, the structure of the work as a whole which makes the intention of the artist accessible to the viewer.

Thinking in color "structuring" is not a single line of thought, observes Ehrenzweig (7), but is several superimposed strands at once requiring a diffuse, scattered kind of attention that contradicts normal logical thinking. Conscious thought is sharply focused whereas the deeper the imagery, the more thought branches so that in the end its structure might appear to be chaotic. The creative thinker is capable of alternating between these modes of thinking, harnessing them together. Gombrich (7) remarks that the experience of color stimulates those deeper levels of the mind.

Color has an aesthetic value quite independent of its function of representing the surface color of real objects (2), and to exploit the richness of color the artist depends
upon his own sensibilities. Color expression is individual and unique, there is no formula for its production. There are, however, "general considerations about the use of color that will increase its understanding, both in use and in appreciation" (24, p. 152).

In the hands of a master, deliberate color building does not become mechanical or dead, according to Collier (6). In fact, he remarks that the reverse is true; it is possible to intensify the optical excitement produced by color and to maintain its expressive qualities. As a result, the response of the observer to the stimuli provided by color is the arbiter of the work's success. Color, observes Birren (5), has been the emotional quality in painting, while design and composition have been the intellectual. In teaching draftsmanship the control of line is more amenable to intellectual mastery. In accordance with the more intellectual climate now seen in some art schools some control of color is taught, but no systematic study of the fundamentals of systems of color expression is attempted. This, Gombrich (7) notes, is partly due to the dearth of good books on the artist's use of color.

Of the design elements with which the artist works, "perhaps color has the greatest emotional impact on the spectator, striking more directly than line or texture or shape" (24, p. 148). While all of the facets of design have elemental powers of their own, color seems to reach man's
innermost reactions most quickly. Cezanne (25) comments that design and color cannot be seen as distinct, that when color is at its richest, design is most complete.

Color, then, helps define space with its areas visually moving into or out of the surface according to its aggressiveness. Color used as line, shape, volume, and texture produces static or dynamic forms (27). It also helps establish a pattern with spots of related hue leading the eye through the rhythm of a composition (29). Color can be presented in such a way that visual unity (or deliberate visual chaos) is the result, making color both the purpose and the arrangement of the work. If the intent is to be clear, all of the elements of the composition must express that unity (21).

Historically

As discussed in earlier chapters, the Florentines solved the problems of creating form and it became possible for the Venetian artists to achieve the idea of color as distinct from form. Once these artists had achieved control over their efforts to record the color of reality, then like the fifth century, B. C. Greeks they realized that man could make color effects and relations other than those in nature. Thus began the conscious exploitation of the manipulative possibilities of color (4).

Whereas early Gothic stained-glass painting held color to be dominant, correlating it to a boundary line in another
material, the Renaissance painters used color along with a tonal and atmospheric three-dimensional space representation (24, 30). Rembrandt absorbed color into light so that colors blazed up to render volume without a tracing of boundary. In the Renaissance pictorial space changed from the flat verticality of the Gothic to a space that carries an illusion of reality. Mundt (28) explains this space as "individualistic space." He concludes that the space carries the illusion of material reality only for one observer which emphasizes a chasm existing between the self and his environment, from the Gothic symbolism to the realism of subject matter.

These conflicts of line, shape and volume were again challenged in the nineteenth century when the Impressionists made a deliberate effort to use color as the activity itself. Monet, like most Impressionists, seemed little interested in the form which could be secured with color. He was interested in the shapes of color (4) in terms of inventing new color experiences, rather than merely creating a substitute for the actual reality. Cezanne tried to equal the intensity of late Romanesque and early Gothic painters on glass with his oils (30) and to remove the restriction of the individual point of view.

The modern artist is substituting distinct, clearly defined color planes, juxtaposing colors. Leppa (24) remarks that there is a return to the vibrancy of the picture plane
itself, rather than the former use of color to depict infinite depth. Harries (17), in commenting on this change, notes that the emancipation of form from its representational function leads to an emancipation of the colors given to these forms. The geometric construction of a modern Alber's painting eliminates the factors which might call the attention of the spectator away from the presence of color alone. These types of paintings, according to Harries, constitute a severe formal approach to restore an immediacy that our vision has lost due to its tendency to associate colors with familiar contexts and meanings. By isolating the geometric, color is liberated to its "sensuous immediacy" (17, p. 107).

**Line**

Elliot (8) divides the problem of relating line to color into three parts: (1) a colored linear composition, (2) "adjustment" of line to color or color to line in reference to a third term, or (3) composition by means of color. The first might be considered the Renaissance method of arriving at color selection after the planning and arranging of the composition are completed. In the second instance, color may be thought of as reinforcing line. The last consideration would be color itself as the fundamental organizing element quite independent of line. Elliot observes that this approach was developed by Robert Delaunay from Chevreul's work in
simultaneous contrast; Delaunay's understanding of Impressionism, Fauvism, and Cubism; and reinterpretation of the first two concepts of color.

Color can provide a method of leading the eye into a piece of artwork and around and through it. It is probably the oldest method, appearing in the primary artist's aesthetic statement in primitive body decoration and continuing through today's marks made on a computer screen by means of a digitized graphics tablet. Since the eye follows the line that is drawn or painted, the line may be considered as movement (24). Yet lines can be used to define form, to overlap or to flatten it, and even to imply it. Not only is the emphasis of one line over another more easily discerned where color is involved, but color use as line can create intellectual, as well as emotional tension.

