THE EFFECTS OF SELECTED COLOR PHENOMENA IN A BASIC PRESENTATION TO COLLEGE STUDENTS

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By

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The problem of this study was to ascertain the effects of selected color phenomena upon the identification and comparison of color by college students.

Instruments used for collecting data for this study were the Snellen Visual Acuity Chart, which measures crudely the binocular visual acuity of an individual; Pseudo-Isochromatic Plates for Testing Color Perception, which roughly determine red-green color deficiency; and the "Isoline Color Phenomena Perception Presentation," which determines how an individual identifies or compares selected color phenomena. Consecutive color, simultaneous color, successive color contrast, mixed color contrast, simultaneous comparison on a black versus white ground, advancing-receding color on a grey ground, simultaneous color comparison on color grounds, and Bezold Effect are the phenomena.

Questions of inquiry were posed, but are condensed here--how will the non-art majors and art majors respond both within and between the groups in identifying and comparing color phenomena, and how will these responses relate to binocular visual acuity, color deficiency rating, each

accompanying color phenomenon, and questionnaire responses?

The Pearson product moment coefficients of correlation were determined between all variables to identify the significant correlations in each of the two groups. The significant differences between the means of the non-art majors and art majors were identified by a *t*-test. The analysis of variance was used to identify significant differences between the means of the repeated measures concerning the color phenomena. In addition, visual observations were made to identify other relationships.

In identifying and comparing selected color phenomena, the non-art majors and art majors responded with averages of 76 and 81 per cent consensus answers, respectively. Within both groups there was a number of significant correlations between responses to the color phenomena, binocular visual acuity test, color deficiency rating, and questionnaire. The correlation coefficients ranged from .3357 to 1.000 at the .01, .02, or .05 levels of significance.

In examination of the difference between the means of the two groups on seventeen variables, the art majors showed a significant difference in seven instances at the .01, .02, or .05 levels with a *t*-test. The non-art majors showed none.

Both groups performed similarly in establishing degrees of difficulty in identifying and comparing selected color phenomena.

It may be concluded that participants who experience success in colors presented consecutively will tend to have similar success in identifying colors presented simultaneously. Participants who succeed in identifying successive color contrast will tend to identify mixed color contrast with equal success. Participants who succeed in comparing simultaneous color contrast on a black versus white ground will tend to have similar success in comparing simultaneous color contrast on color grounds. The student of art will tend to perform better on the color deficiency test than will the non-art student. Also, the student of art will tend to perform better than the non-art student in identifying mixed color contrast, comparing advancing-receding colors on a grey ground, and comparing simultaneous color contrasts on color grounds.

The student of art and the non-art student will tend to perform similarly in the establishment of degrees of difficulty in identifying and comparing color phenomena.

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INTRODUCTION

Through the ages man has utilized art to enrich his environment. Art is a record of the achievements of mankind and reflects the culture in which it is created. Experiences in art can offer many and various opportunities for aesthetic discrimination and judgment. Knowing and understanding color and color relationships can increase significantly the understanding of one's environment. This view of knowing and understanding art is reflected in the National Art Education Association's major goals for art education in the elementary and secondary school art programs. The four major goals suggested are (1) Sense relationships, (2) Art production, (3) Knowing and understanding art, and (4) Evaluating art products (2, pp. 6-7). Knowing and understanding color and color relationships plays a very important role in teaching art at any level.

In most colleges today, basic art courses are required of all students who are pursuing an undergraduate liberal arts and sciences degree. These basic art courses may range from general art appreciation to specific applications of art. Generally, in these basic art courses, the students are presented both basic elements and principles of art in some fashion and nearly always color theory will be included in discussions of them.

Color theorists M. E. Chevreul (4), Joseph Albers (1), and Johannes Itten (6) have related in their writings a number of perceptual color phenomena which can effectively increase understanding of visual color experiences. The most common of these color phenomena are (1) Hue contrast, (2) Successive color contrast, (3) Mixed color contrast, (4) Simultaneous color contrast, (5) Advancing-receding color, and (6) the Bezold Effect. (See the Definition of Terms.) These six phenomena are pertinent to the color studies and theories of Chevreul, Albers, and Itten. They suggest that knowing and understanding basic color phenomena increases most significantly one's grasp of color and color relationships. Albers, especially, believes that by this method the learner becomes intimately absorbed in the interaction of color based upon factual, objective color observations (1, p. 15). This factual, objective way of observing color phenomena is somewhat contrary to learning color from methods which may emphasize cultural association, color schemes, or individual intuition. Experiencing the actual color phenomena, observing factual happenings, and making accurate records can lead to one's increased knowledge and understanding of color and color relationships.

Statement of the Problem

The problem of this study was to ascertain the effects of selected color phenomena upon the identification and comparison of color by college students.

Purposes of the Study

The purposes of the study were to (1) select appropriate color phenomena, (2) design and construct a basic color presentation utilizing color phenomena, (3) design and construct an accompanying response sheet, (4) ascertain the effects of selected color phenomena upon the identification and comparison of color by two groups of college students--one of art majors and the other non-art majors, and (5) compare the responses of the respondents' visual acuity and color deficiency rating to the responses of a color phenomena presentation.

Questions of Inquiry

To carry out the purposes of this study, answers were sought for the following questions concerning color phenomena, binocular visual acuity, and color deficiency rating.

Hue Identification

Question 1.--How will the non-art majors respond in identifying basic hues and values presented consecutively and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomena?

Question 2.--How will the non-art majors respond in identifying basic hues and values presented simultaneously, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomena?

Question 3.--How will the art majors respond in identifying basic hues and values presented consecutively, and how will these responses relate to their bincular visual acuity, color deficiency rating, and each accompanying color phenomena?

Question 4.--How will the art majors respond in identifying basic hues and values presented simultaneously, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomena?

Successive Color Contrast

Question 1.--How will the non-art major respond in identifying successive color contrast of basic hues and values and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomena?

Question 2.--How will the art majors respond in identifying successive color contrast of basic hues and values and how will these responses relate to their binocular visual acuity, color deficiency rating and each accompanying color phenomena?

Mixed Color Contrast

Question 1.--How will the non-art majors respond in identifying mixed color contrast of basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating and each accompanying color phenomena?

Question 2.--How will the art majors respond in identifying mixed color contrast of basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating and each accompanying color phenomena?

Simultaneous Color Contrast

Question 1.--How will the non-art majors respond in comparing the simultaneous color contrast of basic hues, and values and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomena?

Question 2.--How will the art majors respond in comparing the simultaneous color contrast of basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomena?

Advancing-receding Color

Question 1.--How will the non-art majors respond in identifying advancing-receding color of basic color hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each of the accompanying phenomena?

Question 2.--How will the art majors respond in identifying advancing-receding color of basic color hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each of the accompanying phenomena?

Bezold Effect

Question 1.--How will the non-art majors respond in identifying the Bezold Effect utilizing basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency, and each of the accompanyiny color phenomena?

Question 2.--How will the art majors respond in identifying the Bezold Effect utilizing basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency, and each of the accompanying color phenomena?

Summary Questions

1. How will the non-art majors and art majors relate cross-sectionally on the three presentations?

2. How will the questionnaire factors of the non-art majors relate to the response to each color phenomenon?

3. How will the questionnaire factors of the art majors relate to the response to each color phenomenon?

Background and Significance

Art teachers in school art programs at all levels, at one time or another, present color fundamentals in introductory art courses. There seems to be no proved method which is most used. Most teachers use a lecture and visual presentation. This allows the student to "see" color examples while "hearing" about them. Popular visual material used to supplement lectures are color pigment, color paper, a color wheel, a chalk talk, color photography, color slide, an actual art object, film, or perhaps a combination of the above.

As stated earlier, color theorists Chevruel, Albers, and Itten have related in their writings a most effective way of learning color and color relationships--through the knowing and understanding of perceptual color phenomena. Joseph Albers (1, p. 15) says, "--a factual identification of colors within a given painting has nothing to do with a sensitive seeing nor with an understanding of the color action within the painting." He further suggests (ibid.), "Our concern is the interaction of color; that is, seeing what happens between colors." Albers believes that the viewer must have knowledge of what actually happens when he sees color and why it happens. Increasing one's knowledge of color can evoke more searching.

Many authorities echo the sentiments of Joseph Albers. In summarizing the 1959 Woods Hole Conference, a curriculum-planning conference for the sciences, Bruner (3, p. 7) states: "Grasping the structure of a subject is understanding it in a way that permits many other things to be related into it meaningfully. To learn structure, in short, is to learn how things are related." The Central Atlantic Regional Educational Laboratory (CAREL) located in Washington, D.C. was one of the many federally-funded arts and humanities curriculum development programs begun early in 1967. CAREL personnel voiced a concern for the development of literate, critical sensibilities, recognizing the complementary interaction between artistic expression and critical aesthetic responsiveness. They believed that the arts are vivid ways of feeling and knowing and establishing truths (5, pp. 92-93). Jerome Stolnitz (9, pp. 13-14) suggests that students of aesthetics "must organize and systematize their findings in order to arrive at sound beliefs concerning art" and that "we should be prepared to alter our beliefs in the light of new evidence." Musgrave (7, pp. 26-27), in her research, developed and formulated a model of critical performance which distinguishes between critical and non-critical procedure. Her main thesis suggests that "knowing what happens" in a work of art enables the learner to make sound, critical judgments. Johannes Itten (6, p. 12) emphasizes the importance of a thorough knowledge of color, saying, "--if you are unable to create masterpieces in color out of your unknowledge, then you ought to look for knowledge."

Instruments

A questionnaire was designed to collect personal data from all the participants. It was printed and attached as the first page of the "Isoline Color Phenomena Perception Presentation." (See Appendix A.)

The "Isoline Color Phenomena Perception Presentation" was based upon the six color phenomena introduced earlier. The color phenomena utilized are: (1) Hue contrast. (See Appendix D.), (2) Successive color contrast. (See Appendix E.), (3) Mixed color contrast. (See Appendix F.), (4) Simultaneous color contrast. (See Appendix G.), (5) Bezold Effect. (See Appendix H.), and (6) Advancing-receding color. (See Appendix I.) All pigments used were matte, dull finishes in order to keep glare at a minimum. The hues used on these cue cards were actual pigmented hues on paper produced commercially as Color-Vue art paper. The basic colors used were the primaries--red, yellow, blue--and the secondaries--orange, green, and violet. White, black, and grey were used as neutral values. The presentation was accompanied by an answer sheet to be filled in by the respondents. Each respondent recorded his own visual color observations. Total observations numbered 94. The responses can be totaled for each phenomenon or all color phenomena. (See Appendix A.)

The Snellen Visual Acuity Chart, produced by the American Optical Corporation, was administered to all respondents to determine their binocular acuity in a crude manner. The results of this test were scored by recording correct observations. Acuity scores could range from zero through 61. Thirty-six is considered a normal score, equalling twenty-twenty vision or line eight on the chart. (See Appendix B.)

The Pseudo-Isochromatic Plates for Testing Color Perception (8), produced by the American Optical Corporation, was administered to all respondents. This test determines only red-green color deficiency. Fourteen color plates were presented to each respondent, who was to identify hidden numbers or letters within two seconds for each color plate. Score could range from zero to 14. This test is merely a screening test which can indicate the need for further professional testing. An answer sheet was devised to score each respondent. (See Appendix C.)

A panel of three experts from the Dallas-Fort Worth area validated the "Isoline Color Phenomena Perception Presentation" prior to the initiation of the study. The three examined the color presentation and the response sheet and all signed a statement agreeing that the instrument would allow the respondent to record what it purports to record. This statement of content validity was signed by Dr. Malcolm Arnoult, Professor of Psychology, Texas Christian University, Fort Worth, Texas, on March 5, 1974, and Dr. Richard W. Finker, Associate Professor of Psychology, Texas Christian University, Fort Worth, Texas, on January 18, 1974; also signing was Mr. C. Ray Gough, Professor of Art, North Texas State University, Denton, Texas, on January 29, 1974.

Definition of Terms

For the purposes of this study the following definitions have been formulated:

Tone is any value of color or neutral.

Tint refers to a color mixed with white pigment.

Shade refers to a color mixed with black pigment.

Intensity is the chroma, strength, saturation, or brightness or dullness of a color or value.

Hue is the actual name of the color.

Value refers to the lightness or darkness of a color or neutral.

Neutrals are white, black or grey tones.

Subtractive primaries are red, blue, and yellow colors.

Subtractive secondaries are orange, green, and violet colors.

Additive primaries are red, green, and blue colors.

Additive secondaries are magenta, yellow, and cyan colors.

Complementary refers to two hues or values which differ most radically, for examples: red-green, blue-orange, yellow-violet, and white-black.

Matte surface is a color or value pigment paper which has little or no glare.

Hue contrast (or value contrast, if achromatic) is the phenomenon of simply identifying hues (or values) by their given name.

Successive color contrast is the perceptual phenomenon which occurs after one has gazed at a particular color on a white ground for about 15 seconds, then changes his gaze to another blank, white surface; the same shape with the complementary color of the first will soon appear in a weaker image. In a few seconds, the weak image fades and disappears. This phenomenon is also called the "after-image" and sometimes, "post-impression."

Mixed color contrast perceptual phenomenon occurs after the viewer gazes at a block of color on a white ground for about 15 seconds and then transfers his gaze, not to a white ground but to a color ground. This results in a visual mixture of the "after-image" with the color ground, which forms a third color.

Simultaneous color contrast occurs when colors are juxtaposed and specific modifications take place. Colors will simultaneously evoke their exact complements and the juxtaposed colors will seem to change. Also, this phenomenon is referred to as _related color enhancement_.

Bezold Effect is the visual phenomenon of two or more colors being annulled by each other through mixing visually in the eye and thus effecting a new color (1, p. 39).

Advancing-receding color phenomenon is the visual effect which seems to make warm and light colors advance toward the viewer while cool and dark colors recede (1, 4, and 6).

Art majors will be college students who are declared art majors and who have accumulated twelve hours of art or more.

Non-art majors will be college students who are not declared art majors or minors and who have no more than six hours of college credit in art.

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CHAPTER II

REVIEW OF RELATED LITERATURE

Color and Light

Color is defined by Webster as "a phenomenon of light or visual perception that enables one to differentiate between otherwise identical objects, events, or sensory visual sensations." The Optical Society of America states that "color consists of the characteristics of light other than spatial and temporal inhomogeneities; light being that aspect of radiant energy of which a human observer is aware through the visual sensations which arise from the stimulation of the retina of the eye." (4, p. 221). Both Webster and the OSA suggest a stimulus--light, a visual receptor--the eye--and a visual sensory sensation. Let us examine these aspects of "seeing color."

Light is only one of many aspects of radiant energy or electromagnetic waves travelling in all directions through the universe. All objects receive, absorb, and radiate these waves. All the electromagnetic waves are moving at the speed of light--over 186,000 miles per second (13, p. 7). The electromagnetic spectrum (see Figure 1) includes all known radiation; light is only a small but important portion. The electromagnetic spectrum includes radio, infrared, solar (visible light), ultra-violet, x-ray, gamma, and cosmic rays -- all radiant energy. Of course, solar energy or light is necessary for vision and color perception--it is the stimulus for vision (4, p. 41). Visible light is toward the middle of the spectrum and normally stimulates the sense of sight in the eye if no deficiencies exist. In the visible portion of the spectrum, these frequencies and wavelengths are seen as white light or color.

The electromagnetic waves of radiant energy have a continuous range of frequencies and wavelengths. Frequency is a function of the number of wave crests passing a point in one second. (See left column of Figure 1.) These wave frequencies range from about one per second to over a trillion-trillion (10^{24}) per second. For light, the frequencies are roughly four to eight hundred trillion (from 4×10^{14} to 8×10^{14}, violet through red) waves per second. The frequency times the wavelength gives the speed of the wave. The higher the frequency the shorter the wavelength, but the speed remains the same (13, p. 8). For example, red light has a wavelength of about 7,000 Angstrom units and it is known to have a frequency of 430 trillion (4.3×10^{14}) cycles per second. Using the formula, in which frequency times the wavelength equals the velocity or speed of the red light, it is found that 4.3×10^{14} cps $\times 7000 \times 10^{-10}$ = (approximately) 300,000,000 meters per second. So, red light travels at 300,000,000 meters per second or 186,000 miles per second--the speed of light (7, p. 31). The wavelengths of light range from approximately 3800 (violet) through 7600 Angstrom units (red) as shown (Figure 1). The violet wavelengths are shortest; moving through the color spectrum, wavelengths become longest with red. When white light is refracted by a prism, the color spectrum is seen as a continuous graduation in hue from violet through blue, green, yellow, orange, and red (13, pp. 10-11).

Isaac Newton demonstrated this color phenomenon in 1666 with his prismatic dispersion of light into the color spectrum. By reversing the process, mixing the basic color rays, he produced the original light. This led him to believe that color was inherent in light and not in the object seen. This demonstration established the idea that there was an additive-subtractive method in determining color mixtures in light--adding all basic colors resulted in light and adding a lesser number resulted in a color (7, pp. 10-17). Many of these experiments in light led to additional research with color filters and pigments which made him realize that there were different primaries necessary in light color mixing and filter or pigment color mixing. These theories will be presented in a later section.