Therefore, it may be said that line may create pattern with over-all patterning carrying the eye indiscriminately and infinitely over the surface, as opposed to the finite pictorial patterning. Mundt (28) explains this point when he says that the artist composes lines so that they keep the eye moving within the given frame, leading the spectator from some dominant point of departure back through the composition repeatedly during the process to one or several focal points around which the pattern has been built.

In Western civilization people move their eyes from left to right because that is how they are taught to read. Other
cultures read from right to left or from bottom to top. This factor is important to the artist in that habitual movement contradiction demands extra effort from the viewer. Since line is probably the oldest method of leading the eye into and around the picture plane, the artist's manner of using color in relation to line scanning within his culture plays an important part in the total conception of his work.

In the last century Van Gogh used an agitated short stroke, energetic lines which were the boundaries of shapes, built volumes, and stated textures. Pollock, in this century, produced color-line compositions which seem not to move toward shape or volume. His lines form the "background" and each layer of lines seems super imposed with background and foreground fusing, each as a shadow of the other. With contrasts in color and action merging, his intervals, which may be called "weakest color contrasts" and "greatest color contrasts," create a sense of webbing.

Finally, the work of Hans Hofmann might be the clearest example of the third way of relating line to color, in which line all but disappears and color becomes the organizing element. His work has a pulsating quality, a "push-pull" as he terms it, which controls the variation of depth relations. Elliott (8) summarizes the work as "depth experienced as intervals between planes, without continuity, through the psychological or optical interaction of juxtaposed colors" (8, p. 502).
The work of Rothko pushes interaction and saturation of colors with his fuzzy outlines. The weakening of the line weakens the form and increases the color interaction (7). As mentioned earlier Albers' geometric paintings would be considered the formal approach to the interaction of color divorced from subject matter.

Shape

In the absence of color as line, color as closed lines can define shapes. Color against color may be used as a natural boundary to define the edges of objects. As Tucker (33, p. 38) observes, "just as form gives color, colors give form." Perhaps color has been considered less important than form because so little is really known about it (13).

Kandinsky (22) tried to change these concepts by dealing with color as color, as form, and nothing else. He identified the psychological correlation of color and form: blue goes with the circle, yellow with the triangle, and red with the square. Elliott (8, p. 499) lists more of Kandinsky's equivalences: A horizontal is black though in respect to temperature and light it may be blue; a vertical is basically white, but may show yellow; a diagonal is basically gray or green, but may show red; a thirty-degree angle would be yellow; a sixty-degree, orange; a right angle, red; a hundred-and-twenty-degree angle, violet; a hundred-and-fifty degree angle, blue; and a hundred-and-eighty-degree angle, or a
straight line would be black. Kandinsky, Elliot observes, starts from the optical effects of color but moves to their spiritual significance.

Painter Juan Gris' highly intellectualized intuition is comparable to Kandinsky's in the suggestions he makes for the relation of color to form. Gris lists five analogies by which shape or forms correspond to colors. (1) A flat form possesses two basic properties, size and quality; a color has two basic properties, quality and intensity; quality of form (circle, square) corresponds to color, size to tone. (2) Rectilinear shapes correspond to darker colors being more concentrated; circular forms correspond to the more expansive luminous colors; the circle represents maximum expansiveness, the triangle maximum concentration. (3) Geometrical figures are colder, hence they represent cold colors with organic figures responding to warm colors. (4) Some colors, such as earth tones, are more dense, have more weight, and correspond to symmetrical forms. (5) Hence, the analogy found in the opposition of two colors may correspond to a contrast between two different shapes. Gris felt that this was the very basis of pictorial architecture.

Shapes that are organized compositionally are said to be designed. It is the organization of these forms, the design, that stimulates an emotional response, not the forms themselves. Within this context, color and form can function as symbols, isolating color from realistic form or shape in
order to develop a sensitivity toward pure color awareness. Sloan observes that "you can not see the separation of form and color in nature" (32, p. 111). Therefore, color becomes the symbolic building block for naturalistic as well as abstracted work.

In nature, light creates color; in painting and drawing, color creates light. Evans, in his discussion of light, vision, and emotional responses to both, says that

seeing form, therefore, is partly a matter of outline but also, to a great extent, a matter of imagination. All you ever see from the standpoint of form is very largely a mental construction. It is based on what you think is causing the variations of light and shade and the abrupt changes in color which are in front of you. The necessary point to realize is that what you see is the combined result of the light that strikes your eyes, your eyes themselves, and the mind's integration of these into external objects, colors, and situations (9, p. 9).

Arnheim (1) notes that color produces an essentially emotional experience, whereas shape responds to intellectual control. He argues that receptivity and immediacy of experience are more a color response, with active control characterizing the perception of shape with a work of art being understood only by actively organizing the totality of color and passively surrendering to the contemplation of expressive shapes. Conversely, Gerstner (12) defends color as materially the form itself. Itten concludes that "form and color expressions should support each other" (20, p. 75).

Hofmann (19) widely influenced modern American art not only as a teacher of many years and through the impact of
his art but also through his writings. His color organization theory called "push-pull" suggests that every push into depth by a form or color should be answered rhythmically by a pull back out of it and vice versa.

Volume

Works of art of a given period are closely related in their expression through their form; therefore, according to Mundt (28), it is not surprising that changes in pictorial space parallel the changes in concepts of space. If in building compositions color becomes one with tension and space relationships relating forms on the canvas, then color may function either as Renaissance chiaroscuro and perceptual depth or as the later Cubist work, emphasizing the two-dimensional aspects of the canvas (24). While this appears at first to be somewhat an arbitrary distinction, it indicates a difference in the technique as well as the understanding of the use of color. The method of using color more characteristic of the Renaissance is a spotting of color intermeshed with light and dark, but in modern painting the possibilities of color differentiation are more completely exploited. Elliott (8) observes that to break completely with the old methods of thinking in color, color had to be freed from its dependence on the idea of the object depicted.

It was with knowledge of these changes and the problems concerning the part to be played by color that Robert Delaunay
returned to the writings of Chevreul and began a series of experiments in the use of color and the effects of color which resulted in the movement called Orphism. "Color," remarks Elliott, "was both the subject and the form of his pictures" (8, p. 497). It was in this pursuit of nonrepresentational painting that the possibilities of composition by color contrast could be freely explored, liberated from the object, although by no means excluding references to the realistic world.

As a result, modern artists, such as Albers have explored the ambiguity of a weak form on a strong ground to increase color interaction, utilizing squares, circles, chevrons, repeated. Strong form and space inhibit color interaction while strong color interaction obliterates form and space. For instance, grouping complementaries together heightens color interaction locally. Ehrenzweig (7) remarks that this type of local enhancement of color is sometimes achieved at the expense of total color interaction with the effect being rather dull.

Gerstner (5) observes that after Rothko's example many younger artists adopted thin, filmy techniques, covering entire canvases with floats of color, without understanding Rothko's intent, color, or form. In instances such as this Malevich's remark is apropos: Imitators copy forms without understanding their meaning (26).
Cezanne felt that color could be expressed as solids: spheres, cubes, cylinders, pyramids, and cones. He reduced all of these solids and simplified them to basic forms. As discussed earlier, Kandinsky (22) named the primaries in relation to these basic shapes. Itten (10) supports the two when he remarks that color and solids would be more expressive if they supported each other. Form and color, he feels, should be in agreement aesthetically. Malevich (26) carries the thought further by pointing out that the aesthetic arrangement of forms and colors on the picture plane is essentially imperishable because it is timeless.

Hofmann's theory of the color interval coincides with what the Goldsteins (14) call the "Law of Areas." They state that the colors of large forms should be quiet, while small areas may have strong contrasts. These contrasts may be due to decided differences in hue, value, or saturation. Graves (16) explains this as rhythm or measured proportional interval. Langer (23) describes "making space visible" with color by creating tensions and distributing weight.

Barnes (3) speaks of space-composition which is achieved largely through the use of perspective and is at its best when color is the chief constructive factor. But, he finds that skillful perspective is not the same thing as effective space-composition. The difference is that in effective space-composition not only is the illusion of depth rendered, but
the intervals and the relations of distance are intrinsically pleasing and represent personal feeling instead of literal imitation. The ordering of these relationships constitutes the space-composition of the picture as a whole and is an important source of aesthetic pleasure. Space-composition, explains Barnes, like the other plastic functions, reaches its greatest height when color takes the most active part in it.

Texture

Texture is a surface quality that is profoundly affected by light (14). When there is enough light, textures are visible; when light is positioned for a dramatic effect, textures are strongly defined. In such situations there is a gradation of light moving from a high-keyed area to the deeper values. The color in the texture is strongly evident on those lighter-colored surfaces and is lost in the deeper-colored recesses. Unless texture is incorporated into the surface of a painting or a drawing, the texture must be considered to be simulated or invented.

Artists have traditionally used several methods of achieving textural effects. Some artists caught up in the importance of texturing have chosen to physically add other materials to their paints to create a tactile surface. More common, however, are works like collages which, through the works of Picasso and Braque have emerged as an art form this century.
Hofmann's "push-pull" was in part created by the impact of painting in the bold, thickly-textured strokes opposed by delicate, driplike swirls (31). The visual movement of the painted strokes, often applied with a palette knife or a very large brush, was an important part of many of the Abstract Expressionists' work (2). Pollock poured paint creating an impasto which in turn created movement that he called "energy made visible." The surfaces of a Van Gogh painting have that very energy because of their thick brushstrokes heightening the tensions of the color choices. These types of work bring the viewer's attention to the surface.

By reproducing the color and the value patterns of familiar textures, that texture may be felt to be seen where none actually exists. This simulated texture is what is referred to as visual texture. Lines, forms, and volumes combine as psychological stimuli to produce this patterning (18). There is a very thin line between patterning and texture. Closely related colors will seem to lie on the same plane, flattening a design. A repeated design of color in a regular texture or pattern might also serve to visually flatten an area, but could be used to add weight to a particular portion of a work. Cezanne (25) used textures as this plastic balance and considered them to be related to the conscious abstract textures that developed in his later, more abstract works. Color may be used to dominate texturally or to create an
all-over pattern, to invent a form, or to implement the production of the effect of texture.

Summary

A region of color will not only reveal its hue, value, and saturation, but it will also have an area, or mass, or shape with actual or implied line, where the color itself might actually be, or might imply texture. Gouk observes that "color is always colored line or colored shape, shape with edges" (15, p. 145). This releases color from realism and naturalism and returns with color as a presentation of opposing forces or balance, opposition, contrast, or even symmetry. It may allow color to become movement which appears as rhythm, sequence, repetition, gradation, or transition. Color may still appear as line, shape, volume, and texture, but according to Mutz (29) it might also provide temperature (warm-cool), emotion (cheerful-depressing), movement (advancing-receding), energy (active-passive), and weight (light-heavy).