Newton observed other important aspects of light behavior. He realized that when light strikes a surface it may be either reflected, absorbed, or transmitted. Today, it is

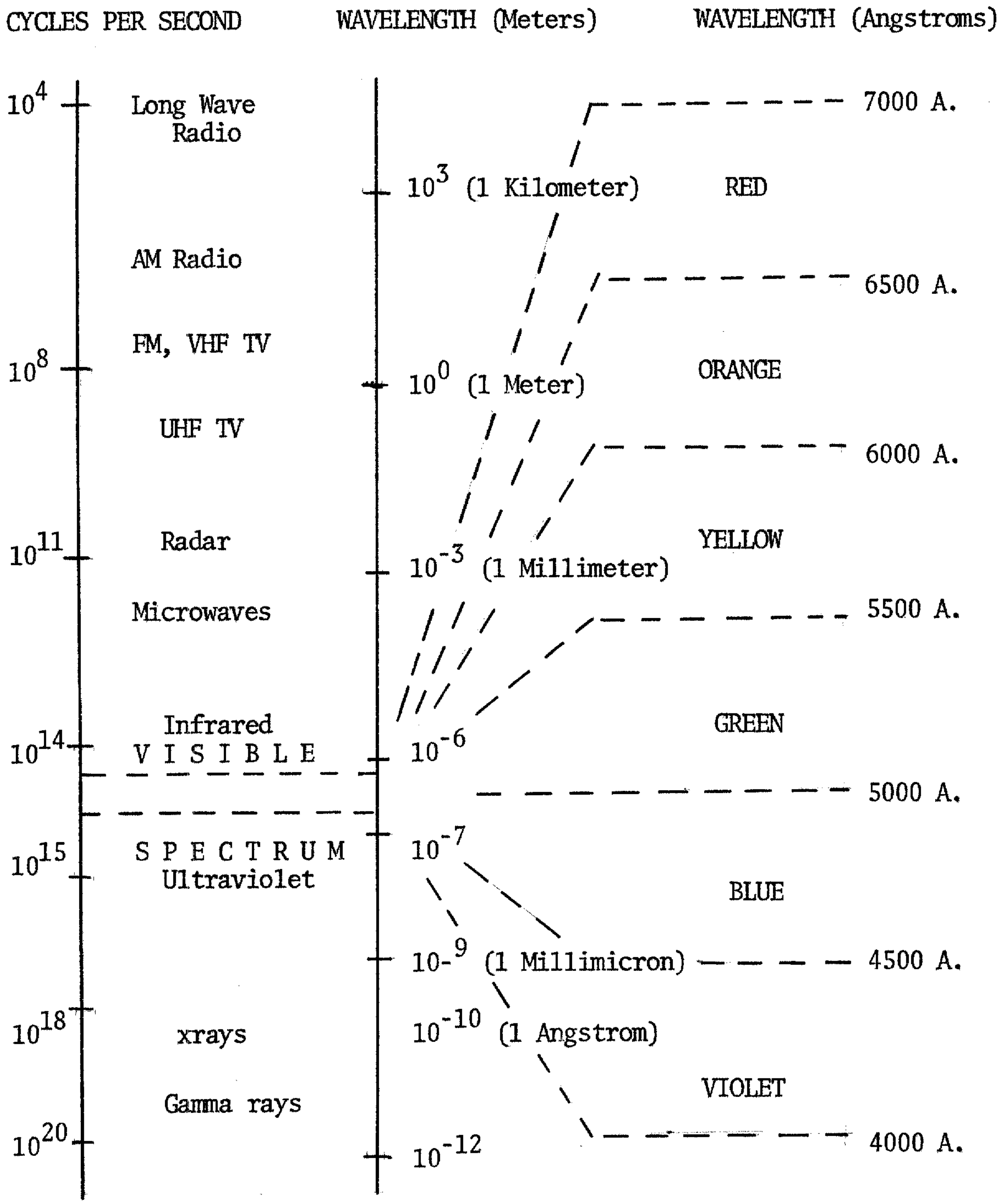

Figure 1--The Electromagnetic Spectrum

known that light may be modified in many ways which may be determined by the nature of the surface. (See Figure 2.) When light strikes a surface, it can be modified by reflection, absorption, scattering (random deflection), refraction (bending), diffraction (distorted), interference (change of intensity or redistribution), or polarization (clears up haze, glare, scattering), before it is observed.

The modification of light by all the various behavioral processes of light and matter determines how we see (13, pp. 36-57).

Newton's early studies in light demonstrate that light is the stimulus and that it can be modified in many and various ways. Even though there are many modifiers, generally three stand out as basic: reflectance, absorption, and transmission. Eventually, the light is modified and transmitted or reflected to the eye. The substances through which light is transmitted or from which it is reflected can be many and varied. Most of these substances are called colorants. There are some distinctions between transmitted and reflected light. Maitland Graves classifies all colorants in four basic types which are achromatic and chromatic transmitters and achromatic and chromatic reflectors:

> (1) Achromatic transmitters are colorless, nonselective colorants, such as, transparent or translucent white and gray gloss, films, or liquids. These are nonselective because they absorb and transmit equally light of any color. In nature, water globules are similar.

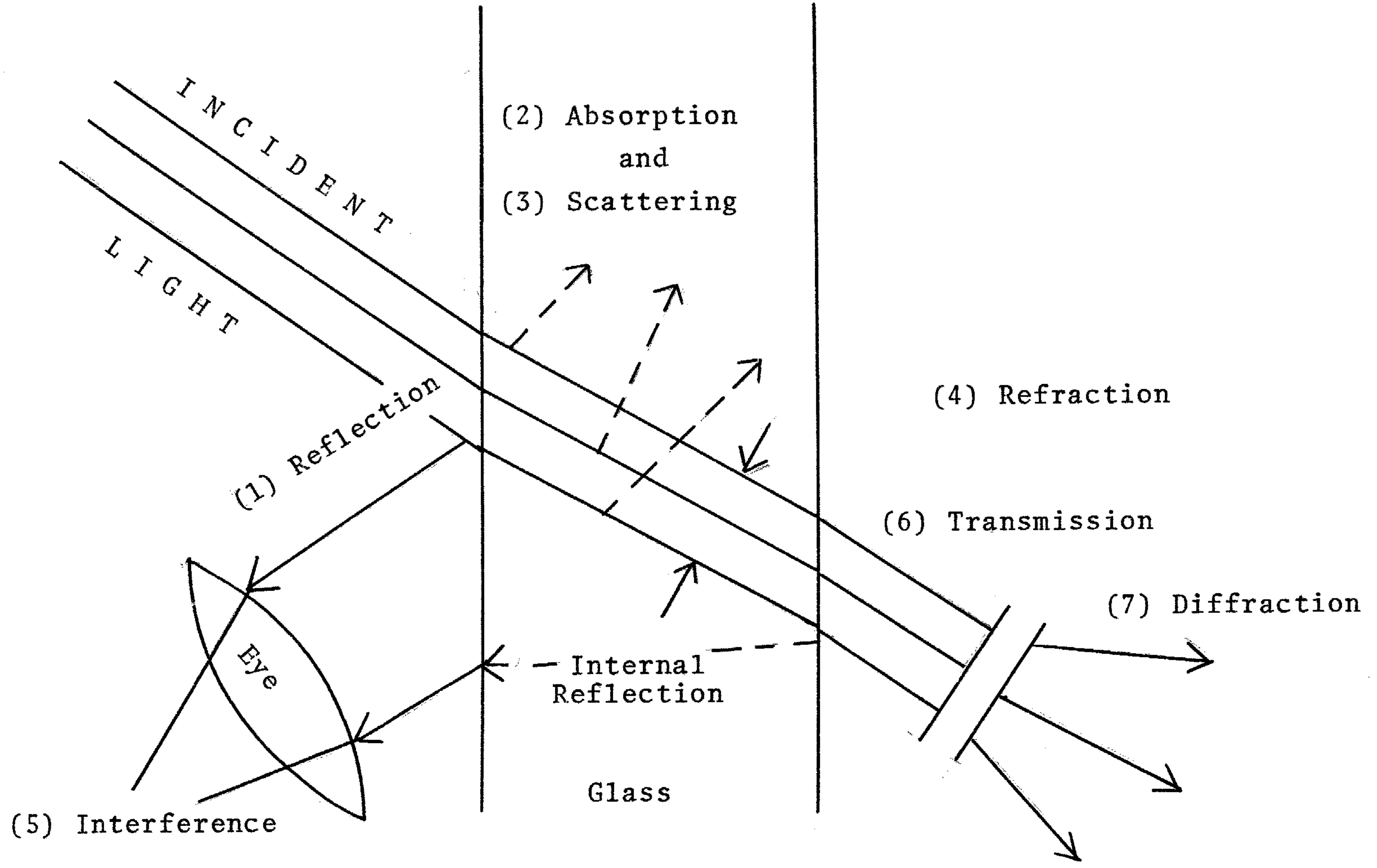

Figure 2--Light Behavior

(2) Chromatic transmitters are colorful, selective colorants, such as, transparent or translucent chromatic liquids, films and glass. Photographic filters, theatrical spotlight filters, and stained-glass windows are chromatic transmitters. The colorants of these materials are selective in that they unequally absorb and transmit light of different colors.

(3) Achromatic reflectors are colorless, nonselective, opaque colorants, such as white, gray, and black papers or paints. These colorants are nonselective because they absorb and reflect equally light of any color but with different degrees of intensity. White absorbs less and reflects more and black absorbs more and reflects less.

(4) Chromatic reflectors are colorful, selective colorants, such as, opaque paints, pigments, and dyes. The chemical or molecular structure of these opaque colorants enables them to absorb and reflect light of different colors unequally or selectively (6, pp. 16-20).

Many colorants or substances may possess any or a combination of the above characteristics; consequently, they could be both transmitting and reflecting light to the eye (6, pp. 15-20). Graves believes that any substance that modifies the appearance of light is a colorant and many color sensations are produced by this modification of light by both transmission and reflectance (6, p. 15).

The Optical Society of America has suggested that color is perceived in various kinds of context or settings which are referred to as modes of appearance. They believe any kind of classification must be quite arbitrary because of the infinite variety of texture and settings with which colors are perceived in common visual experiences. Like so many investigators such as David Katz, L. T. Troland and R. S. Woodworth, the OSA has been content with a fairly small number of listed general modes of appearance, which has been quite agreeable to all. Their classification is labeled "The Attributes or Dimensions of Perceived Color with Respect to the Principal Forms of Color Perception or Modes of Appearance." Under this title are listed the five general modes of appearance of color: (1) Illuminant (the glow or source), (2) Illumination (the light in space), (3) Surface (texture in objects), (4) Volume (the transparency in objects), and (5) Film (reflecting surface through an aperture). Also listed and classified as fourteen attributes of modes of appearance are (1) Hue, (2) Saturation, (3) Brightness, (4) Lightness, (5) Duration, (6) Size, (7) Shape, (8) Location, (9) Texture, (10) Gloss, (11) Transparency, (12) Fluctuation, (13) Insistence, and (14) Pronouncedness. This color perception classification allows the viewer to identify the general modifier and its attributive characteristics. The OSA clearly points out the fact that there are normal external conditions and mental attitudes which evoke these sensations and close substitute situations may do likewise and produce illusions (4, p. 51). By this time, it should be quite clear that there are many contributing factors which play an important role in perceiving light and color.

Light is the visual stimulus, the eye is the visual receptor, and visual sensory sensation is perceived by the human visual system. The visual receptor--the eye--the optical nerves, and the brain make up the visual system with which color is perceived. Light is the most common stimulus of color sensation, but color can be produced by other means; for example, color sensations can appear through pressure on the eye, a blow on the head, drugs, hypnotic suggestions, and electricity (6, p. 70). Let us examine the human visual system to see how it is constructed and how it works.

Light enters the eye as an optic array (Figure 3) through the transparent cornea where the light bending or converging begins and where its speed starts to slow down because of the aqueous humor. The flexible iris regulates the quantity of light admitted into the eye. The iris contracts and expands according to the intensity of illumination. In strong light the iris closes to about two millimeters and in weak light it opens to about eight millimeters. The iris also contracts when focused on nearby objects and expands when focused on faraway objects. Decreasing the size of the iris opening increases visual acuity. Of course, the human eye is focused by changing the shape of the flexible lens once the light is through the iris. The curvature of the lens can be modified so that objects distant from eight to ten inches to infinity can be focused sharply on the retina. But, once through the lens the light must travel through the vitreous humor where it is slowed down again before striking the retina at the fovean network (Figure 4) where all the ganglia and nerve cells pick up the light rays. Covering the retina is the choroid coat, the black pigmented cells that prevent light reflection from the retina. Immersed in the eye liquids are approximately seven million cones and one hundred and thirty million rod nerve endings which gather light impulses. The rods are the brightness-sensitive elements, irrespective of color, and the cones are the color-sensitive receptors. The rods and cones are named after their particular shapes. Occupying the center of the fovea is the fovea centralis where there are approximately 34,000 tightly packed cones but no rods (Figure 4). It is the spot of sharpest vision and keenest color perception. The rods increase in number as they appear further from the fovea. The rods are most active in low-light or darkness. The cones and rods account for the light-dark accommodation of the eye. Once adjusted to the darkness, the rods increase its light perception a thousand times (6, p. 72). Upon the stimulation of light, the excited cones or rods send impulses via the optic nerve to the brain.

In 1630 the French philospher Descartes recognized the fact that color in an object was reflected by light rather than just light making an object visible (13, p. 98). The modern concept of color is much the same. Light (the physical stumulus) is transmitted or reflected to the eye (the physiological receptor) which gathers light impulses and

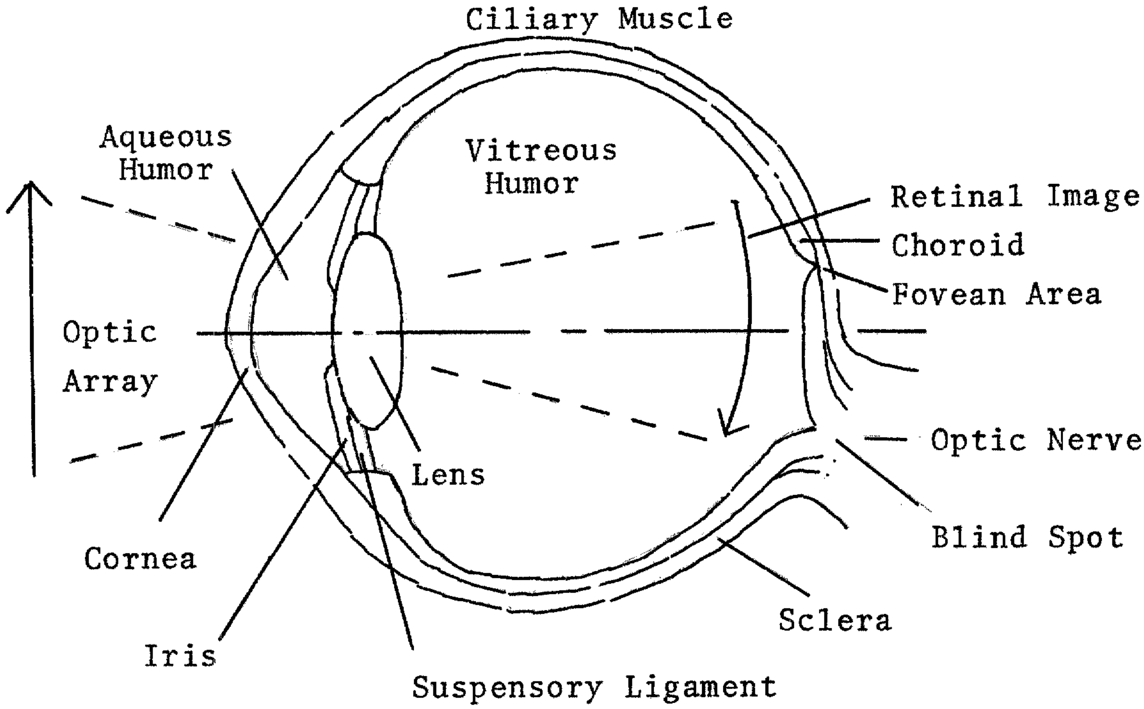

Figure 3--Horizontal cross section of right eye (4, pp. 73-80).

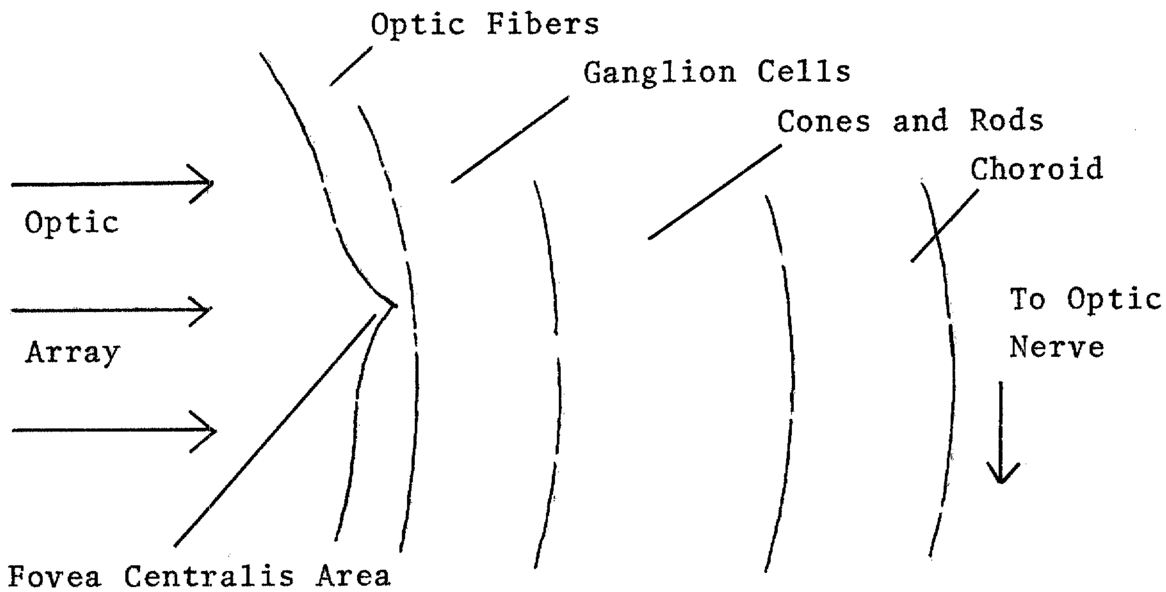

Figure 4--Fovean area cross section (4, pp. 73-80).

passes them on to the brain (the psychological response) which results in the observer seeing the color of an event or an object. The color received by the observer depends on the intensity and wavelengths of the light that illuminates the object, on the wavelengths of light reflected or transmitted by the object, on the color which surrounds the object, and on the absorptive or reflective substances in the light path (6, p. 99). There are two types of physical color: (1) Color in transmission, which includes luminous effects such as filter-colored lights, neon, and the natural dispersion of light-rainbows, and (2) color by selective absorption or surface color. Sometimes, both types are seen simultaneously; for example, a translucent material such as stained glass or flower petals may reflect surface color and transmit colored light at the same time (6, p. 20).

There are three psychological aspects of color sensation--hue, brightness, and saturation. Hue is the visual sensation which distinguishes one color from others. Each hue has a dominant wavelength of light and can be measured. Brightness is the quantity of light, value, intensity, or lightness or darkness of the color sensation and is easily measured. Saturation refers to the degree of change in dullness or brightness of a color (13, pp. 101-103). In this study the terms hue, intensity, and value are used. Hue, intensity, and value may be labeled separate visual sensations, but they are not independent of one another. A change in one variable may affect the other two. For example, decreasing the value can cause a change in the intensity and the hue (13, p. 103).

Many colorists desire an organized system on which to base their rationale and judgments, hence emerged color primaries or a few colors from which all others can be mixed. Certain hues are designated arbitrarily by colorists of various professions. In dealing with light, the physicist uses blue, green, and red which are called the primaries of "additive color mixing." (See Figure 5.) Also, note that mixing the primaries results in the secondaries: magenta, yellow, and cyan. When all are mixed, white light results. Blending colored light from more than one source is additive color mixing, but the passage of light through successive colored filters is subtractive color mixing. Pigment mixing is mainly "subtractive color mixing" (Figure 6) even though paints are added to one another. It is subtractive because pigments subtract (absorb) some wavelengths of light and reflect the remaining which the viewer sees. The artist's subtractive color mixing primaries are red, yellow, and blue. His secondaries are green, violet, and orange. Mix all of the primaries and secondaries and black results. (See Figure 6.)