It is as impossible to speak of one element of design without the others as it is to separate the physical, physiological, and psychological facets of color. Line can be used to define volume, can be overlapped to describe it, or can be flattened into shape implying it. When color is the expression of the line-shape-volume sequencing, it is an integral part of their make-up with the power to modify the effects created by them. If volumes express the
three-dimensionality of an object on a two-dimensional surface, the shapes or forms need also to be defined as denoting edges of planes. The color-bearing plane is an integral part of the color-designing process. The manipulation of this plane called the "color interval" is one of Hofmann's central themes. It deals with the relation of each color plane with regard to its standing in the greatest possible contact to its neighbor, being held within the balance of the whole.
CHAPTER BIBLIOGRAPHY


CHAPTER IX

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Despite Shulman's (31) caveat that research is done on what "is" rather than what "ought to be," this study has attempted to address both of these aspects of color. The intention of this course of inquiry has been to obviate awareness of the problems which exist in this field of study and so to facilitate their eventual solution.

The various aspects of color studies are so interwoven that at no place in this paper have all of the facets pertaining to any one of them been fully explored. Likewise, discussions relating to specific areas of color study were interspersed throughout all related chapters. It has therefore been suggested that the work be considered as a whole before firm conclusions concerning any structures or relationships be formed.

The success of the emotion-induced properties of color in an artistic product depends upon the response of the public for whom that art is intended. Therefore, the successful art of any specific age reflects the emotional palette of that self-same period. The explanation of these attitudes and the referencing of them to art of the respective periods is the domain of the art historian who, by synthesizing all
influence within a period and identifying dominant factors also helps students to simplify and unify the flow of art history. Nevertheless, the research efforts during the course of this study revealed that color systems analysis was found to be an area of this discipline which art history has ignored as a rigorous study although much information is available piecemeal in the literature.

The milestones of color in art can first be seen in prehistoric man's desire to expand his matrix of visual expression with the use of color (30). As he learned to produce color from plants and the soil, his chromatic expression became richer. One of the most important successive steps was taken sometime in the period of the Egyptian First Dynasty when a word appeared expressing the abstract idea of color. Records exist from shortly thereafter telling of Greek scholars and their scientific explorations in color. The forms of color expression which have been chosen during each artistic and historical period, from Medieval religious art and the Renaissance, through the Baroque and Romantic eras, to Post-Impressionism and the fragmented, many-sided contemporary scene are a matter of record.

Perhaps the most important artistic occurrence within the last century has been the emergence of abstract and non-objective art. Although figurative, representational, objective art has never ceased to exist, in recent years the
accent has been on experimental art, referred to by Hodin (15) as the art of the scientific age. It is of interest to note the formal conceptual origin of terms such as "experiment" and "research," terms so often applied to modern artistic efforts. However, criticism of the cohesiveness of contemporary color choices is probably best left to those reviewers who enjoy the perspective of time.

Scientists who remark upon the similarities between modern science and art often begin by observing that the twentieth-century scientist differs from scientists of the past in that he now knows that he is a part of the thing that he studies. This discovery—that the observer is a significant part of the thing observed—has altered the attitude of artists so that the entire course of art has been affected (2). Arnheim (1) stresses the importance of combining scientific investigations and the arts when he says that one cannot renounce the new scientific efforts and technological achievements of the twentieth century, but must find concrete means of dealing with them both internally through creative, emotional, and artistic insights and externally through constructive measures. The physicist Gerald Holton (17), in surveying the various ways in which visual images can facilitate the comprehension of complex information, concludes that immediate sense images can be developed through close communication between artists and scientists. True science, says physicist Lenid Ponovarev (27) is akin to art just as
real art always includes elements of science. They reflect
different, complementary aspects of human experience and
give a complete view of the world only when taken together.

The physical, physiological, and psychological aspects
of color are an appropriate background for a fuller under-
standing of the artistic application of pigment or light.
With this in mind, Fish (11) observes that color can be
divided into three separate parts that parallel these
scientific approaches to it: color stimuli, color property,
and color sensation (11). The color stimulus is physical,
the color is psychophysical, and the color sensation is
psychological. This information is of value to the artist
who, through his creative nature, can turn it into an excit-
ing emotional statement.

Although the ordinary observer takes color largely for
granted, it has been shown to be a complex phenomenon involv-
ing the physics of the light source, the chemistry of the
colored object which is modified by the light falling upon
it, and the psychophysical response of the observer to the
resulting stimulus. Any vast cross-disciplinary inquiry into
the nature of color provides valuable information to the
artist. Meier (26) comments that in the teaching of color
the scientific data offer much to the serious-minded art
student. On the other hand, Fish (11) concludes that the
scientist's concepts of color are incomplete and it is time
for the artist and the scientist to develop a more adequate philosophy of color to which each can subscribe.

The study of light through physics has been alien to the art student until recently. Developments in such fields as video, photography, lasers, holography, and computers offer an exciting terra incognita for artistic exploration. Some basic information about light, the visual spectrum, waves, and the many possibilities inherent in light as an artistic medium tantalize the contemporary artist and student.

Physics, because it describes color through light, calling it the additive process of color display, is particularly applicable to the work of today's artist who is increasingly involved in using the materials of his culture. For example, Webber (34) discusses the use of liquid crystals in painting. His experiments indicate that the light achieved in these liquid crystal paintings is reflected in a very narrow, bright band, much brighter than the Munsell colors and in a wider gamut, producing effects that can be obtained in no other way.

Seeing involves high-level processes in the brain as well as in the brain's outgrowth, the eye. Color vision originates in the central foveal area in the cones with the rods acting principally as light receptors. The constant pulsating, saccading, and smooth-muscle movement of the eye focuses the small area of detailed vision forming quickly-fading mosaic patterns which are interpreted by the brain as a single image.
The primaries of the physiological aspects of light and color have been found to be the same as that of physics: red, green, and blue (15). Concepts of color are formed in the mind, generally from the impressions the eye receives and the brain translates. Although there are aspects of color vision which cannot yet be described by science, color may be explored as a psychophysical sensation.

Physiologically, perception involves the amount of light on the subject, the contrast of the surrounding area, the size of the subject, and the time allotted to view the subject. Perception is felt by some to be culturally motivated while others consider it a subconscious stimulus.

When Zenzen remarkes that "color has always got something mysterious about it that cannot be properly understood, that colors are the most irrational elements in painting," he is referring to still unexplored psychological effects (35, p. 186). This is the facet of color study which generally intrigues the artist.

Psychologists conclude that there are four unique primary colors: red, blue, green, and yellow. Within this construct the human mind would perceive all other colors as mixtures. "Lightness" or "darkness," or judgments in hue, saturations, and value are mental constructs which are determinants of mood, temperament, and behavior subconsciously influencing the response of the viewer (19).
Closely tied with the psychological effect of color and almost indistinguishable from it is the symbolic impact of the use of color. Early man's symbolic use of color is shrouded in mystery and magical powers. Historically color has often been used only in prescribed manners, impersonally, to perpetuate a cultural message while at other times it has been used extravagantly, carrying no particular cultural message (35). Generally, color symbolism within a society can be so deeply ingrained that it becomes part of a common unspoken language transferred from generation to generation. Religion has for a large part of man's history played a role in the symbolic impact of color by using color didactically. Currently, most art experts agree that the symbolic use of color is the expression of the artist's feelings which are experienced by the viewer subjectively, without rational relationships intervening.

The literature indicates that research into color-theory teaching appears to have been sporadic during the last half of this century. In most cases the experience gained through existing research has been used for the creation of the artist's own work, and not for general dissemination through the teaching field. As a result, a gap has been left between research and practical use of that research. Barkan observes that "in the past it has been estimated that there has been a twenty- to forty-year gap between the development of new
knowledge and its translation into teaching practice" (4, p. 8). Kuehni (20) expresses surprise that there are not available textbooks on color for the teacher to use since he considers color to be one of the fundamental human sensations. He remarks that aside from the appreciation of art, every person as a consumer should have an understanding of certain aspects of the science of color, the influences of one color upon another, and the visibility of colors.

The logic of color concepts can be equated with color theory. Gerstner observes that "it is particularly fascinating that precisely such an emotion-charged medium as color forms a logically coherent system; virtually inexhaustable in its nuances, clear and simple in its categories" (12, p. 111). The whole question of defining or redefining terms relating to color is one to which disciples of color study must ultimately address themselves. Many of the terms are archaic, they have broad meanings outside the field of art, and the basic nomenclature varies in meaning. Basic theoretical structures or arrangements chosen by the teacher or the artist are found to be tempered by the reminder that any systematic use of color may result in insensitive results.

Dickson remarks that the "aspect of color still presents numerous problems. Not the least of the problems awaiting solution are those presented by the primary colors" (8, p. 64). The additive primaries of red, green, and blue are the only
three types of light to which all colors that humans perceive are reducible. The photographic and graphic artist's primaries of cyan, magenta, and yellow are the only three pigments which absorb all light, as each reflects two primary lights. The psychological primaries of red, blue, yellow, and green are the only four colors which by general consent are chromatically pure. Yet most subtractive color theory information is taught through the Munsell or the Ostwald systems which designate the primaries to be red, yellow, and blue. Obviously, relationships may be drawn and correlations made with regard to the primaries arrived at by physics, psychology, and subtractive color theory, for no single group of primaries will work in all instances.

Color creates its own meaning, interacting with its own forces through personal involvement by quantity, repetition, emphasis, opaqueness, transparency, texture, area, intensity, additive and subtractive characteristics, and lighting. This complexity unites into line, form, space, and texture in color. Hofmann observes that "art is color and light integrated into planes" (16, p. 54). In chronicling that light, the artist records the energy formed by the color differences in light and in shade, grouping the elements to make the emotional statement.

When a piece of work is before the eyes, it constitutes the sum of all of the ocular sensations with the viewer's knowledge of the nature of each shape and each color in the
unit giving information about the effectiveness of the entire unit. In most work the image-color factors of appearance, retention, or recall, plus symbolism or association are the basic visual sensations with which the artist hopes to elicit a physiological effect or response. Designing within the color arena involves breaking down color into its parts, such as hue, saturation, value, receding, advancing, expanding, contracting, weight, temperature, and the way in which these act together within lines, forms, space, and textures.