Other additive methods of mixing color are the Maxwell disc spinning and the mosaic fusion. The Maxwell disc

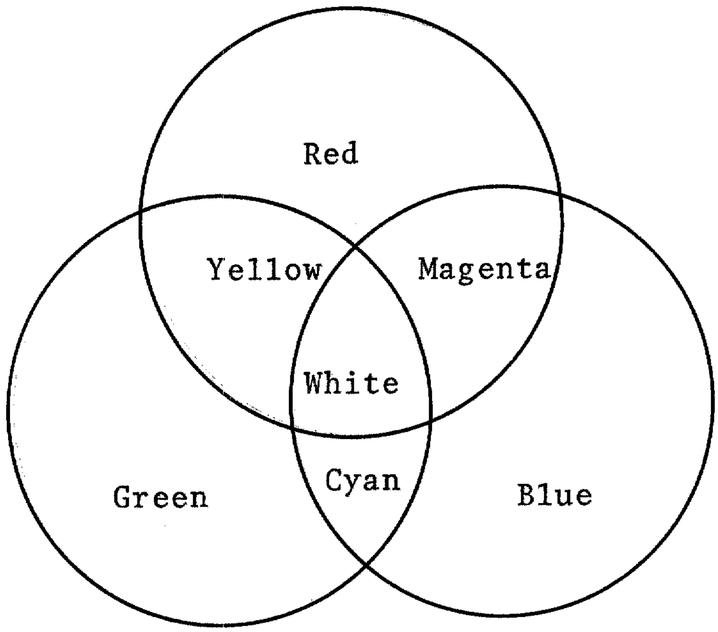

Figure 5--

Additive
Color Mixing

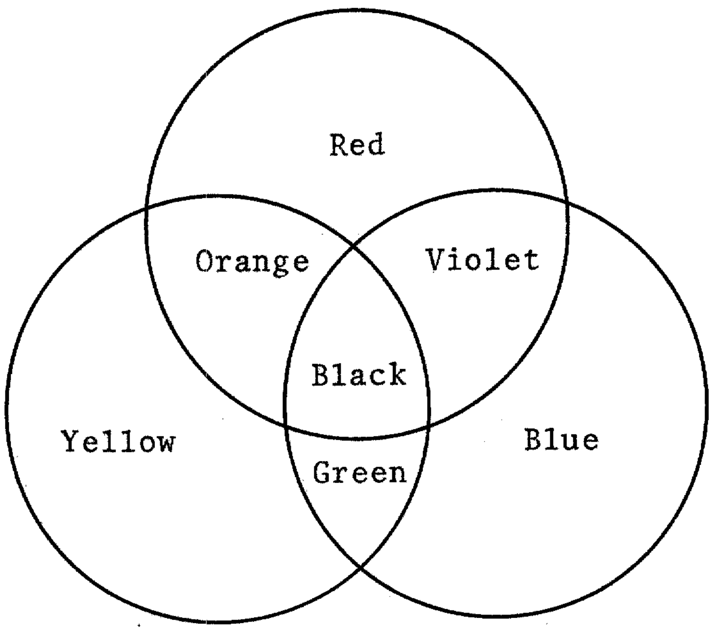

Figure 6--

Subtractive
Color Mixing

spinning makes use of the "persistence of vision" phenomenon--the retention of an image for a fraction of a second after the stimulus has ceased. Adjusting pie-shaped color discs and spinning them in rapid sucession will fuse them into one another to form a composite image. Mosaic fusion is the term used when one's eyes mix the colors, as in viewing autumn leaves, dots of color-television, a pointillistic painting, or in a color photograph printed in a magazine. Color mixing may be achieved by either additive, subtractive, or both color mixing methods simultaneously (13, pp. 104-109).

Color Theories and Systems

Through the centuries color enthusiasts have viewed with delight and wonder the phenomena of color. Many of them have put forth color theories and systems of their beliefs. Much of the early theories were based upon personal observation and feeling rather than fact or proof. Consequently, earlier theories were somewhat hazy and not too logical.

One of the earliest color theories was attributed to the Hindus. In the Hindu Upanishads, appearing about the seventh or eighth century B.C., we read, "whatever they thought looked red, they knew was the color of fire. Whatever they thought looked white, they knew was the color of water. Whatever they thought looked black, they knew was the color of earth. What they thought was altogether unknown, they knew was some combination of these three beings" (2, p. 16). Most early theories of color were related to supreme deities. The Hindus seem to have had primaries of fire, water, and earth--all beings.

Later, the Greeks added air as an element. Pythagoras related colors and forms to the elements, and he reserved the sphere as the symbol of the supreme deity. Somewhat later, in his treatise, De Coloribus, Aristotle states:

> Simple colors are proper colors of the elements, i.e., of fire, air, water, and earth. . . . Verifications from experience and observation of similarities are necessary, if we are to arrive at clear conclusions about the origin of different colors, and the chief ground of similarities is the common origin of nearly all colors in blends of different strengths of sunlight and firelight, and of air and water (2, p. 16).

Aristotle believed that darkness was due to the privation of light (2, p. 16). In a sense, Aristotle's thinking seemed to be forecasting discoveries which were to come much later. In his writings, Aristotle mentioned the colors of white, black, grey, yellow, gold, crimson, pink, brown, violet, and dark blue (2, p. 16).

With the invention of oil painting in the fifteenth century during the renaissance, artists became more interested in color and color mixing. Leonardo da Vinci was interested in practically all areas of human knowledge. In his Treatise on Painting, he states:

> The first of all simple colors is white, though philosophers will not acknowledge either white or black to

> be colors; because the first is the cause, or the receiver of colors, and the other totally deprived of them. But as painters cannot do without either, we shall place them among the others; and according to this order of things, white will be the first, yellow the second, green the third, blue the fourth, red the fifth, and black the sixth. We shall set down white for the representative of light, without which no color can be seen; yellow for the earth; green for water; blue for air; red for fire; and black for total darkness (2 , p. 18).

Centuries later, da Vinci's primaries of red, yellow, green, and blue were to be recognized as the four primaries of the modern day psychologists as suggested by the four-color theory of Hering (8, p. 35).

In the early part of the seventeenth century, René Descartes stated that all space was pervaded by the ether--the "plenum." He believed light was a pressure transmitted through a dense mass of invisible particles and the diversities of color and light were due to the different ways in which the matter moved. To him, various hues had different rotary speeds, rapid for red, slow for blue.

About the same time, perhaps a little later, about 1670, Robert Boyle, an English physicist, published his book, Experiments and Considerations Touching Colours. Boyle assumed that light had to travel in or upon something. He assumed that ether existed, as had others before him. He believed all hues were contained in white light which was distorted by substances to form hues (2, p. 21). This was quite similar to what Newton was able to prove.

Isaac Newton, in about 1666, while trying to make improvements in a telescope, observed that a beam of white light passing through a triangular prism would disperse into a color spectrum and cast its image onto another surface. He assumed that light was generated by an emission of particles--posited as his theory of light corpuscles. Newton named, somewhat arbitrarily, seven hues in the spectrum: red, orange, yellow, green, blue, indigo, and violet. He related the seven colors to the seven notes of the diatonic scale in music and to the seven heavenly planets. Newton saw that the true extremes of the visual spectrum, red and violet, bore visual resemblances and twisted the straight band into a circular one, touching the red and violet, and made it continuous or a color wheel. Newton made note that his color theory and primary colors related to light. He had nothing to do with pigments (2, p. 21).

It was not until about the 1720's that red, yellow, and blue were established as primary colors in the mixture of pigments. J. C. Le Blon set forth his treatise on color some time before 1731. He also distinguished between additive and subtractive color mixtures. Le Blon's color treatise of 1756 was applied widely to painting, printing, engraving, tapestries, and brocades throughout Europe (2, p. 25).

In 1810, Johann Wolfgang von Goethe's Farbenlehre was published. In this publication appeared Goethe's Color

Triangle. His primaries were red, yellow, and blue and secondaries were orange, green, and purple. His tertiaries were dull yellow, dull red, and dull blue (2, p. 29). Goethe, like Newton, only theorized basic colors.

The first well-thought-out color wheel came from Moses Harris, an Englishman, who in about 1766 published The Natural System of Colours. It contains the first recorded example of a color circle illustrated in full hue. He used the red, blue, and yellow primaries and the orange, green, and violet secondaries and on into the tertiaries, etc. The Harris system featured two plates of colors, shades, and tones--660 colors in all (2, p. 26). It set a pattern for future color organization.

Other theories and color wheels soon followed. In 1772, in Vienna, Ignaz Schiffermuller's color circle was published. Charles Hayter published his in 1826, George Field his in 1845, and M. E. Chevreul's color circle was printed in 1839 in his De la Loi du Contraste Simultané des Couleurs (2, pp. 26-28).

Many colorists subscribed to the red-yellow-blue doctrine of color primaries in paint mixtures. Among them were Goethe, Chevreul, and many Americans. In 1831, Sir David Brewster presented A Treatise on Optics and gave the doctrine his blessing. Since then, in honor of Brewster, the system has been called the Brewsterian (2, p. 29).

Today, most colorists recognize three different sets of primary colors--one for light, one for pigments, and one for human vision. In light mixtures, the primaries are red, green, and blue-violet. Red and green make yellow, red and blue-violet make magenta, green and blue-violet make cyan, and all primaries and secondaries make white light (Figure 5). Of course, if the relative intensities of color lights are adjusted, it is possible to gradually change the hue of any mixtures. Generally, color light mixing is called "additive" (13, p. 107). Pigments or colorants have the primaries of red, yellow, and blue and secondaries of green, orange, and violet. When all pigments are mixed, supposedly, a black or near black results. Colorant mixing is referred to as "subtractive." (See Figure 6.) The use of color filters over white light is a form of subtraction. The colors not absorbed in a filter are transmitted whereas in colorant mixing, colors not absorbed are reflected (13, p. 107). The third set of primaries, called the psychological primaries, is still an issue among the psychologists. According to the Young-Helmholtz theory, there are three kinds of cones in the eye which are equally sensitive to one region of the color spectrum and each producing a sensation of one of the primary hues of red, green, and blue. All hues are considered to be a combination of the three primaries. This theory fits well into the color light facts of additive mixing discussed earlier (10, p. 21). In about 1872, Ewald Hering stated that color vision primaries were red, green, blue, and yellow. Also, he suggested that there are "whiteness" and "blackness" which can mix with the primaries to make all hues (8 , pp. 26-47). In 1955, L. Hurvick and D. Jameson proposed an opponent-color theory based upon Hering's form color theory. This opponent-color theory suggested that there were four basic hues paired as red-green and blue-yellow along with a white-black pair. They suggested these three pairs could account for all color mixing when received by the nerve receptors of the retina. Psychologists seem to prefer the opponent-color theory at present, although the issue is still open (8, p. 21). The Young-Helmholtz theory was adopted by the International Commission on Illumination (6, p. 73).

Many colorists feel they should have a system for specifying color in order to identify or describe objects or light and to enable them to reproduce such at a later time or place. The mode of observation, be it illuminant, illumination, object, volume, or aperture, should not affect the color reproduction. There are over ten million distinguishable colors and less than four thousand have names (13, p. 125). These beliefs have led many to create and utilize color systems.

The Munsell Color System, the Ostwald Color System, and the CIE or the Commission International de l' Eclairage (the

International Commission of Illumination) are the most widely used color systems in the world today (13, p. 125).

The Munsell Color System was originally devised by Albert H. Munsell, an art teacher and painter. The system is an ordered array of rectangular colored paper samples. Munsell used ten basic colors which are red, yellow-red, yellow, green-yellow, green, blue-green, blue, purple-blue, purple, and red-purple. Hue, chroma, and value are the three variables used to differentiate his color samples. His ten basic colors are mixed subtractively and multiplied into one hundred gradations or distinct hues. Each hue has variations of nine values and seven chromas equaling sixty-three distinctions. One hundred hues times sixty-three distinctions equals 6300 total distinct gradations. Each one is labeled and sub-labeled. For example, a sample may be labeled 5B 4/8 or hue equals number five blue, value equals four, and chroma, eight. The National Bureau of Standards, Washington, D.C., distributes color specifications for the Munsell System (13, pp. 126-7).

The Ostwald Color System, similar to the Munsell system, uses a hexagonal colored paper chip to display its different hues. The Ostwald System labels its three color variables dominant wavelength, purity, and luminance compared to Munsell's hue, chroma, and value. The Ostwald System has four fundamental colors which are red, yellow, ultramarine blue, and seagreen. Leafgreen, orange, purple, and turquoise are added to make the eight principal colors of the Ostwald System. The eight principal hues are expanded by mixing subtractively to twenty-four, more recently expanded to thirty principal hues. Each thirty hues have gradations of twenty-eight variations, equaling 840 distinct hue variations. Each sample is identified by three numbers representing percentage of color, white, and black. For example, color sample C34-W22-B44 would read 34 per cent color, 22 per cent white, and 44 per cent black of a particular hue. Ostwald calls this his color equation: C plus W plus B equals 1 or full color plus white plus black equals unity. The Container Corporation of America distributes a Color Harmony Manual complete with all hue gradations in practical use today (9, p. 30).

The CIE (Commission Internationale de 1' Eclairage) Color System, using a colorimeter, made a series of color matches against a spectrum of monochromatic colors employing a mixture of three primary colors--red, green, and blue. Based upon the results, three color mixture curves were produced--$\bar{x}$ representing red, $\bar{y}$ representing green, and $\bar{z}$ representing blue. From these were derived the coordinates for a series of points representing a spectrum of fully saturated colors. (See Figure 7.) Plotting these points and making them a curve provided a basic triangle of the chromaticity diagram. All visible colors can be represented by points within this figure. The entire spectrum ranges

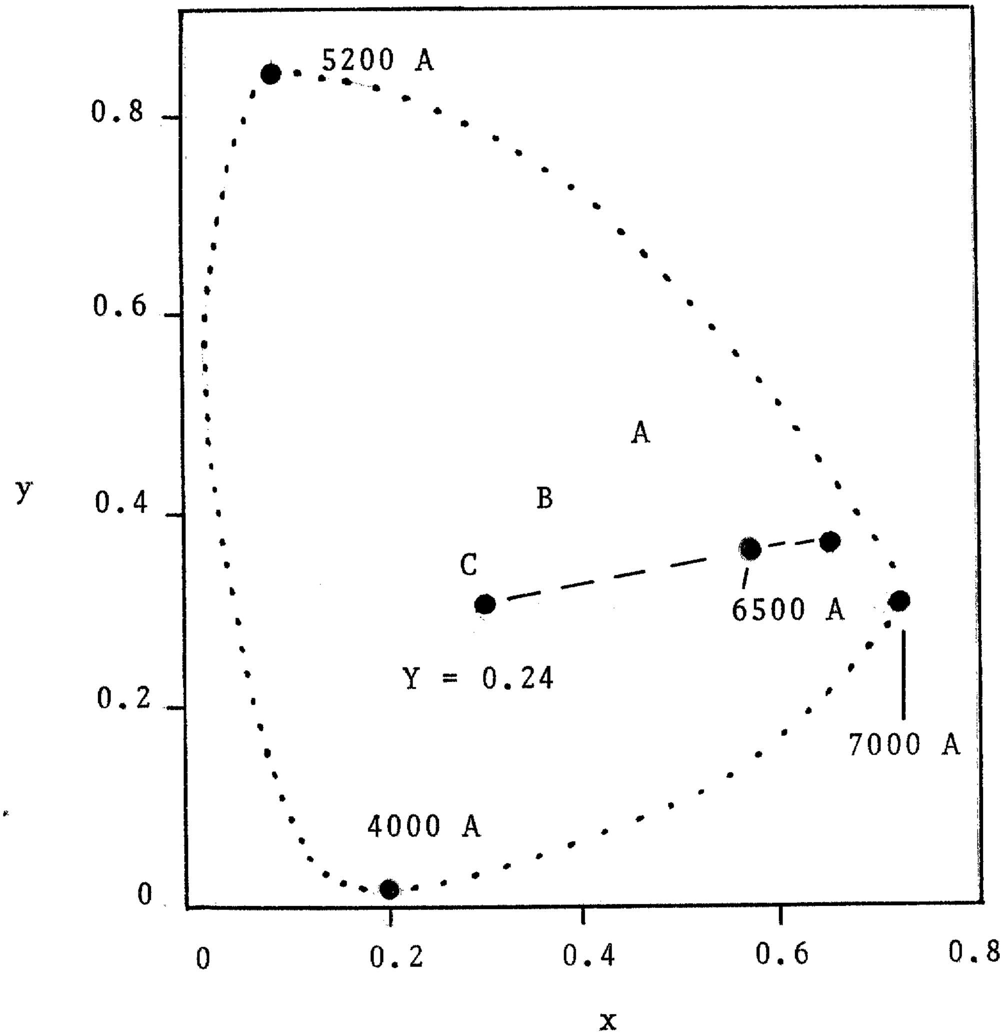

Figure 7--Chromaticity Diagram

from violet (4,000 A) at the lowest point through hues of green (5,200 A) at the top to red (7,000 A) at lower right of the chromaticity diagram. Three standard light sources A (incandescent), B (noon sunlight), and C (average daylight) also have been plotted on the chromaticity diagram near the center. C and B are more near white light, whereas A is more reddish. A typical CIE notation for an impure red color sample might appear as x=0.58, y=0.33, and relative luminance (Y)=0.24 (13, pp. 130-131). The widespread use of color names and specifications has led to the compilation of many color dictionaries to provide a ready means of determining the color and its associated name. A few of these are the Ridgway Color Dictionary for describing birds, flowers, and insects, Maerz and Paul Dictionary of Color for color printing, The Standard Color Card of the textile industry, and the I.S.C.C.-N.B.S. method of designating color devised by the Inter-Society Color Council and the National Bureau of Standards. A group of standards specifying a method of measuring and determining color has been adopted by the American Standards Association, called the American Standard Z58.7.1, Z58.7.2, and Z58.7.3. By using a spectrophotometer, color samples can be tested and a permanent quantitative record of the proportion of the light reflected by each sample for each portion of the visible spectrum can be produced (4, pp. 337-339).