When color, defining space, is used as line, shape, volume, and texture it constructs visual unity which communicates the purpose or message of the art (28). Yet, it is considered by many that color does not have enough significant meaning to give rise to an independent art-form without the aid of other means: form, material, subject-matter. These are thought by some to constitute the dominant means while color is the supporting element only. Saarinen (30) observes that color must be considered with other means until man can reach an understanding of the meaning of color as an independent phenomenon in art. He cites the instance of dance being considered without music, music without human voice, and voice as rhythm (poetry) as an entrée into color as an independent art-form in design. In speaking of a chapel he finished shortly before his death, Matisse observed that drawing, color, values, and composition, when they are brought together in a
synthesis, allow each element its full scope undiminished by the presence of the others (15).

Conclusion

An internal conflict arose with the progression of this study: a clinging to the pure, intuitive criteria or judgment employed by many artists and teachers was juxtaposed with a struggle to define problems and to approach the thought needed to envision a possibility of a pedagogical framework. At present there is no known way to measure the impact of training as opposed to or in connection with pure intuition upon the artist's mature work since decisions made while an artist works are determined by countless interrelated factors. In art absolutes are non-existent since the artist struggles to express himself within the construct of subjective decision-making. The choices are, therefore, difficult. It is proposed that these choices might be made more easily when couched within the framework of research, study, experimentation, manipulation, observation, and discussion, thus incorporating instinctive knowledge in forming the visually coherent statement, the intent sent within the color message.

Traditionally artists have relied on a "feeling" for color relationships rather than concrete knowledge regarding color. Problems in color and composition are so intricate that final judgments are generally considered to be intuitive. The mature artist uses the trained and disciplined mind which
long ago passed through stages of preparation. These educational processes involve the solution of similar problems. This earlier training serves to simplify these complex problems and permits the artist to solve present complexities with an ease which becomes, in essence, intuitive. This might be called empirical competency in color.

The seemingly incongruous statements of the two camps of color (intuitive versus structured curriculum) are united in the final result: creative expression in color. Huxley (18) explains that by long obedience and hard work the artist comes to unforced spontaneity and consummate mastery.

In working creatively with color the need arises for a sound understanding of not only the resources of color and their expressive potentials, but of the means and techniques of ordering color so that it will convey personal expression. There is a structural order underlying effective color expression, and that order many times parallels the basic elements of design. Of all of the elements, color seems to influence most directly the sensory organ of vision; it therefore has the most impact upon the emotions, sometimes without intellectual intervention. This might be considered the most powerful aspect of color.

Therefore, the study of color can follow predetermined developmental paths: identification, manipulation, and expansion into creativity. The step of identification might include the development of a vocabulary to aid in the understanding of
the interrelationships of art, its history, and the sciences. The manipulatory stage would include laboratories in pigment study, design, and exploration of all color media. The expansion into creativity occurs with the synthesization of information into the personal concept. In an outstanding discussion of the fusion of affective and cognitive achievement, Schulman concludes that the "fusion of the cognitive and affective is undeniable in aesthetic education" (31, p. 27).

The question must be asked if there is a valid reason to believe that didactic, guided instruction dooms the student to rote learning, thereby inhibiting creativity. Have there been any studies in the Fine Arts to bear this thought out? Shulman (31) is ignorant of any contemporary work of this nature in the arts. Further, studies in geology by Finley (31) suggest inventiveness may actually spring from didactic instructions. Groen and Resnich (14) conducted studies in which they found that math students had heuristically transformed algorithms; that is, they had actually created new algorithms of their own volition from those presented to them in classes.

This is not to imply that the problems faced by different areas of instruction are not varied and complex, but that the results of studies in one field might be relevant to another with research in the broad area of general education
benefiting all educational practitioners. The chain of events that lead to a student's expression through color is essentially intuitive, yet the question must be submitted: could he arrive at the same effective color choices sooner and more assuredly through structured studies? This study submits that education consists of the integration of new concepts with the old ones to produce a new depth of understanding, a new awareness which taps the inner resources. Ehrenzweig (10), in focusing his attention on the interplay between disciplined formal ability and free visual invention arising from the deeper levels of the imagination, concludes that those artists who are able to find their inner freedom and to combine it with disciplined control of expression attain the richest, most complete artistic achievements. In color-teaching there is a store of subject matter or content which has been deemed useful to the student, but it is of a cross-disciplinary nature, thereby requiring extra time and effort for retrieval on the part of instructors. The most serious obstacle is the building of an acceptable framework upon which this information may be organized and presented to the teacher for dissemination.

Stanley S. Madeja (24), in speaking of art in higher education during the decade of the eighties, concludes that the growing arts audience needs education in and about the arts. Further, he supports enhancing people's aesthetic sensibilities and exposing students at any level—whether
kindergarteners, teenagers, college students, or older adults—to the history and background of the arts they are creating, propagating, and preserving.

The role of color, the development of color awareness, could be defined as a refined response to differences (23). Historically, these differences might be considered as a sequencing of problems and solutions. If color problems may be related to Ecker's theory that masterpieces are solutions to problems, then color as a problem could be considered within the framework of qualitative problem-solving. He observes that it is conceivable that "the history of art could be viewed as a record of the highest achievements of man's qualitative problem-solving behavior" (9, p. 285). Problems and solutions within time-frames and their divergencies and solutions are recommended as being useful to the student who is trying to grasp the fundamentals of a subject in order to assimilate broadly and disseminate in a highly personal manner.

Sculptor and teacher Mirko Basaldella (5) concentrates upon the conflict between the present range of our sensibilities and the immense power of modern scientific knowledge. The conclusion to be drawn is that the student must be concerned with some of the scientific aspects of color in order to fully understand its power. Both light and pigment require exploration for a full and complete understanding and for an aesthetic sensitivity concerning each and their interaction.
For example, the unique quality of luminous color that can be achieved by video art, apart from normal commercial television, has intriguing prospects when artists are involved in the development of unusual sequences incorporating form and color. The technology of the electronics field should be at the command of the artist so that the creative results can flow into the technically-oriented society of which he is a part.

There is a need for courses structured toward teaching color relationships, particularly with regard to how color is perceived, its effect upon voluntary and involuntary behavior, its physical properties and its chemistry. In colleges and universities basic color classes would be of value to fine arts, advertising, interior, and fashion design students if a fundamental common set of principles underlying all color relationships could be formulated using the input of a broad range of the faculty. Since color is basic to the art student's educational process, a major effort should be expended toward constantly enlarging the pool of information available to the student through support faculty, faculty from other areas, data available through libraries, data from paint companies, technical facilities, industry, and research.

Education research theorist L. S. Shulman lists three constituents in the field of fine arts: the subject matter or content of art and aesthetic education, (2) the process of pedagogy in art and aesthetic education, and (3) the processes
of research in art and aesthetic education (32, p. 4). He suggests that there should be accord among these elements, ensuring that they are consistent with one another.

In keeping with the idea of parallelism of subject matter information, teaching skills, and availability of current research is Kepes' theory (19) of the fundamental interdependence of the sensory and the intellectual systems. He calls for a re-evaluation of the misunderstood and consequently neglected unity of art and science. Arnheim (1) reinforces this unity when he notes that it is the sensory, emotional, and rational that makes orderly forms of artistic vision. This special kind of problem-solving which requires the concurrency of artistic vision (generally called creativity) involves allowing the conscious mind to gain insights from, and to establish an intuitive relationship with, the whole of organized experience. Statements of this magnitude would then be called art and would make unique contributions to human culture.

Breaking down the art of a culture in order to study its structure or content would involve Sulman's tripartite theory, Kepes' theory of interdependence, and Arnheim's unity of artistic vision through the historical referencing of color preferences. It would also involve communication by symbolism as well as the senses' (physiological and psychological) apprehension of the outside world through light (physics) and line (design). Raphael (29) concludes that in nature these
occur in undifferentiated unity, not in isolation, but by a mixture thereby equating all parts with the whole. If color can be conceived as being the sum of a series of natural events, the definition of color may be broadened to describe more clearly and logically the rationale on which color relationships are based.

Studies in color have been bounded by myriad secret formulas, tenets of the state and church, limited materials, and sparse communication between artists. Research, new materials, a further development of theories, and availability of information exploration has created a domino effect with the advances in one field benefiting all other fields. The leading edge in a new dimension of color (that is yet to be explored and understood) according to artist-teacher Gregor (13), will require a new language and a much wider complex color understanding which will make most present color theory courses seem primitive by contrast. He continues by observing that its character would have a conceptual dimension only vaguely perceived at the present, a new concept based upon color-formed qualitative ordered space open to an infinite array of variations and requiring a different set of attitudes, skills, and awarenesses to make and to appreciate. Further, he predicts that the student will need to understand and to work with what he calls multiple and diverse gradient orchestrations which are based not on simpler linear
polarities (like hot, warm, lukewarm, cool, cold, where temperature differences unite all in a single linear progression), but on complex interwoven gradients, reachable on a qualitative basis. Once isolated to reveal their own organizational patterns, new dimensions of color possibilities will lengthen the color perception scale. He is speaking not only of new surfaces to receive color, but of colors which did not exist even ten years ago: iridescents, radiants, opalescents, fluorescents.

Dickson adds another facet to the problem of teaching color theory when he cautions that "there are still aspects of color which present numerous problems, not the least of which awaiting solution are those presented by the primary colors" (8, p. 64). Could the pigment primaries (red, yellow, and blue) which are now accepted by most students, artists, and teachers be primaries by default? They do not, after all, work in mixture to produce all colors. This presents an interesting question: why do teachers, artists, and students continue to accept this serious limitation?

Red and cyan are said to be complementary because red light added to blue-green light equals white light, and inversely, red pigment added to blue-green equals no clear emission or gray. Complementary pigments become perceptually hueless because they absorb the three primary lights. Further, a neutralizing complement of red pigment may be any
combination of pigments reflecting the blue-green combination. Combined in proper proportion even a blue-violet and a yellow-green would produce the desired mix. Red pigment absorbs blue-green while its own red light is absorbed in turn by the blue-green pigment. The assumption is that if those complementary pigments were totally subtractive they would be black when blended. They are not. This leads to the interesting prospect that pigment colors have not been developed to the intensity needed to make the theory upon which color-mixing assumptions are established a tenable one. As chemists explore the use of more stable pigment compounds, some color theorists (21, 25, 33) are advocating the use of a new set of pigment primaries: cyan or blue-green, magenta or red-violet, and yellow.

Burris-Meyer (7) feels that before many more years have passed a slightly different but much more beautiful and useful set of primaries will be in use, which will be (approximately) red-purple, yellow, and blue-green. But Brocklebank (6) theorizes that it takes at least 150 to 200 years for a theory based on the sciences to become actively taught in the field of art-color theory.