Color Perception

Let's briefly review the modern concept of color perception which was established in an earlier section. Light, the physical stimulus, is transmitted or reflected to the eye, the physiological receptor, which gathers light impulses and passes them on to the brain where the psychological responses are recorded. This results in the observer's seeing color of an object or an event. The color received by the observer depends on the intensity and wavelength of the light that illuminates the object, on the wavelength of light reflected or transmitted by the object, on the color which surrounds the object, and on the absorptive or reflective substances in the light path (13, p. 99). One aspect of color perception, one which is very pertinent to this study, is the "color which surrounds the object" or the immediate surroundings of the observed object or event. Many and various perceptual color phenomena can take place and affect the sensation perceived by the observer. Let's examine the most common ones.

Hue contrast is the most obvious perceptual color phenomenon. It is simply identifying, naming a specific hue which may vary in intensity and value, such as, red, red-orange, or pink (11, p. 36). (See Appendix D.)

Successive color contrast is the perceptual color phenomenon which occurs after one has gazed at a particular color for a short time, then looks to a blank, white surface where a similar shape but a weaker complementary image will appear. In a few seconds, the weak image fades and disappears. This phenomenon is called post-impression or an after-image (3, p. 78). After-images are caused by excitation and subsequent fatigue of the retina. When an achromatic or chromatic light stimulus is transmitted or reflected to the retina, the receptors are stimulated by the light which produces a fatigue which makes the receptors less responsive or partially color blind to the light of the particular color and evokes a weaker complementary image. For example, white evokes black, black evokes white, red evokes blue-green, etc. The after-image of a color is complementary only when the after-image appears on an achromatic or hue complementary surface (6, pp. 125-129). (See Appendix E.)

Mixed-color contrast perceptual phenomenon occurs after the viewer gazes at a color for a short time and then looks to another surface color. The after-image of the original color will mix visually with the surface color and form a third color after-image of a weaker nature. Again, these after-images are caused by excitation and subsequent fatigue of the retina, but a different response is evoked (6, pp. 125-9). For example, a black will evoke white and when mixed visually on a green, a lighter green will appear. (See Appendix F.)

The simultaneous color contrast phenomenon occurs when colors are juxtaposed and specific modifications take place. Colors will simultaneously evoke their exact complements and the juxtaposed colors will react upon each other. For example, if a red square were juxtaposed where one edge would touch a white square and the other edge a black square, the edge of the red near the white would appear darker than the edge of the red near the black. The white evokes black which makes the red edge appear darker in appearances, and the black evokes white which makes the red edge appear lighter. Albers calls the edge changes "fluting" (1, p. 14). It can affect the appearance of the total shape, but it is most noticeable at the point where color edges touch one another. The result is caused by the same excitation and subsequent fatigue of the retina which causes after-images (1, p. 14). (See Appendix G.)

Another, the advancing-receding perceptual color phenomenon, is the visual or psychological effect which seems to make light and warm colors advance toward the viewer and dark and cool colors recede when viewed on dark backgrounds. This phenomenon is reversed when the colors are placed on light surroundings. These spatial relationships are altered by hue, intensity, value, warm-cool, size, background, direction, and over-lapping of objects perceived (1, pp. 122-123). Value and background seem to make the most noticeable differences and changes in appearance of colors in space. The explanation of this spatial phenomenon is the fact that the eye has different focal lengths for different colors which make them appear inconsistently in space and surroundings (5, p. 323). (See Appendix I.)

The Bezold Effect is the perceptual color phenomenon of two or more colors being annulled by each other by mixing visually in the eye and effecting a new color (1, p. 39). This, an "optical mixture" of the eye, was named after Wilhelm von Bezold who recognized the effect and utilized it in rug designs (1, p. 39). This optical mixing has been referred to as "mosaic fusion" (13, p. 109) and "additive mixture" (5, p. 85) in other sources. It is suggested that it is the result of color splotches being so close together or so far from the eye that they are mixed additively before they reach the retina (5, p. 85). (See Appendix H.)

The spreading effect, described by both von Bezold and Rood before 1900, is the direct opposite of simultaneous contrast. In simultaneous contrast, when red is juxtaposed with white and black, the white evokes black making a darker red and black evokes white making a lighter red. In the spreading effect the opposite will occur. It is said that it may be the result of the bleaching of cone pigments in the retina and their subsequent diffusion into neighboring cone cells (13, p. 124).

According to Joseph Albers, all of these and similar deceptions are the result of one perceptual color phenomenon--the successive color contrast or after-image. Also, he suggests that "in visual perception a color is almost never seen as it really is, . . . as it physically is. This fact makes color the most relative medium in art" (1, p. 10).

There are many and varied perceptual color phenomena which can take place and affect the sensation perceived by the observer. These are in addition to all the modes of appearance, attributes, and other modifiers which may determine how and what the observer visually perceives.

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CHAPTER III

PROCEDURES

The Pilot Study

A pilot study, administered to an intact group of fourteen art majors, was undertaken to experience the actual presentation of all the tests. Results of the pilot study pointed out that all tests must have its proper and constant lighting, constant distance, constant timing, and accurate recording.

One factor brought out by the pilot study was that some viewers were confusing the colors of red and orange in identification. An additional part, Section B, of the "Isoline Color Perception Presentation" was included to find out if there was confusion in identifying red and orange consecutively and simultaneously.

After the pilot study was completed, minor changes in techniques of presentation and timing were altered to speed up actual testing, allowing much less time in completion of all the tests.

The most important aspect of the pilot study was that it provided information which encouraged the continuation of the color study.

The Collection of Data

Respondents, representing two different populations, were asked to participate in this experimental research project. One group comprised non-art majors and one group comprised art majors. The two groups were drawn from three college populations. Non-art majors could not have over six hours of art and the art majors had to have twelve or more. The respondents were volunteers both from intact art class groups and at-large college students. A number of students hearing of the project volunteered to be participants.

Initially, there were fifty respondents in each group. The samplings were finally trimmed to forty respondents in each group. Many respondents were eliminated because of disqualifying factors, such as: did not complete all tests, did not view all tests with consistent mode (lenses when needed), or did not qualify for one of the two groups in having the required art hours.

The two groups represent samplings from one major state university and two major private universities. Although each group testing was accomplished in four weeks, the total time of data collection spanned two and one-half years.

The Experimental Research Design

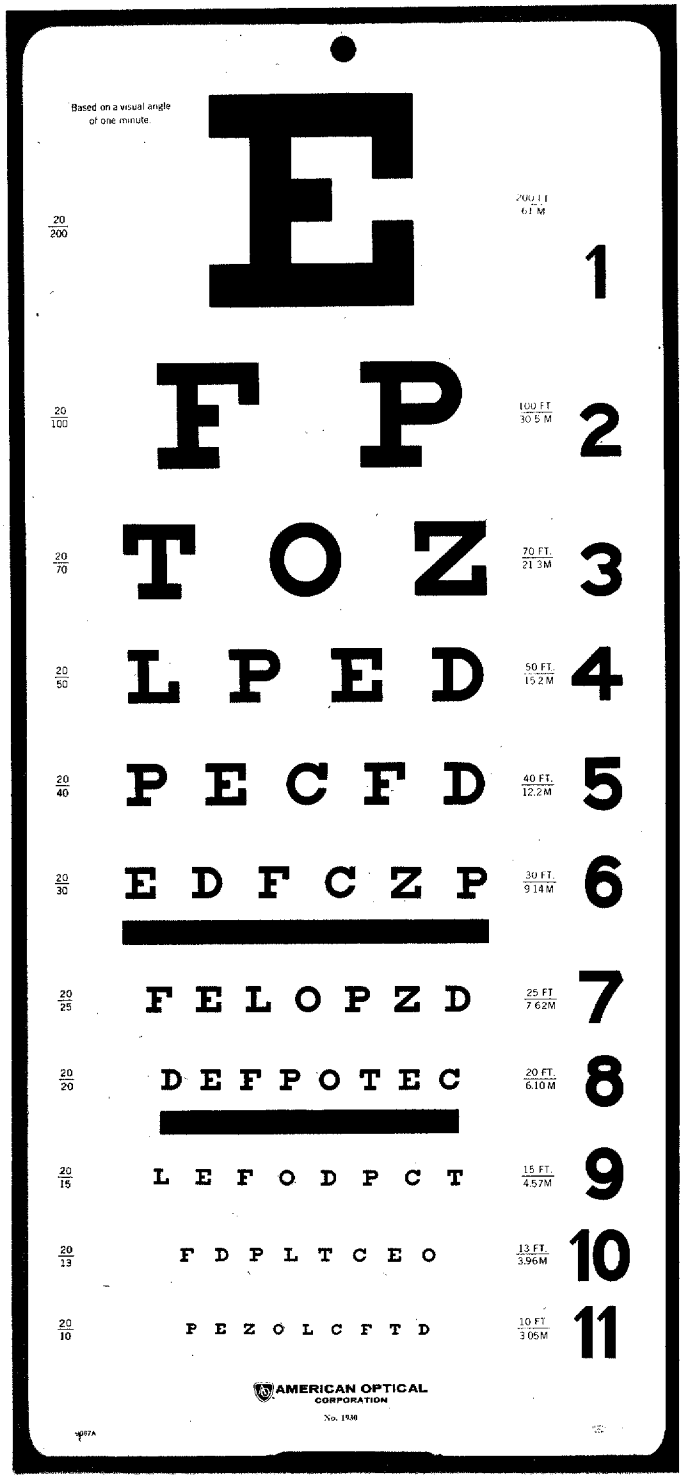
There were four different testing periods. During the first week, the Snellen Visual Acuity Chart (3) and the Pseudo-Isochromatic Plates for Testing Color Perception (1) were administered to both the non-art and art major groups. After one week passed, the "Questionnaire" and the "Isoline Color Phenomena Perception Presentation" were administered to the two groups. The "Questionnaire" and "ICPP Presentation" were administered the second and third times at one week intervals. (See Figure 8.)

The Snellen Visual Acuity Chart, Number 1930, was purchased from the American Optical Corporation (AOC). The chart is approximately twelve inches wide and twenty-four inches high. (See Figure 9.) The chart was attached to a neutrally colored wall. The top edge was six feet from the floor. Two 500 watt day-light type photo-floods were placed at right angles and about six feet from the Snellen Visual Acuity Chart. The two lights were six feet high. The respondent stood twenty feet from the chart. (See Figure 10.) The administrator stood to the left of the respondent and charted responses which were incorrect. It was possible to score anywhere from zero through sixty-one. An effort was made to keep sun-glare and other distracting light from the room by the use of shades and blinds. The administration of the visual acuity chart took less than two minutes in most cases.

The Pseudo-Isochromatic Plates for Testing Color Perception (deficiency) was administered in the same room and immediately after the visual acuity test. The physical setting was altered. (See Figure 11.) The two 500 watt

Respondents	First week: Pre-tests	Second week: First testing	Third week: Second testing	Fourth week: Third testing
Non-Art Majors	1. Snellen Chart 2. Pseudo-Isochromatic Plates	1. Questionnaire 2. Isoline Color Presentation	1. Questionnaire 2. ICP	1. Questionnaire 2. ICP
Art Majors	1. Snellen Chart 2. Pseudo-Isochromatic Plates	1. Questionnaire 2. Isoline Color Presentation	1. Questionnaire 2. ICP	1. Questionnaire 2. ICP

Figure 8. Experimental Research Design



Scale: 1"=5"

Figure 9. The Snellen Visual Acuity Chart

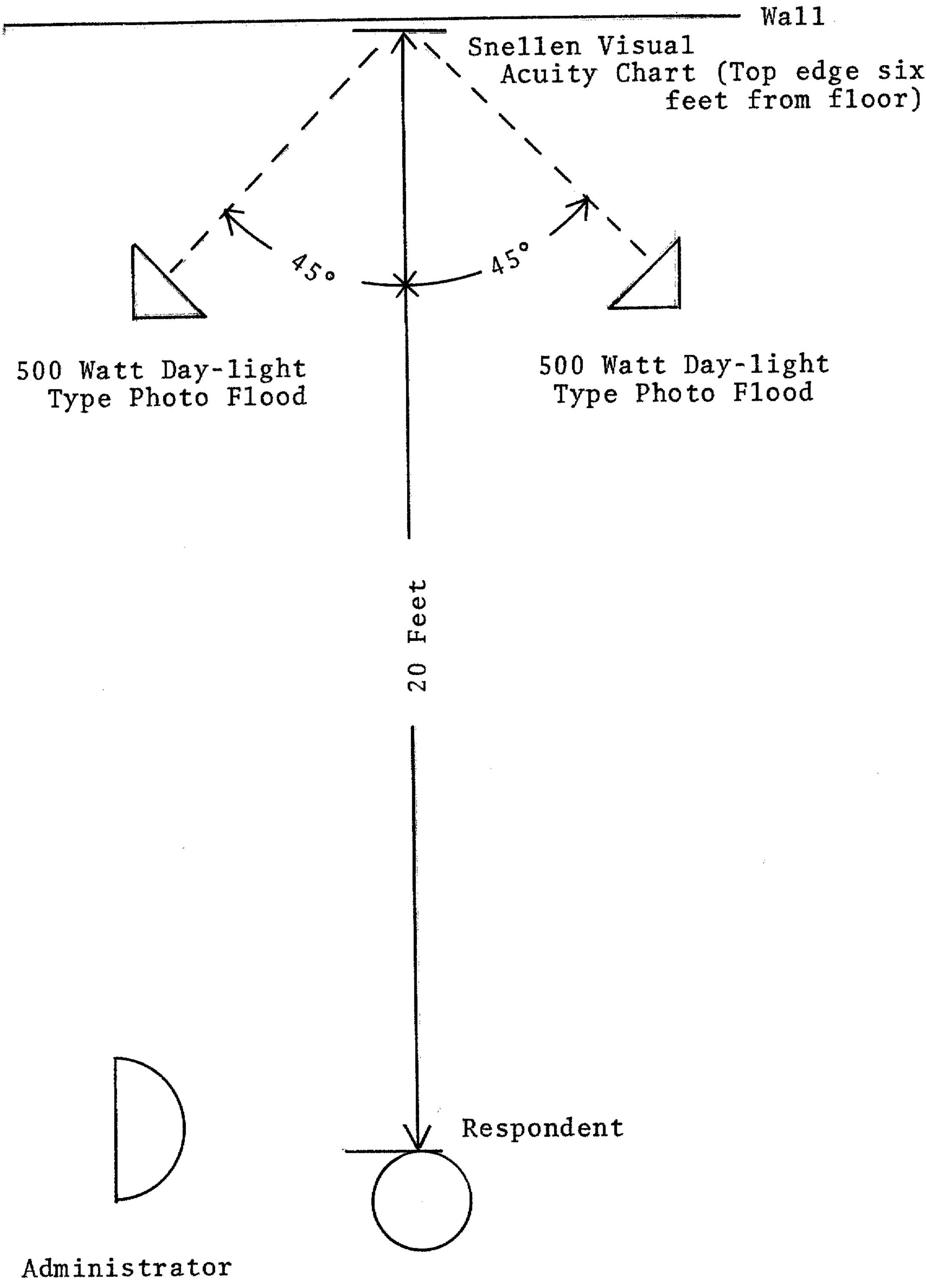


Figure 10. Physical Arrangement for Snellen Visual Acuity Chart

day-light type photo-floods were placed at right angles, about six feet distance, above the plates to be viewed. The actual size of the color plates was 3 3/4 inches high with the width varying from 3 3/4 inches to 4 1/2 inches. (See Figure 12.) There were fifteen plates to be viewed. The first one was a practice one. Plates number two through number fifteen were the actual test plates. The distance from the eyes to each plate was thirty inches, as recommended by the AOC.

The administration of the _Pseudo-Isochromatic Plates for Testing Color Perception_ was conducted as follows:

1. The examiner instructed the subject to "please read the numbers." The examiner did not give other instructions and did not ask other questions. The subject was not allowed to trace the patterns or touch the plates.

2. The demonstration plate was shown first (a red "12" on a blue background). All of the remaining 14 plates were then shown. About 2 seconds were allowed for response to each plate. If the subject hesitated, he was asked again to "read the numbers"; if he failed to respond, the examiner turned to the next plate without comment.

3. With the exception of the demonstration plate which was always first, the examiner changed the order of the plates if there was suspicion that the numbers had been learned in serial order by subjects (1, p. 1).

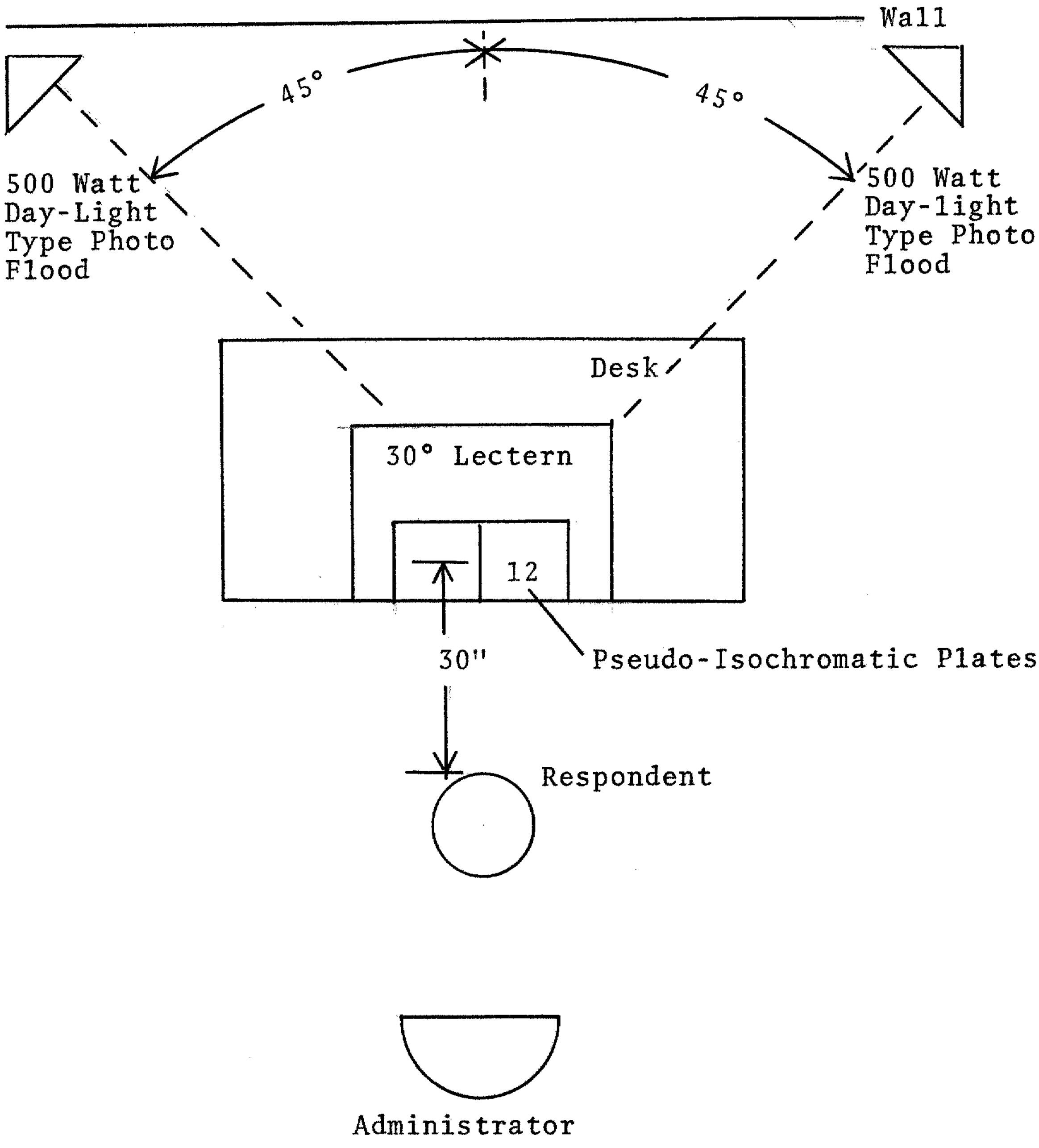
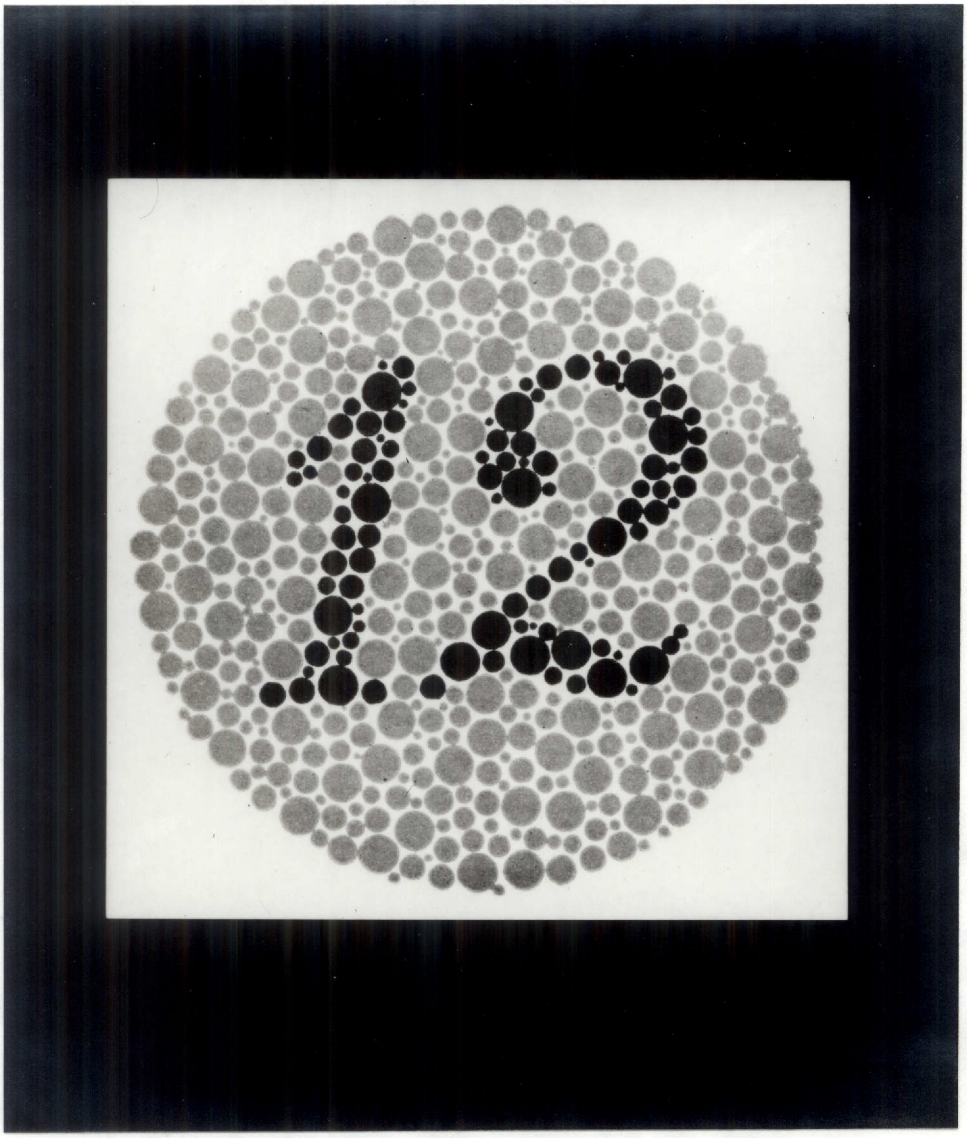


Figure 11. Physical Arrangement for the Pseudo-Isochromatic Plates for Testing Color Perception



Black and white reproduction

Figure 12. The Practice Pseudo-Isochromatic Plate for Testing Color Perception

The color deficiency test is merely a crude screening test which may determine if more scientific, professional tests should be made. If the subject scores ten or more correctly, he is considered to have "normal" red-green color vision. If less than ten, he is considered to have "defective" red-green color vision and should have further professional tests from medical doctors. The plates can be scored from zero through fourteen if a quantitative score must be used. However, the instructions state that the test is red-green only with no provisions for detecting blue-yellow defects. The scoring was quantified zero through fourteen for this study. The administrator sat behind the respondent and recorded incorrect responses. (See Appendix C.)

There was a "Questionnaire and General Directions" sheet attached to the Experiencing Color (phenomena) response sheet. (See Appendix A.) The respondents were asked to give their name, address, city, phone, zip code, and grade level. Also, they were asked to give their sex and the number of art hours completed up to the time of testing. In addition, they were asked if correcting lenses were needed, if they were being used on each administration, and whether or not they were color blind. At the bottom of the page was a paragraph of general directions for taking the test.

The "Isoline Color Phenomena Perception Presentation" was administered in the same room as the other tests, but the physical arrangements had to be altered. In the front of the room was a standard desk and chair where the administrator sat. On the desk to the right of the administrator was an L-shaped grey screen where the color presentation was kept out-of-view until the actual presentation. Two 500 watt day-light type photo-floods were placed at right angles, six feet from the position of the viewed color plates and six feet high. (See Figure 13.) The first row of respondents was positioned six feet from the viewing area, second row at nine feet, third row at twelve feet, and the fourth row at fifteen feet. Shades and blinds were used to cut out interfering light or glare. Constant lighting was sought. The respondents were asked to circle their responses as they viewed each color plate. (See Appendix A, "Questionnaire and General Directions.")

The Treatment of Data

Data from all tests were recorded as numerical values. Any data numerically quantified was left as such and any data needing quantification was given it. This was done to simplify organization and to make for easy coding for manual or automatic processing which will allow for easy and quick interpretations of the relationships pertinent to the study and to determine the relative importance of all factors.

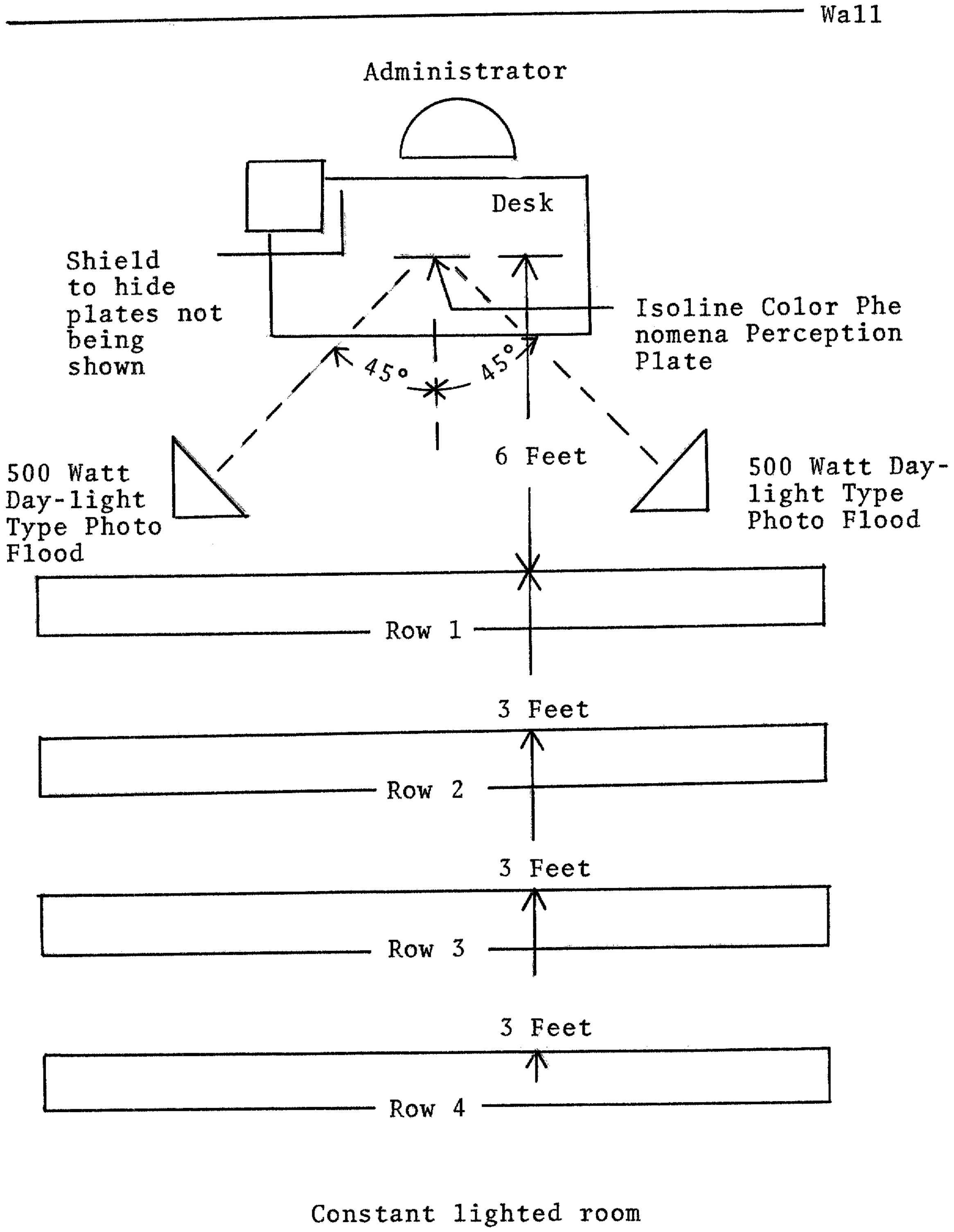


Figure 13. Physical Arrangement for the "Isoline Color Phenomena Perception Presentation"

Initially, the variables utilized in the collection of data numbered one through thirty-three and were quantified in the following manner:

1. Grade level, 1 through 12

2. Sex (females equals 1 and male equals 2)

3. Art hours completed, 0 or more

4. Corrected vision (yes equals 1 and no equals 2)

5. Distance from the "Isoline Color Phenomena Presentation (ICPP)" test--first administration, 6, 9, 12 or 15 feet

6. Distance from the ICPP test--second administration, 6, 9, 12, or 15 feet

7. Distance from the ICPP test--third administration, 6, 9, 12, or 15 feet

8. Snellen score, 0 through 61

9. Pseudo-Isochromatic score, 0 through 14

10. Consecutive color identification score, 0 through 16--first administration

11. Consecutive color identification score, 0 through 16--second administration

12. Consecutive color identification score, 0 through 16--third administration

13. Simultaneous color identification score, 0 through 16--first administration

14. Simultaneous color identification score, 0 through 16--second administration

15. Simultaneous color identification score, 0 through 16--third administration.

16. Successive color identification score, 0 through 16--first administration

17. Successive color identification score, 0 through 16--second administration

18. Successive color identification score, 0 through 16--third administration

19. Mixed color identification score, 0 through 16--first administration

20. Mixed color identification score, 0 through 16--second administration

21. Mixed color identification score, 0 through 16--third administration

22. Simultaneous color on black versus white ground comparison score, 0 through 36--first administration

23. Simultaneous color on black versus white ground comparison score, 0 through 36--second administration

24. Simultaneous color on black versus white ground comparison score, 0 through 36--third administration

25. Advancing-receding color on grey ground comparison score, 0 through 16--first administration

26. Advancing-receding color on grey ground comparison score, 0 through 16--second administration.

27. Advancing-receding color on grey ground comparison score, 0 through 16--third administration

28. Simultaneous color on color grounds comparison score, 0 through 16--first administration

29. Simultaneous color on color grounds comparison score, 0 through 16--second administration

30. Simultaneous color on color grounds comparison score, 0 through 16--third administration

31. Bezold effect color identification score, 0 through 42--first administration

32. Bezold effect color identification score, 0 through 42--second administration

33. Bezold effect color identification score, 0 through 42--third administration

Variables one through seven concern general information. Variables eight and nine concern scores for binocular visual acuity and color deficiency, respectively. Variables ten through thirty-three concern the repeated measures--three administrations for each color phenomenon. The responses from variables ten through thirty-three were scored 2 for the consensus answer and 1 for the secondary answer. This allowed for quantification of the color phenomena.

In a previous section of this paper (Questions of Inquiry) questions concerning both the non-art and art majors were asked. The following statistical tests were made to determine the answers of the posed questions.

1. Pearson product-moment correlation coefficients were determined between all variables to identify the significant correlations at the .01, .02, or .05 levels (2, p. 72).

2. The t-test was used to identify the significant differences between the means of the non-art and art majors on all variables (2, p. 72).

3. The analysis of variance was used to identify the significant differences between the means of the repeated measures on each of eight variables in both the non-art and art majors (2, p. 72).

4. Visual observations of the descriptive statistics were made to identify other relationships which occurred within or across the groups.

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CHAPTER IV

PRESENTATION, ANALYSIS, AND DISCUSSION OF DATA

The purposes of this chapter are to present, analyze, and discuss the data which were collected to answer the questions of inquiry concerning the non-art majors and the art majors. The answers to the questions were determined by the examination of the data gathered from the tabulation of the results of the *Snellen Visual Acuity Test*, *Pseudo-Isochromatic Plates for Testing Color Perception*, "Isoline Color Phenomena Presentation," and the factors included in the accompanying questionnaire.

Initially, there were thirty-three variables (subsequently reduced to seventeen) utilized in the collecting of data. (See page 59.) The Pearson product moment coefficients of correlation were determined between the thirty-three variables to identify the significant correlations in each of the groups (4, p. 71). The differences between the means on the repeated measures of the non-art majors and the art majors were examined.

In the examination of the repeated measures, it was evident that the means varied very little in either group. (See Table I). To confirm this observation, an analysis of

TABLE I

THE COMPARISON OF GROUP MEANS OF
THE NON-ART AND ART MAJORS
N=40

Variables		T*	Non-Art Majors		Art Majors	
			M	S.D.	M	S.D.
Consecutive Color Identification	10.	A	15.97	.15	15.95	.22
	11.	B	16.0	.0	16.0	.0
	12.	C	15.97	.15	15.97	.15
Simultaneous Color Identification	13.	A	15.97	.15	15.97	.15
	14.	B	16.0	.0	16.0	.0
	15.	C	16.0	.0	16.0	.0
Successive Color Identification	16.	A	13.42	1.86	13.57	1.56
	17.	B	13.35	1.61	13.87	1.41
	18.	C	13.72	1.41	14.42	1.41
Mixed Color Identification	19.	A	11.95	1.51	12.85	1.67
	20.	B	12.12	1.96	13.32	1.74
	21.	C	12.65	1.90	12.87	1.78
Simultaneous Color on Black and White Ground Comparison	22.	A	31.90	3.15	32.42	3.27
	23.	B	32.22	2.99	32.57	4.13
	24.	C	32.10	2.64	33.45	3.60
Advancing-receding Color on Grey Ground Comparison	25.	A	11.07	2.29	12.35	2.66
	26.	B	11.25	2.13	12.57	2.56
	27.	C	11.25	2.20	12.90	2.35
Simultaneous Color on Color Ground Comparison	28.	A	34.82	3.58	36.57	3.24
	29.	B	33.27	3.16	36.62	3.14
	30.	C	35.72	3.21	37.02	3.36
Bezold Effect Identification	31.	A	29.75	.58	29.80	.60
	32.	B	29.80	.51	29.92	.26
	33.	C	29.87	.40	29.72	.78

*Treatments repeated

variance (4, p. 230) was used to identify the significant differences between the means of the repeated measures on each of eight variables in both groups. (See Table II.) With the exception of two variables, successive color contrast in the art group and mixed color contrast in the non-art group, the means of the repeated measures were consistent. Therefore, repeated measures in each group were combined and treated as eight single measures. Variables ten through thirty-three became ten through seventeen on subsequent statistical tests of significance.

The questions of inquiry focused on the responses of the participants from three instruments, the "Isoline Color Phenomena Presentation," the Snellen Visual Acuity Tests, and the Pseudo-Isochromatic Plates for Testing Color Perception. The questions of inquiry (see Chapter One) were combined, condensed, and restated in the order in which they were asked originally. The questions are followed below by answers determined by the examination of the responses of the participants from the collected data. Responses of the participants from the "Isoline Color Phenomena Presentation" were reported as per cent consensus answers and per cent secondary answers. The coefficients of correlation were identified as being significant at the .01, .02, or .05 level. The significant difference between the means for the non-art majors and art majors were reported as *t* values and

TABLE II

ANALYSIS OF VARIANCE FOR REPEATED MEASURES ON COLOR PHENOMENA IN THE NON-ART MAJORS AND THE ART MAJORS
df = 2, 78

Variable	Non-Art Majors		Art Majors	
	F	P	F	P
10. Consecutive Color Identification	1.00000	0.37256	1.51948	0.22521
11. Simultaneous Color Identification	1.00000	0.37256	1.00000	0.37256
12. Successive Color Identification	1.21015	0.30365	6.50486	0.00244*
13. Mixed Color Identification	3.14727	0.04847**	1.78431	0.17468
14. Simultaneous Color on Black and White Ground Comparison	0.42097	0.65790	2.54194	0.08521
15. Advancing-receding Color Black & White Ground Comparison	0.17709	0.83804	0.89720	0.41188
16. Simultaneous Color on Color Ground Comparison	2.45074	0.09284	0.91358	0.40543
17. Bezold Effect Identification	2.17302	0.12066	2.00946	0.14093

*Significance at the .01 level
**Significance at the .05 level

identified as being significant at the .01, .02, or .05 level.

Questions of Inquiry

Hue Identification

1. How will the non-art majors and art majors respond in identifying basic hues and values presented consecutively, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

2. How will the non-art majors and art majors respond in identifying basic hues and values presented simultaneously, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

Successive Color Contrast

How will the non-art majors and art majors respond in identifying successive color contrast of basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

Mixed Color Contrast

How will the non-art majors and art majors respond in identifying mixed color contrast of basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating and each accompanying color phenomenon?