Artists and students who spend years studying the elements of design are often called upon to give rational accounts of their choices in relation to line, form, color, volume, and texture. Since color choices are critical to the life of the piece of art, literacy about all those choices must be the
responsibility of the educator. Barnes (3) observes that color relations are all-important, that composition is affected by means of color, and that a great majority of writers seem to be totally oblivious of its importance. Students are taught to think in terms of the elements of design as opposed to objects. The concept of color as independent of its object is a difficult one to assimilate, but one which must be isolated. Writer Patricia Sloane concludes that color imagination and color sensibility can exist only as long as color thinking continues; when color thinking stops, color convention begins. In discussion color used as pure color (or color for its own sake) Mondrian (22) emphasizes that color intensifies its own potentialities. What the study of color theory and design does is to add to the artist's repertoire a greater number of potential relationships.

The study of color and its physiological and psychological impact on the viewer is not a matter of memorizing a series of scientific facts, but rather is an attempt to understand the subtlety and variety of options open to the artist. Once these options are appreciated, they can become a part of a student's total aesthetic so that long after he has forgotten the specific facts that influenced his color choice, he can rely on unconscious impulse and intuition to guide him to the best possible color selection.
Recommendations

The study of art history has proven its value in helping students gain a broader perspective on their own art and the way that it reflects the culture of which it is a part. Since color has so often in the history of art been subject to scientific, religious and socioeconomic influences, its study should prove useful to the student who is trying to grasp the fundamentals of his art.

It is not, of course, essential that every student make an extensive scientific study of color to achieve the goals of his own aesthetic, but for many the study of color and its composition, presentation, and emotional impact should prove a useful tool. For the student interested in pursuing such a study, courses which cover the physics, physiology, and psychology of light should be available as should laboratory time and space for the study of both pigment and light to help the student develop aesthetic sensitivity regarding color. Use could also be made of numerous modern teaching aids such as video-disc technology to explore the possibilities of creative expression in the technically-oriented society of which the student is a part.

Students and instructors should not be bound by strict adherence to color theories. On the contrary, further studies in the field of color should concentrate on exploration, on helping the individual artist to develop his own color
potential. Yet to this end, much confusion could be saved if certain jargon terms were clarified. For example, a clear distinction should be made between color theory (charts) and the pigment-mixing function. Pigment compound manufacturers should be petitioned by artists, students, and instructors to list specific ingredients using a clearly-defined model. To promote consistency in color-related terms, the reorganized Munsell system might be considered a viable, open-ended color scale suitable for teaching purposes. In short, further studies dedicated to creating a field-wide vocabulary which was organized, standardized, and coherent would be of great value to the field of art in allowing individual artists to communicate their discoveries and innovations to other artists.

In any teaching field related to the fine arts there is always the danger that more energy will be expended in reproducing old theories than in searching for new methods to form a framework of logic from which to examine current problems. In forming any kind of coursework to study the nature of color there should be accord among the three elements of subject matter, pedagogy, and research to ensure that they are consistent with one another. Artists and art educators should discuss the meaning of quality color education and determine exactly how it should be taught so as to accept and integrate diverse input from a heterogenic society.
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Abstract.—originating with a recognizable form, but distorted in some manner.

Additive.—color mixing by light.

Additive primaries.—green, red, blue.

Analogous.—any three to five colors in an arrangement which lay adjacent to each other on the theoretical color wheel.

Chiaroscuro.—use of value for dramatic effect.

Complementary.—colors lying directly across from each other on the theoretical color wheel.

Cool colors.—typically green, blue, and violet on the theoretical color wheel.

Curvilinear.—curved lines or shapes, biomorphic, irregular.

Cyan.—green-blue.

Double-split complement.—theoretical color arrangement involving the two colors on each side of the original color plus the two colors on either side of the original color's complement; generally described a rectangle within the color circle.

Dyad.—theoretical complementary color arrangement.
Hue.—color name, i.e., red, blue.

Local color.—naturalistic, real color of objects.

Magenta.—red-blue.

Mixing pigment primaries.—magenta, cyan, yellow.

Naturalistic.—true to the natural world, realistic.

Neutral.—grayed color achieved when complementary colors are theoretically mixed or achromatically when black and white are mixed.

Non-objective.—subject matter not drawn from the natural world.

Primary colors (color theory).—red, yellow, and blue set equal distances from one another on a color wheel.

Primary colors.—commonly accepted set of any three colors whose mix in various proportions will produce all colors in the visual spectrum.

Rectilinear.—straight lines.

Saturation.—intensity, color strength, chroma.

Secondary colors (color theory).—green, violet, and orange set equal distances from one another on a color wheel.

Shade.—color plus black.

Split-complement.—theoretical color arrangement involving original hue plus the two colors adjacent to its complement.

Subtractive.—color mixing by pigment.

Tertiary colors.—range of intermediary (general double-named) colors on the theoretical color wheel, e.g., yellow-green.
Tint.—color plus white.

Theoretical subtractive primaries.—red, yellow, blue.

Tone.—color plus black and white.

Triad.—theoretical color arrangement involving red-yellow-blue or orange-green-violet.

Value.—placement of color, tint, shade within a gray scale framework.

Warm colors.—typically yellow, red, and orange on the theoretical color wheel, but may also include red-violet and yellow-green.

Yellow.—red-green.
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