Simultaneous Color Contrast

How will the non-art majors and art majors respond in identifying the simultaneous color contrast of basic hues, and values and how will these responses relate to binocular visual acuity, color deficiency rating and each accompanying color phenomenon?

Advancing-Receding Color

How will the non-art majors and art majors respond in identifying advancing-receding colors of basic color hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying phenomenon?

Bezold Effect

How will the non-art majors and art majors respond in identifying the Bezold Effect utilizing basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency, and each accompanying color phenomenon?

Summary Questions

1. What will be the relationships between non-art majors and art majors with respect to the seventeen variables?

2. How will the responses of the questionnaire of the non-art majors and the art majors relate to the responses from the binocular visual acuity chart, color deficiency rating, and color phenomena presentation?

Answers to the Questions of Inquiry

Hue Identification

How will non-art majors and art majors respond in identifying basic hues and values presented consecutively, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

Non-art majors.--The results of the "Isoline Color Phenomenon Presentation" are presented in Table III. The per cent consensus and the secondary answers were recorded as average percents for each color phenomenon for the non-art majors and for the art majors. In identifying basic hues and values presented consecutively, the non-art majors responded with a 99.5 per cent consensus answer and .5 per cent secondary answer. In short, the majority of the non-art majors responded with the same answers.

The correlation coefficients of all seventeen variables for the non-art majors are shown in Appendix J. There were no significant correlations ($P < .05$) between consecutive color identification, binocular visual acuity, nor color deficiency rating.

Consecutive color identification had a perfect correlation coefficient (1.000) with simultaneous color identification. Also, consecutive color identification correlated with successive color identification (.5504, $P < .01$), with simultaneous color comparison on a black-white ground (.4353, $P < .01$), and with simultaneous color comparison on color grounds (.4506, P .01). In addition, consecutive color identification correlated with mixed color identification (.4003, $P < .02$). According to Garrett (1, p. 176), correlation coefficients from .40 to .70 are substantial or marked relationships and .70 to 1.00 are high to very high.

Art majors.--Table III shows that the art majors, identifying basic hues and values presented consecutively, responded with a 99.5 per cent consensus answer and a .5 per cent secondary answer. The majority of the art majors responded with the same answers.

The correlation coefficients (in Appendix K) showed no significance ($P < .05$) when consecutive color identification was related to binocular visual acuity and color deficiency rating.

In the art majors, consecutive color identification correlated with simultaneous color identification (.4287, $P < .01$) and Bezold Effect identification (.3357, $P < .05$). In Garrett's (1, p. 176) description of correlation coefficients, .40 to .70 indicates a substantial or marked relationship.

How will the non-art majors and art majors respond in identifying basic hues and values presented simultaneously, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

Non-art majors.--Table III showed that the non-art majors, identifying basic hues and values simultaneously, responded with a 99.8 per cent consensus answer and .2 per cent secondary answer. The majority of the non-art majors responded with the same answers.

The results of the correlation coefficients (in Appendix J) show no significant correlation ($P < .05$) between simultaneous color identification, binocular visual acuity, nor color deficiency rating. Simultaneous color identification correlated with successive color identification (.5004, $P < .01$), mixed color identification (.4007, $P < .02$), simultaneous color comparison on color grounds (.4506, $P < .01$). According to Garrett (1, p. 176), these correlation coefficients from .40 to .70 show substantial relationships.

Art majors.--Table III shows that the art majors, identifying basic values and hues presented simultaneously, responded with a 99.5 per cent consensus answer and a .5 per cent secondary answer. The majority of the art majors responded with the same answers.

The correlation coefficients (in Appendix K) showed no significance ($P < .05$) when simultaneous color identification was correlated with binocular visual acuity and with color deficiency rating. Appendix K showed no significant correlation coefficients ($P < .05$) for the art majors when simultaneous color identification was correlated with each of the accompanying phenomena.

Successive Color Contrast

How will non-art majors and art majors respond in identifying successive color contrast of basic hues and values, and how will their responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

Non-art majors.--The non-art majors responded with a 65 per cent consensus answer and an 18 per cent secondary answer in identifying successive color contrasts. (This is shown on Table III.) Third and fourth place answers accounted for the remaining percentage. The majority of the non-art majors responded with the same answers.

The coefficients in Appendix J showed no significant correlations ($P < .05$) when successive color contrast identification was correlated with binocular visual acuity and color deficiency rating. Successive color contrast identification correlated with mixed color identification (.4836, $P < .01$), simultaneous color comparisons on black-white ground (.4446, $P < .01$), and simultaneous color comparisons on color grounds (.5706, $P < .01$). Garrett (1, p. 176) says these coefficients from .40 to .70 show substantial or marked relationships.

Art majors.--The art majors responded with a 71 per cent consensus answer and an 18 per cent secondary answer. (This is shown on Table III.) The majority of the art majors responded with the same answers.

The coefficients (in Appendix K) showed that successive color contrast identification did not correlate significantly $(P < .05)$ with binocular visual acuity nor with color deficiency rating in the art major group.

There was a significant correlation between successive color contrast identification and mixed color identification (.4458, $P < .01$). Garrett (1, p. 176) says a correlation coefficient from .40 to .70 indicates substantial or marked relationship.

Mixed Color Contrast

How will the non-art majors and art majors respond in identifying mixed color contrast of basic hues and values, and will these responses relate to their binocular visual acuity, color deficiency rating and each accompanying color phenomenon?

Non-art majors.--The non-art majors responded with a 56 per cent consensus answer and 19 per cent secondary answer. (This is shown in Table III.) The majority of non-art majors gave the same answers.

Mixed color identification had no significant correlation ($P < .05$) with binocular visual acuity nor with color deficiency rating. (This is shown in Appendix J.) There were no significant correlations ($P < .05$) between mixed contrast identification and any of the accompanying phenomena.

Art majors.--In identifying mixed color contrast of basic hues and values, the art majors responded with a 62 per cent consensus answer and a 19 per cent secondary answer. (This is shown in Table III.) The majority of the art majors gave the same answers.

Mixed color contrast identification had no significant correlation ($P < .05$) with binocular visual acuity nor with color deficiency rating. This is shown in the correlation coefficients in Table III. Mixed color contrast identification correlated significantly with successive color contrast identification (.4458, $P < .01$) in the accompanying color phenomena.

Simultaneous Color Contrast

How will non-art majors and art majors respond in comparing the simultaneous color contrast of basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and each accompanying color phenomenon?

Non-art majors.--Table IV shows that in comparing simultaneous color contrast on a black-white ground the non-art majors responded with a 79 per cent consensus answer and a 22 per cent secondary answer. In comparing simultaneous color contrast on color grounds, they answered with a 71 per cent consensus answer and a 28 per cent secondary answer. In both cases, the majority of the non-majors' answers were the same.

Simultaneous color contrast comparisons either on black-white or color grounds had no significant correlation ($P < .05$) with binocular visual acuity nor with color deficiency rating.

In examining the correlation coefficients, Appendix K shows that simultaneous color comparison on a black-white ground score correlated with simultaneous color comparison on color grounds (.7985, $P < .01$). Garrett (1, p. 176) labels the .70 to 1.00 range as a high to very high relationship.

Art majors.--In comparing simultaneous contrast on a black-white ground, the art majors responded with an 82 per cent consensus answer and a 17 per cent secondary answer. The simultaneous color contrast comparisons on color grounds yielded a 76 per cent consensus and a 23 per cent secondary answer. In both cases the majority gave the same answers.

The simultaneous color contrasts (black-white and color grounds) had no significant correlation ($P < .05$) with binocular visual acuity and with color deficiency rating.

In the art majors, simultaneous color contrast comparisons on black-white and color grounds were significantly correlated (.8618, $P < .01$). Garrett (1, p. 176) describes this relationship as high to very high.

Advancing-receding Color

How will the non-art majors and art majors respond in identifying advancing-receding colors of basic hues and values on a grey ground, and how will these responses relate to their binocular visual acuity, color deficiency rating, and to each of the accompanying color phenomena?

Non-art majors.--(This is shown in Table III.) The non-art majors responded with a 42 per cent consensus answer and a 22 per cent secondary answer. Less than the majority gave the same answers.

The advancing-receding color identifications on a grey ground had no significant correlation ($P < .05$) with binocular visual acuity or color deficiency. (This is presented in Appendix J.) There were no significant correlations with any of the color phenomena in the non-art majors group.

Art majors.--The art majors responded with a 59 per cent consensus answer and an 18 per cent secondary answer in identifying advancing-receding hues and values on a grey ground. The majority of the art majors responded with the same answers. (This is shown on Table III.)

There was no significant correlation ($P < .05$) between identifying advancing-receding color on a grey ground and color deficiency rating. However, there was found (see Table III) a significant correlation coefficient between advancing-receding color and binocular visual acuity (.3357, $P < .05$). According to Garrett (1, p. 176), this is a low, slight relationship.

Bezold Effect

How will the non-art majors and art majors respond in identifying the Bezold Effect utilizing basic hues and values, and how will these responses relate to their binocular visual acuity, color deficiency rating, and to each accompanying color phenomenon?

Non-art majors.--From Table III it was seen that the non-art majors responded with a 97 per cent consensus answer and a 2 per cent secondary answer. The majority of them answered with the same responses.

In examining Appendix J, it was found there were no significant correlations ($P < .05$) between the Bezold Effect identification and binocular visual acuity, color deficiency rating, nor any of the accompanying color phenomena.

Art majors.--In Table III, it is shown that in identifying the Bezold Effect utilizing basic hues and values, the art majors responded with a 97 per cent consensus answer and a 2 per cent secondary answer. The majority of them answered with the same responses.

In the examination of Appendix K, the Bezold Effect identification measure in the art majors group correlated to consecutive color identification (.3336, $P < .05$). This was reported in the hue identification section. Garrett (1, p. 176) labels this coefficient a low, slight relationship. There were no significant correlations between the Bezold Effect and binocular acuity and color deficiency rating.

This concludes the presentation, analysis, and discussion of the data collected from the three major instruments, the "Isoline Color Phenomena Presentation," Snellen Visual Acuity Chart, and the Pseudo-Isochromatic Color Plates for Testing Color Perception.

Summary Questions

There were two summary questions posed for this study. They were (1) What will be the relationships between non-art and art majors with respect to the seventeen variables? (2) How will the questionnaire factors of the non-art majors and the art majors relate to the responses from the binocular visual acuity chart, color deficiency rating, and color phenomena presentation?

Between the Groups

The *t*-test was utilized to identify the significant differences between the means of the non-art majors and the

TABLE III

THE "ISOLINE COLOR PHENOMENA PERCEPTION PRESENTATION"
EXPERIENCING COLOR: ANSWERS FROM BOTH
NON-ART AND ART MAJORS

Question		Non-Art Majors N=40				Art Majors N=40			
		Per Cent	Consensus	Per Cent	Secondary	Per Cent	Consensus	Per Cent	Secondary
A. Consecutive Color Identification	1.	100	Yellow			100	Yellow		
	2.	100	Violet			100	Violet		
	3.	98	Red	2	Orange	98	Red	2	Orange
	4.	100	Blue			100	Blue		
	5.	100	Orange			98	Orange	2	Red
	6.	100	Green			100	Green		
	7.	98	White	2	Violet	100	White		
	8.	100	Black			100	Black		
		Av.=99.5	(1918)*	Av.= .5		Av.=99.5	(1917)*	Av.= .5	
B. Simultaneous Color Identification	9.	100	Green			100	Green		
	10.	100	Yellow			100	Yellow		
	11.	98	Violet	2	Yellow	100	Violet		
	12.	100	Red			98	Red	2	Yellow
	13.	100	Orange			100	Orange		
	14.	100	White			100	White		
	15.	100	Blue			98	Blue	2	Green
	16.	100	Black			100	Black		
		Av.=99.8	(1919)*	Av.= .2		Av.=99.5		Av.= .5	

*Total raw score

TABLE III--Continued

Question		Non-Art Majors N=40				Art Majors N=40			
		Per Cent	Consensus	Per Cent	Secondary	Per Cent	Consensus	Per Cent	Secondary
C. Successive Color Contrast Identification	17.	63	Violet	19	Blue	67	Violet	18	Blue
	18.	69	Yellow	9	Blue-green	80	Yellow	16	Other
	19.	45	Blue-green	38	Blue	68	Blue-green	28	Blue
	20.	85	Yellow	8	Orange	90	Yellow	6	Orange
	21.	63	Blue	32	Blue-green	66	Blue	38	Blue-green
	22.	57	Red	9	Violet	50	Red	11	Violet
	23.	56	Gray	16	Black	65	Gray	11	Black
	24.	83	White	13	Nothing	82	White	15	Nothing
		Av.=65	(1620)*	Av.=18		Av.=71	(1675)*	Av.=18	
D. Mixed Color Contrast Identification	25.	58	Dark blue	9	Blue-violet	69	Dark blue	8	Blue-violet
	26.	67	Green	12	Light blue	71	Green	13	Light blue
	27.	47	Yellow-green	41	Light green	53	Yellow green	43	Light green
	28.	47	Orange	17	Light yellow	60	Orange	20	Light yellow
	29.	48	Red-orange	22	Light red	49	Red orange	20	Light red
	30.	51	Light red	34	Violet	50	Violet	31	Light red
	31.	44	Dark green	11	Light green	67	Dark green	11	Light green
	32.	84	Light violet	3	Blue-violet	80	Light violet	3	Dark violet
		Av.=56	(1465)*	Av.=19		Av.=62	(1562)*	Av.=19	

*Total raw score

TABLE III--Continued

Question		Non-Art Majors N-40				Art Majors N=40			
		Per Cent	Consensus	Per Cent	Secondary	Per Cent	Consensus	Per Cent	Secondary
E. Simultaneous Color Contrast Comparison on Black-white Ground	33.1	84	Lighter right	16	Lighter left	88	Lighter right	10	Lighter left
	34.2	(69) 52	Brighter left	31-48	Brighter right	(76) 68	Brighter right	(23) 33	Brighter left
	35.3	71	Different	29	Same	73	Different	27	Same
	36.1	96	Darker left	4	Darker right	92	Darker left	6	Darker right
	37.2	(85) 83	Brighter right	15-18	Brighter left	(86) 89	Brighter right	(13) 11	Brighter left
	38.3	76	Different	24	Same	78	Different	23	Same
	39.1	85	Lighter right	15	Lighter left	85	Lighter right	11	Lighter left
	40.2	(79) 82	Duller left	21-18	Duller right	(85) 93	Duller left	(14) 7	Duller right
	41.3	69	Different	31	Same	76	Different	24	Same
	42.1	98	Darker left	2	Darker right	91	Darker left	6	Darker right
	43.2	(83) 73	Brighter right	17-27	Brighter left	(88) 88	Brighter right	(12) 13	Brighter left
	44.3	79	Different	21	Same	84	Different	16	Same
	45.1	92	Lighter right	8	Lighter left	91	Lighter right	7	Lighter left
	46.2	(78) 58	Duller right	24-42	Duller left	(75) 65	Duller left	(24) 35	Duller right
	47.3	83	Different	23	Same	70	Different	30	Same
	48.1	98	Darker left	3	Darker right	93	Darker left	6	Darker right
	49.2	(80) 65	Brighter right	20-35	Brighter left	(83) 81	Brighter right	(17) 19	Brighter left
	50.3	77	Different	23	Same	75	Different	25	Same
		Av.=79	(3849)*	Av.=21		Av.=82	(3938)*	Av.=17	

Non-Art Majors: Degree of Difficulty	(High Percent--Easier)	Art Majors: Degree of Difficulty	(High Percent--Easier)
92% (1) Value	85% Orange (36-38)	90% (1) Value	Green (42-44)
76% (3) Hue	83% Green (42-44)	81% (2) Intensity	Orange (36-38)
69% (2) Intensity	80% Violet (48-50)	76% (3) Hue	Yellow (39-41)
	79% Yellow (39-41)		Violet (48-50)
	78% Blue (45-47)		Red (33-35)
	69% Red (33-35)		Blue (45-47)

*Total raw score

TABLE III--Continued

	Question	Non-Art Majors N=40				Art Majors N=40			
		Per Cent	Consensus	Per Cent	Secondary	Per Cent	Consensus	Per Cent	Secondary
F. Advancing-receding Color Comparison on a Grey Ground	51	35	Red	33	White	56	White	25	Red
	52	30	Green	25	Orange	64	Yellow	13	Red
	53	42	Orange	18	Yellow	53	Orange	20	Red
	54	23	Orange	19	Yellow	37	Red	23	Orange
	55	43	Green	22	Violet	62	Green	21	Orange
	56	31	Blue	31	Green	52	Blue	19	Violet
	57	48	Violet	19	Blue	58	Violet	18	Blue
	58	83	Black	9	White	86	Black	4	Violet
		Av.=42 (1343)*		Av.=22		Av.=59 (1513)*		Av.=18	

Degree of Difficulty: Non-Art Majors

Per Cent	Consensus
83	Black
48	Violet
43	Green
42	Orange
35	Red
33	White
31	Blue
23	Orange

Degree of Difficulty: Art Majors

Per Cent	Consensus
86	Black
64	Yellow
62	Green
58	Violet
56	White
53	Orange
52	Blue
37	Red

*Total raw score

TABLE III--Continued

Question		Non-Art Majors N=40				Art Majors N=40			
		Per Cent	Consensus	Per Cent	Secondary	Per Cent	Consensus	Per Cent	Secondary
G. Simultaneous Color Comparison on Color Grounds	59 (1)	69	Darker right	31	Darker left	78	Darker right	22	Darker left
	60 (2)	(77) 93	Brighter right	7	Brighter left	(74) 70	Brighter right	30	Brighter left
	61 (3)	70	Different	30	Same	73	Different	27	Same
	62 (1)	73	Darker right	27	Darker left	63	Darker right	37	Darker left
	63 (2)	(70) 74	Brighter right	26	Brighter left	(68) 73	Brighter right	27	Brighter left
	64 (3)	63	Different	37	Same	69	Different	31	Same
	65 (1)	93	Darker left	7	Darker right	93	Darker left	6	Darker right
	66 (2)	(77) 60	Brighter right	40	Brighter left	(85) 76	Brighter right	24	Brighter left
	67 (3)	77	Different	23	Same	85	Different	15	Same
	68 (1)	62	Lighter left	87	Brighter right	83	Lighter left	17	Brighter right
	69 (2)	(63) 73	Duller right	27	Duller left	(81) 87	Duller right	13	Duller left
	70 (3)	54	Different	46	Same	74	Different	26	Same
	71 (1)	92	Lighter right	7	Lighter left	94	Lighter right	5	Lighter left
	72 (2)	(75) 56	Duller right	44	Duller left	(79) 62	Duller left	38	Duller right
	73 (3)	76	Different	24	Same	81	Different	19	Same
	74 (1)	43	Lighter right	48	Lighter left	67	Lighter right	23	Lighter left
	75 (2)	(62) 61	Duller left	33	Duller right	(66) 72	Duller left	20	Duller right
	76 (3)	83	Different	17	Same	60	Different	40	Same
	77 (1)	73	Lighter right	26	Lighter left	87	Lighter right	12	Lighter left
	78 (2)	(72) 72	Duller right	28	Duller left	(77) 61	Duller left	39	Duller right
	79 (3)	71	Different	29	Same	82	Different	18	Same
		Av.=71	(4233)*	Av.=28		Av.=76	(4909)*	Av.=23	

Non-Art Majors — Degree of Difficulty

72%	(1)Value	77%	Violet on blue-orange ground
71%	(3)Hue	77%	Green on yellow-violet ground
70%	(2)Intensity	75%	Blue on white-black ground
		72%	Grey on orange-blue ground
		70%	Orange on red-green ground
		63%	Yellow on black-white ground
		62%	White on red-green ground

Art Majors — Degree of Difficulty

81%	(1)Value	85%	Green on yellow-violet ground
75%	(3)Hue	81%	Yellow on black-white ground
72%	(2)Intensity	79%	Blue on white-black ground
		77%	Grey on orange-blue ground
		74%	Violet on blue-orange ground
		68%	Orange on red-green ground
		66%	White on red-green ground

*Total raw score

TABLE III--Continued

Question		Non-Art Majors N=40				Art Majors N=40			
		Per Cent	Consensus	Per Cent	Secondary	Per Cent	Consensus	Per Cent	Secondary
H. Bezold Effect Identification	80.	79	Orange	21	Other (red and yellow)	94	Orange	3	Other (red and yellow)
	81.	(93) 100	Yellow			(96) 98	Yellow	2	Red
	82.	100	Red			96	Red	3	Orange
	83.	99	Blue-violet	1	Violet	96	Red	4	Violet
	84.	(98) 98	Violet	1	Blue-violet	(97) 96	Violet	3	Blue-violet
	85.	98	Red-violet	2	Violet	98	Red-violet	2	Violet
	86.	98	Dark orange	2	Orange	98	Dark orange	2	Light orange
	87.	(97) 98	Orange	2	Light orange	(96) 98	Orange	1	Light orange
	88.	96	Light orange	2	Dark orange	91	Light orange	2	Dark orange
	89.	97	Violet	1	Red	98	Violet	1	Red
	90.	(99) 100	Red			(99) 99	Red	1	Violet
	91.	99	Blue	1	Red	99	Blue	1	Violet
	92.	100	Grey			97	Grey	2	Other
	93.	(100) 99	White	1	Other	(98) 99	White	1	Other
	94.	100	Black			98	Black	1	White
		Av.=97	(3577)*	Av.=2		Av.=97	(3578)*	Av.=2	

Non-Art Majors — Degree of Difficulty

Per Cent	Consensus
100	Grey, white, black
99	Violet, red, blue
98	Blue-violet, violet, red-violet
97	Dark-orange, orange, light-orange
93	Orange, yellow, red

Art Majors — Degree of Difficulty

Per Cent	Consensus
99	Violet, red, blue
98	Grey, white, black
97	Blue-violet, violet, red-violet
96	Orange, yellow, red
96	Dark-orange, orange, light-orange

*Total raw score

art majors on all variables. The t values are presented in Table IV, Analysis of Variance Between the Groups. The art majors showed a statistically significant difference between the means in seven instances. This significant difference between the means is reflected in the t values of the variables. Art hours (t equals 12.0258) was significant at the .01 level. This meant that the art majors accumulated more art hours than the non-art majors. Corrected vision (t equals 2.0564) was significant at the .05 level. This indicated that fewer art majors wore correcting lenses. Seating distance C, third administration of the "Isoline Color Phenomena Presentation" (t equals 2.6312) was significant at the .02 level. This indicates that the art majors sat further from the ICPP test on the third administration. The color deficiency rating difference between the means (t equals 2.3647) was significant at the .02 level. This would indicate that the art majors scored higher on the color deficiency test than the non-art majors. The mixed color identification response (t equals 2.4365) was significant at the .01 level. This indicates significantly higher scores for the art majors. In identifying advancing-receding colors on a grey ground (t equals 3.2772), the response was significant at the .01 level. This indicates significantly higher scores for the art majors than for the non-art majors. In comparing simultaneous color contrasts on color grounds (t equals 2.2062), the art majors' scores were significant at

TABLE IV

MEANS, STANDARD DEVIATIONS, AND RESULTS OF TEST
OF SIGNIFICANCE BETWEEN THE MEANS
NON-ART MAJORS AND ART MAJORS

Variable	Non-Art Group		Art Group		d.f.	t
	M	S.D.	M	S.D.		
1. Grade Level	14.75	1.15	14.98	1.10	78	.8955
2. Sex	1.25	.44	1.35	.48	78	.9694
3. Art Hours Completed	1.10	1.45	22.43	11.12	78	12.0258*
4. Corrected Vision	1.45	.50	1.68	.47	78	2.0564***
5. Seating Distance A	8.80	2.40	7.92	2.05	78	1.3350
6. Seating Distance B	8.22	2.43	8.67	2.46	49	.6872
7. Seating Distance C	7.24	1.70	8.55	2.14	57	2.6312**
8. Visual Acuity	49.85	6.75	47.75	6.68	60	1.3991
9. Color Deficiency	12.45	1.88	13.28	1.15	78	2.3647**
10. Consecutive Color I.D.	47.95	.32	47.93	.35	78	.3352
11. Simultaneous Color I.D.	47.97	.16	47.98	.16	78	.0
12. Successive Color	40.50	4.05	41.88	3.54	78	1.6167
13. Mixed Color	36.62	4.70	39.05	4.18	78	2.4365*
14. Simultaneous Color-White Ground	96.22	7.91	98.45	9.67	78	1.1266
15. Advancing-Receding Color-Grey Ground	33.58	5.49	37.83	6.09	78	3.2772*
16. Simultaneous Color-Color Ground	105.83	8.94	110.23	8.90	78	2.2062***
17. Bezold Effect	89.43	1.38	89.45	1.40	78	0.0807

*.01 level of significance
**.02 level of significance
***.05 level of significance

the .05 level. This indicates a significantly higher response by the art majors than by the non-art majors.

Within the Groups

Non-art majors.--In the examination of the correlation coefficients (in Appendix J), grade level of non-art majors was significantly correlated with their seating distance in the third administration (.3579, $P < .05$). This meant that non-art majors with high grade levels sat further distances from the color phenomena on the third administration. In this group, art hours completed significantly correlated with successive color contrast identification (.3930, $P < .02$), mixed color contrast identification (.4590, $P < .01$), and advancing-receding colors on a grey ground (.3571, $P < .05$). Garrett describes coefficients from .20 to .40 as showing present but slight correlations and those from .40 to .70 as showing substantial or marked correlations (1, p. 176).

Art majors.--Within the art majors, it is shown (in Appendix K) that the grade levels were significantly correlated with the seating distance on the third administration (.3809, $P < .05$). This meant the high grade levels of the art majors were related with the further seating distance from the color phenomena on the third administration. The seating distance A (first administration of the color phenomena presentation) correlated significantly with seating distance B (second administration) (.4405, $P < .01$) and seating distance C (third administration) (3201, $P < .05$). This suggested that the art majors sat at nearly the same distance on each administration. Garrett (1, p. 176) labels coefficients from .20 to .40 as showing substantial or marked correlations. Also, seating C (third administration) significantly correlated with simultaneous color comparisons on a black-white ground (.3537, $P < .05$). In addition, binocular visual acuity significantly correlated with color deficiency rating (.3733, $P < .02$) and advancing-receding colors on a grey ground (.3357, $P < .05$). This suggested those art majors with better vision performed better on the color deficiency test and advancing-receding color comparison. Garrett would label them both as present but slight relationships.

This concludes the examination of the non-art majors' and art majors' responses on the color phenomena presentation, binocular visual acuity, color deficiency rating, and questionnaire factors.

Additional Findings

Some rather low, but infrequent, scores appeared primarily on the _Snellen Visual Acuity Chart_ and the _Pseudo-Isochromatic Plates for Testing Color Perception_ both among the non-art major and art major groups. It was interesting and informative to track down the low scores of visual acuity and color deficiency and see how the individuals did on the accompanying color phenomena. Several low-scoring subjects of both groups were examined to see how they responded individually.

From the Snellen Visual Acuity Chart (Appendix L and Appendix M) and the Pseudo-Isochromatic Plates for Testing Color Perception (Appendix N and Appendix O) the less than normal scores were selected and examined.

Non-art major subject number 11 scored a 55 on the Snellen Visual Acuity Chart Scores, approximately five above the mean. (See Appendix L.) The same person scored a low four on the Pseudo-Isochromatic Plates for Testing Color Perception. (See Appendix N.) This was eight points below the mean. The low color deficiency score seemingly did not affect the response on the color phenomena. (See Appendix P under Color Phenomena Consensus.) The respondent was at the 83 per cent consensus which was higher than the average either of the non-art or art major groups. (See Table V under Average Consensus Scores.)

Let us take a look at non-art major number 35. (See Appendix P.) The respondent scored a 29 on the Snellen Visual Acuity Chart. This was slightly lower than normal. The same person scored a 12 on the Pseudo-Isochromatic Plates for Testing Color Perception. This was two points above normal. This person had an 87 percent concensus which was higher than the average of either group.

TABLE V

COLOR PHENOMENA DEGREE OF DIFFICULTY

Color Phenomena	Non-Art Major Consensus Per Cent	Art Major Consensus Per Cent
A. Consecutive Color Identification	99.8	99.5
B. Simultaneous Color Identification	99.5	99.5
C. Bezold Effect Color Identification	97	97
D. Simultaneous Color Comparison on Black-White Ground	79	82
E. Simultaneous Color Comparison on Color Grounds	71	76
F. Successive Color (Afterimage) Identification	65	71
G. Mixed Color (Mixing Afterimages) Identification	56	62
H. Advancing-receding Color Comparison	42	59

VISUAL ACUITY AND COLOR DEFICIENCY DEGREE OF DIFFICULTY

I. Color Deficiency Rating	88.9	95
J. Visual Acuity	81.7	76.6

Now, let us examine the results of art major number 14 who scored less than normal, a 27, on the Snellen Visual Acuity Chart and a perfect 14 on the color deficiency rating. (See Appendix P.) The same person scored a 90 per cent consensus on the accompanying color phenomena.

The other art major, number 29, scored a high 56 on the Snellen Visual Acuity Chart and a deficient 8 on the color deficiency rating. (See Appendix P.) However, the same person scored 86 per cent consensus on the accompanying color phenomena. This was above the average of either group.

It seemed that in several cases where the respondent scored low on the visual acuity and color deficiency, this did not indicate difficulty with identifying and comparing color phenomena.

Let us examine (in Table III) the most frequent responses given on the color phenomena presentation. When the respondents answered in the consensus response, it is quite understandable; but when they gave a secondary response (or other), certain influential factors can be assumed.

Consecutive Color Identification

Question 3.--One respondent identified red as an orange. Assumption: The red used in the presentation was a slightly orangish red.

Question 7.--One respondent identified white as a violet. Assumption: A probable error in circling "violet," next to the answer "white."

Simultaneous Color Identification

Question 11.--One respondent identified violet as yellow. Assumption: The respondent made an error in circling Question 10 and miscircled "yellow" on Question 11, directly below.

Question 12.--One respondent identified red as yellow. Assumption: No logical explanation. Had to be gross misjudgment in circling the response because the red and yellow are very different and would be difficult to confuse.

Question 15.--One respondent identified blue as green. Assumption: Blue is analogous to green, easily confused, or the respondent hurriedly encircled "green" which is next to "blue."

Successive Color Identification

Question 17.--Blue was confused with analogous color, violet, or the respondents encircled incorrectly the neighboring answer.

Question 18.--Blue-green was confused with yellow or the respondent encircled hurriedly the neighboring answer. Nothing was seen by a few respondents. When nothing is seen, it is assumed the respondent truly saw nothing or did not concentrate enough.

Questions 19-23.--Blue was confused with blue-green, orange with yellow, violet with red, and gray with black. In all cases, a confusion of analogous colors occurred.

Question 24.--An intense white on white was seen by most. Some could not see the contrast or lacked concentration.

Mixed Color Identification

Question 25-29.--Blue-violet confused with a dark blue, light blue with a green, light-green with yellow-green, light-yellow with orange, light red with red-orange. In all cases, a confusion of analogous colors occurred.

Question 30.--The art-major and non-art major responded oppositely on this observation. Violet confused with light red is an analogous confusion. This is the only observation where the two groups disagreed on a consensus. The problem was mixing the after-image of orange (blue) on an orange ground, resulting in a violet response.

Question 31.--Light green was confused with dark green, an analogous confusion.

Question 32.--A blue-violet and dark violet were confused with a light violet, an analogous confusion.

Simultaneous Color Comparison on a Black-white Ground

Questions 33-50.--In comparing basic hues and values on a black-white ground, in all cases, both groups agreed on the consensus observation but with varying percentages.

Both groups compared values easier. The non-art group had an easier time with hues and more difficulty with intensities, whereas the art group had an easier time with intensities and more difficulty with hues. (See questions 33-50, Degree of Difficulty, Table III.)

In comparing particular colors, the non-art group compared first orange, then green more easily than they compared violet, yellow, blue, and red. The art group compared with less difficulty green, then orange followed by yellow, violet, red, and blue. (See questions 33-50, Degree of Difficulty, Table III.)

Questions 51-58.--In comparing advancing-receding basic hues and values on a grey ground the art majors, in consensus observation, placed them in the expected order--white, yellow, orange, red, green, blue, violet, and lastly black. The non-art majors confused questions 52-54; rather than observing the expected yellow, orange, red, they responded--green, orange, and yellow. The non-art majors confused yellow, orange, and green--all somewhat analogous in intensity, value, and hue with exception of green in hue. The only observation in which the two groups agreed was the placement of black seemingly the farthest from the respondents. (See Table III, questions 51-58, Degree of Difficulty.)

Questions 59-79.--In comparing basic hues and values on color grounds, in all cases both groups agreed on the consensus observations but with varying percentages. (See Table III, questions 59-79.)

Both groups compared values, hues, and intensities with the same degree of difficulty but in varying percentages. (See Table V, Degree of Difficulty--non-art and art majors.)

In comparing particular colors, the two groups compared with similar degrees of difficulty the colors blue on white-black ground, grey on orange-blue ground, and white on red-green ground. They varied considerably on the remaining colors and grounds. (See Table III, Degree of Difficulty under non-art and art majors.)

Questions 80-94.--In identifying basic hues and values utilized for the Bezold Effect, the non-art majors and art majors, in all cases, agreed on the consensus observation but with varying percentages. (See Table III, questions 80-94 under non-art and art majors.)

In identifying basic hues and values of the Bezold Effect, the two groups varied somewhat in the degree of difficulty. The non-art groups had an easier time with the grey, white, black grouping followed by the violet, red, blue grouping, whereas the art group switched the two observations. Both groups responded about the same on the blue-violet, violet, and red-violet grouping--it was the median difficulty. Both groups responded similarly in identifying the oranges. The non-art majors had dark-orange,

orange, light-orange in fourth position followed by the orange, yellow, and red grouping; again, the art group had them in reverse order. (See Table III, Degree of Difficulty under non-art and art majors.) In most cases, secondary observations represented a confusion of analogous, similar colors or incorrect circling of responses. In question 80, both groups named "other" for a secondary response and in most cases both red and yellow (rather than orange) were given.

In addition to the scanning and analyzing of the more obvious aspects of the descriptive data, a degree of difficulty seems to establish itself when summarizing all the consensus observations in both the non-art and art majors. (See Table V, Color Phenomena Degree of Difficulty.) A common degree of difficulty appears. Within both groups, A. Consecutive Color Identification appears easiest, followed by B. Simultaneous Color Identification, C. Bezold Effect Color Identification, D. Simultaneous Color Comparison on Black-white Ground, E. Simultaneous Color Comparison on Color Grounds, F. Successive Color (Afterimages) Identification, G. Mixed Color (Mixing Afterimages) Identification, H. Advancing-receding Color Comparison, and the most difficult, I. Advancing-receding Color Comparison.

Both the statistically significant data and the descriptive aspects of the findings have been presented, analyzed and discussed. This concludes the presentation, analysis, and discussion of the collected data.

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CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

The problem of this study was to ascertain the effects of selected color phenomena upon the identification and comparison of color by college students.

The purposes of this study were to (1) select appropriate color phenomena, (2) design and construct a basic color presentation utilizing color phenomena, (3) design and construct an accompanying response sheet, (4) ascertain the effects of selected color phenomena upon the identification and comparison of color by two groups of college students--one of non-art majors and the other of art majors, and (5) compare the responses of the respondents' visual acuity and color deficiency rating to the responses of a color phenomena presentation.

Instruments used for collecting data for this study were the _Snellen Visual Acuity Chart_ which measures crudely the binocular vision of an individual; _Pseudo-Isochromatic Plates for Testing Color Perception_, which roughly determine red-green color deficiency; and the "Isoline Color Phenomena Perception Presentation," which determines how an individual would identify or compare specific color phenomena such as consecutive color identification, simultaneous color identification, successive color identification, mixed color identification, simultaneous color comparison on a black-white ground, advancing-receding color comparison on a grey ground, simultaneous color comparison on color grounds, and the identification of colors by the Bezold Effect. In addition to the three instruments mentioned above, a questionnaire was used to gather general information concerning each individual participant.

Data were collected from two college-level populations ranging from freshmen to graduate students. One group comprised non-art majors who had not completed over six hours of art on a college level and one group comprised art majors who had completed not less than twelve hours of college art. The participants from each group were volunteers both from intact art class students and at-large college students. Initially, there were fifty participants in each group. The samplings were finally trimmed to forty non-art majors and forty art majors in each of the groups. The two groups represented samplings from one major state university and two major private universities.

There were four different testing periods. During the first week, the _Snellen Visual Acuity Chart_ and the _Pseudo-Isochromatic Plates for Testing Color Perception_ were administered to both the non-art major and art major groups. After one week passed, the "Questionnaire" and the "Isoline Color Phenomena Perception Presentation" (ICPP) were administered to the two groups. The "Questionnaire" and the "ICPP Presentation" were administered the second and third times at one week intervals. (See Figure 8.)

Initially, thirty-three variables were utilized in the collection of data. They were (1) grade level, (2) sex, (3) art hours completed, (4) presence or absence of corrected vision, (5) distance from the "ICPP Presentation" at the first administration, (6) distance from the "ICPP Presentation" at the second administration, (7) distance from the "ICPP Presentation" at the third administration, (8) Snellen Chart, (9) Pseudo-Isochromatic Plates, (10) consecutive color identification, first administration, (11) consecutive color identification, second administration, (12) consecutive color identification, third administration, (13) simultaneous color identification, second administration, (14) simultaneous color identification, second administration, (15) simultaneous color identification, third administration, (16) successive color identification, first administration, (17) successive color identification, second administration, (18) successive color identification, third administration, (19) mixed color identification, first administration, (20) mixed color identification, second administration, (21) mixed color identification, third administration, (22) simultaneous color comparison on black versus white ground, first administration, (23) simultaneous color comparison on black versus white ground, second administration, (24) simultaneous color comparison on black versus white ground, third administration, (25) advancing-receding color on a grey ground, first administration, (26) advancing-receding color on a grey ground, second administration, (27) advancing-receding color on a grey ground, third administration, (28) simultaneous color comparison on color grounds, first administration, (29) simultaneous color comparison on color grounds, second administration, (30) simultaneous color comparison on color grounds, third administration, (31) Bezold Effect color identification, first administration, (32) Bezold Effect color identification, second administration, and (33) Bezold Effect color identification, third administration.

Subsequently, due to the lack of significant differences between the means on the repeated measures in the color phenomena presentation, the repeated measures were combined within each group and treated as single measures. Consequently, variables ten through thirty-three became ten through seventeen. This reduced the number of variables from thirty-three to seventeen on subsequent tests of significance. The seventeen variables represent the data collected, tabulated, presented, and analyzed.

Responses of the participants from the "Isoline Color Phenomena Perception Presentation" were reported as per cent consensus answers (majority answers) and per cent secondary answers (answers occurring second to the majority). The correlation coefficients were identified and reported as being significant at the .01, .02, or .05 level. The significant difference between the means for the non-art majors and art majors were reported as *t* values and identified as being significant at the .01, .02, or .05 level.

An abbreviated version of the original questions of inquiry is formulated and posed in order to summarize the answers to the questions of inquiry. How will the non-art majors and art majors respond both within and between the groups in identifying and comparing color phenomena and how will these responses relate to binocular visual acuity, color deficiency rating, each accompanying color phenomenon, and questionnaire responses?

Answers from Color Phenomena Presentation

Within the non-art majors.--In identifying and comparing color phenomena, the non-art majors responded with an average 76 per cent consensus answers. (See Table V.)

Consecutive color identification correlated with simultaneous color identification (1.000 equals perfect), successive color identification (.5004, $P < .01$), simultaneous color comparison on a black versus white ground (.4353, $P < .01$), simultaneous color comparison on color grounds

(.4506, $P < .01$), and mixed color identification (.4003, $P < .02$).

Simultaneous color identification correlated with successive color identification (.5004, $P < .01$), mixed color identification (.4007, $P < .02$), simultaneous color comparison on a black versus white ground (.4353, $P < .01$), and simultaneous color comparison on color grounds (.4506, P.< .01).

Successive color contrast identification correlated with mixed color identification (.4836, $P < .01$), simultaneous color comparison on a black versus white ground (.4446, $P < .01$), and simultaneous color comparison on color grounds (.5706, $P < .01$).

Simultaneous color comparison on a black versus white ground correlated with simultaneous color comparison on color grounds (.7985, $P < .01$). Garrett labels correlation coefficients from .40 to .70 as substantial or marked and from .70 to 1.00 as high to very high relationships (1, p. 176).

Within the art majors.--In identifying and comparing color phenomena, the art majors responded with an average 81 per cent consensus answers. (See Table V.)

In the art majors, consecutive color identification correlated with simultaneous color identification (.4287, $P < .01$) and the Bezold Effect identification (.3357, $P < .05$).

There was a significant correlation between successive color contrast identification and mixed color contrast identification (.4458, $P < .01$).

In the art majors, simultaneous color contrast comparisons on black versus white correlated with simultaneous color contrast comparison on color grounds (.8618, $P < .01$). Also, it was found that advancing-receding color identification on a grey ground correlated with the art majors' binocular visual acuity (.3357, $P < .05$). Garrett describes correlation coefficients ranging from .20 to .40 as present but slight, from .40 to .70 as substantial or marked, and .70 to 1.00 as high to very high relationships (1, p. 176).

Between the groups.--The art majors showed a significant difference between the means in seven instances. (See Table IV.) The significant difference between the means is reflected in the *t* values of the particular variable. Accumulated art hours (*t* equals 12.0258) was a significant variable at the .01 level. Corrected vision (*t* equals 2.0564) was significant at the .05 level. Seating distance, third administration of the "Isoline Color Phenomena Perception Presentation" (*t* equals 2.6312) was significant at the .02 level. For the color deficiency rating (*t* equals 2.3647), it was found to be significant at the .02 level. The mixed color contrast identification response (*t* equals 2.4365) was significant at the .01 level. In identifying advancing-receding colors on a grey ground (*t* equals

3.2772), the response was significant at the .01 level. In the comparison of simultaneous color contrasts on color grounds (t equals 2.2062), the art majors' difference between the means was significant at the .05 level.

Answers from the Questionnaire

Within the non-art majors.--Grade level of the non-art majors correlated with the seating distance of the color phenomena presentation's third administration (.3579, $P < .05$). Completed art hours had a significant relation with successive color contrast identification (.3930, $P < .02$), mixed color contrast identification (.4590, $P < .01$), and advancing-receding color identification on a grey ground (.3571, $P < .05$). Garrett suggests correlation coefficients ranging from .20 to .40 as present but slight and from .40 to .70 as substantial or marked relationships (1, p. 176).

Within the art majors.--In the art majors' group, grade levels were significantly correlated with seating distance, third administration of the color phenomena presentation (.3809, $P < .05$). Seating distance, first administration of the color phenomena presentation, had a significant correlation to second administration seating distance (.4405, $P < .01$) and to third administration seating distance (.3201, $P < 050$). Also, the third administration seating distance or the color phenomena presentation correlated with simultaneous color comparison on a black versus white ground (.3537, $P < .05$). In addition, the art majors' binocular visual acuity correlated significantly with their color deficiency rating (.3733, $P < .02$) and advancing-receding colors on a grey ground (.3357), $P < .05$). Garrett suggests correlation coefficients ranging from .20 to .40 as present but slight and from .40 to .70 as substantial or marked relationships (1, p. 176).

This concludes the summary of the responses of the non-art majors and art majors tabulated from the color phenomena presentation, binocular acuity test, color deficiency test, and questionnaire.

Additional Findings from the Color Phenomena Presentation

In both the non-art major and art major group there appeared a degree of difficulty in identifying and comparing color phenomena. This is shown in Table V. All respondents dealt more easily with consecutive color identification, followed in order of increasing difficulty, by simultaneous color identification, Bezold Effect identification, simultaneous color comparison on a black versus white ground, simultaneous color comparison on color grounds, successive color identification, mixed color identification, and--most difficult--advancing-receding color identification. At the bottom of Table V it is shown that both groups had more difficulty with color deficiency rating than with binocular visual acuity.

Now, let us look at the more specific findings from the color phenomena presentation. In consecutive color identification and simultaneous color identification, respondents confused similar hues or encircled the wrong response. In successive color and mixed color identification, respondents confused analogous hues or encircled their response hurriedly. Some of them saw nothing at times or did not answer. This is observed in Table III.

In the simultaneous color comparison on a grey ground, both groups compared values more easily than they compared hues or intensities. The non-art group dealt more easily with hues and less easily with intensities; on the other hand, the art groups dealt more easily with intensities and less easily with hue comparisons. In comparing colors on a black-white ground, the non-art majors fared better on the orange hues, values, and intensities; whereas, the art majors had better comparisons on green. (See Table III.)

In the advancing-receding color comparisons on a grey ground, the non-art majors had more difficulty putting yellow, orange, and red in proper placement. In the consensus observation, the art majors placed the advancing-receding colors in the expected order--white, yellow, orange, red, green, blue, violet, and lastly black.

In the simultaneous color comparisons on color grounds, both the non-art group and the art group had an easier time with values than with hues or intensities, in that order. They compared the blue, grey, and white with similar degrees of difficulty. This is shown in Table III.

In the Bezold Effect identification of basic hues and values, both the non-art group and the art group, in all cases, agreed on the consensus observation as the degree of difficulty but varied in percentages. The non-art group dealt more easily with the grey, white, black grouping; the art group, on the other hand, had an easier time with the violet, red, blue grouping. Both groups had more difficulty identifying visual mixtures of yellow, orange, and red.

Conclusions

The findings of this study apply to the population studied, but they do have certain general implications for similar groups.

It may be concluded that participants who experience success in identifying colors presented consecutively will tend to have similar success in identifying colors presented simultaneously.

Participants who succeed in identifying successive color contrast will tend to identify mixed color contrast with equal success.

Participants who succeed in comparing simultaneous color contrast on a black versus white ground will tend to have similar success in comparing simultaneous color contrast on color grounds.

The student of art will tend to perform better on the color deficiency test than will the non-art student.

The student of art will tend to perform better than the non-art student in identifying mixed color contrast, comparing advancing-receding colors on a grey ground, and comparing simultaneous color contrast on color grounds.

The student of art and the non-art student will tend to perform with similar success in the establishment of a degree of difficulty in identifying and comparing color phenomena.

Recommendations for Further Study

1. Replicate the study in the near future on the college level.

2. Consider the possibility of administering the study to other age levels.

3. In an additional study, consider the possibility of establishing a control group rather than two different groups.

4. Do not use repeated measures on the color phenomena presentation.

5. Transfer the cue card images in the color phenomena presentation to color slides, which would allow for larger groups of participants.

6. Consider the possibility of redesigning the color phenomena presentation.

7. Eliminate one section of the hue identification--either the consecutive or simultaneous presentation.

8. Consider the possibility of designing a course on color at the college level by utilizing the experience of this study.

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APPENDIX

APPENDIX A

QUESTIONNAIRE AND GENERAL DIRECTIONS

Name____
Address____ Phone__________
City____ Zip code__________

Circle your grade level. 1 2 3 4 5 6 7 8 9 10 11 12 Fr. Soph. Jr. Sr.
Circle your sex. male female
Circle the number of art course hours completed in college.

Art education	3	6	9	12
Drawing	3	6	9	12
Life Drawing	3	6	9	12
Design and Color	3	6	9	12
Painting	3	6	9	12
Art Appreciation	3	6	9	12
Art History	3	6	9	12
Crafts	3	6	9	12

Circle the appropriate response for each question concerning your vision.

First administration:

Do you wear corrective lenses?	yes	no	
Are you wearing corrective lenses?	yes	no	
Are you color blind?	yes	no	don't know

Second administration:

Are you wearing corrective lenses?	yes	no

Third administration:

Are you wearing corrective lenses?	yes	no

Please read carefully

You will be asked to identify or compare basic colors appearing on cue cards. It will require complete concentration. You will be given ample time to read each question, identify or compare colors, and "circle" your answer. Each cue card will be presented only one time. The same procedure will be used for each question. If you have difficulty responding on time, leave it blank and get ready for the next question.

There are no right or wrong answers. Circle the answers which appear to be what you observe.

Thank you for your cooperation.

EXPERIENCING COLOR

A. Circle the color that appears on each card presented.

1.	red	orange	yellow	green	blue	violet	white	black	gray
2.	red	orange	yellow	green	blue	violet	white	black	gray
3.	red	orange	yellow	green	blue	violet	white	black	gray
4.	red	orange	yellow	green	blue	violet	white	black	gray
5.	red	orange	yellow	green	blue	violet	white	black	gray
6.	red	orange	yellow	green	blue	violet	white	black	gray
7.	red	orange	yellow	green	blue	violet	white	black	gray
8.	red	orange	yellow	green	blue	violet	white	black	gray

B. A gray card with eight color blocks will be presented. Circle the color appearing above each number corresponding with the question number appearing below.

9.	red	orange	yellow	green	blue	violet	white	black	gray
10.	red	orange	yellow	green	blue	violet	white	black	gray
11.	red	orange	yellow	green	blue	violet	white	black	gray
12.	red	orange	yellow	green	blue	violet	white	black	gray
13.	red	orange	yellow	green	blue	violet	white	black	gray
14.	red	orange	yellow	green	blue	violet	white	black	gray
15.	red	orange	yellow	green	blue	violet	white	black	gray
16.	red	orange	yellow	green	blue	violet	white	black	gray

C. Stare continually at the color block on each card presented. When the card is flipped over, continue staring at the same spot until a color appears. The color appearing will be very light. For each card circle the color that appears on the blank white side. If nothing appears, circle the word, nothing. Blank is for write-in responses.

17.	red	orange	yellow	blue-green	blue	violet	nothing	other__________
18.	red	orange	yellow	blue-green	blue	violet	nothing	other__________
19.	red	orange	yellow	blue-green	blue	violet	nothing	other__________
20.	red	orange	yellow	blue-green	blue	violet	nothing	other__________
21.	red	orange	yellow	blue-green	blue	violet	nothing	other__________
22.	red	orange	yellow	blue-green	blue	violet	nothing	other__________
23.	white	black	gray	nothing	other________			
24.	white	black	gray	nothing	other________			

D. Stare continually at the color block that is shown on each card. When the card is flipped, a different color will be on the opposite side. Continue staring at the spot. What color appears on the larger block of color? Circle the color that appears on each flipped card. If nothing appears, circle nothing. Blank is for write-in response.

25.	dark blue	light blue	blue-violet	nothing	other________
26.	green	light blue	dark blue	nothing	other________
27.	light green	yellow-green	dark yellow	nothing	other________
28.	orange	light yellow	dark yellow	nothing	other________
29.	light red	red-orange	dark red	nothing	other________
30.	dark red	light red	violet	nothing	other________
31.	dark green	light green	yellow-green	nothing	other________
32.	dark violet	light violet	yellow-violet	nothing	other________

E. Two cards, one white and one black, will be presented. On these cards are various colors. Each color is in the same position on each card. Compare the same color on each card and circle the answer to each question.

Compare red:
33. Lighter? left right
34. Brighter? left right
35. Color? same different

Compare orange:
36. Darker? left right
37. Brighter? left right
38. Color? same different

Compare yellow:
39. Lighter? left right
40. Duller? left right
41. Color? same different

Compare green:
42. Darker left right
43. Brighter? left right
44. Color? same different

Compare blue:
45. Lighter? left right
46. Duller? left right
47. Color? same different

Compare violet:
48. Darker? left right
49. Brighter? left right
50. Color? same different

F. A grey card will be presented. On this card are eight colors. Decide which colors seem closest to you. Circle the closest color as number one, second closest as number two, and so on.

51.	One?	red	orange	yellow	green	blue	violet	black	white
52.	Two?	red	orange	yellow	green	blue	violet	black	white
53.	Three?	red	orange	yellow	green	blue	violet	black	white
54.	Four?	red	orange	yellow	green	blue	violet	black	white
55.	Five?	red	orange	yellow	green	blue	violet	black	white
56.	Six?	red	orange	yellow	green	blue	violet	black	white
57.	Seven?	red	orange	yellow	green	blue	violet	black	white
58.	Eight?	red	orange	yellow	green	blue	violet	black	white

G. A card with two background colors, one color on the left and one color on the right, will be presented. Smaller blocks of color, separated by a gray dividing area, will be present on the colored backgrounds. Questions will be asked of the smaller color blocks only. Circle the appropriate answer at the end of each question.

Blue-orange background:

59.	Which small color block appears darker?	left	right
60.	Which small color block appears brighter?	left	right
61.	The color blocks appear to be?	same	different

Red-green background:

62.	Which small color block appears darker?	Left	right
63.	Which small color block appears brighter?	Left	right
64.	The color blocks appear to be?	same	different

Yellow-violet background:

65.	Which small color block appears darker?	left	right
66.	Which small color block appears brighter?	left	right
67.	The color blocks appear to be?	same	different

Black-white background:

68.	Which small color block appears lighter?	left	right
69.	Which small color block appears dullers?	left	right
70.	The color blocks appear to be?	same	different

White-black background:

71.	Which small color block appears lighter?	left	right
72.	Which small color block appears duller?	left	right
73.	The color blocks appear to be?	same	different

Red-green background:

74.	Which small color block appears lighter?	left	right
75.	Which small color block appears duller?	left	right
76.	The color blocks appear to be?	same	different

Orange-blue background:

77.	Which small color block appears lighter?	left	right
78.	Which small color block appears duller?	left	right
79.	The color blocks appear to be?	same	different

H. Cards with three vertical color divisions will be presented. Circle the color that seems to appear on each division for each card.

80. Left: orange yellow red other________
81. Center: orange yellow red other________
82. Right: orange yellow red other________

83. Left: blue-violet violet red-violet other________
84. Center: blue-violet violet red-violet other________
85. Right: blue-violet violet red-violet other________

86. Left: light orange orange dark orange other________
87. Center: light orange orange dark orange other________
88. Right: light orange orange dark orange other________

89. Left: violet red blue other________
90. Center: violet red blue other________
91. Right: violet red blue other________

92. Left: grey white black other________
93. Center: grey white black other________
94. Right: grey white black other________

APPENDIX B

SCORE SHEET

SNELLEN CHART

NAME____DATE________________

SUBJECT'S RESPONSE AND LINE NUMBER

E	1
F P	2
T D Z	3
L P E D	4
P E C F D	5
E D F C Z P	6
F E L O P Z D	7
D E F P O T E C	8
L E F O D P C T	9
F D P L T C E O	10
P E Z O L C F T D	11

DO NOT WRITE BELOW LINE

SUBJECT'S RESPONSE:

BINOCULAR SCORE________

APPENDIX C

SCORE SHEET

PSEUDO-ISOCHROMATIC PLATES

NAME______________________________ DATE____________

PLATE NUMBER AND SUBJECT'S RESPONSE

1	12	9	56
2	6	10	27
3	42	11	89
4	56	12	86
5	57	13	15
6	75	14	74
7	5	15	47
8	3		

DO NOT WRITE BELOW LINE

SUBJECT'S RESPONSE:

CORRECT____________

APPENDIX D

HUE CONTRAST

Hue Contrast (or value contrast) the color phenomenon of identifying hues (or values) by their given name.

APPENDIX E

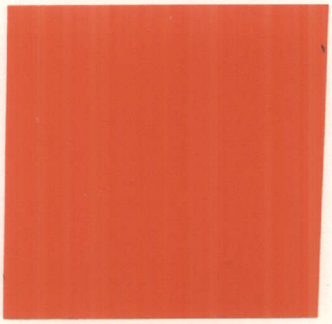
SUCCESSIVE COLOR CONTRAST

A. B.

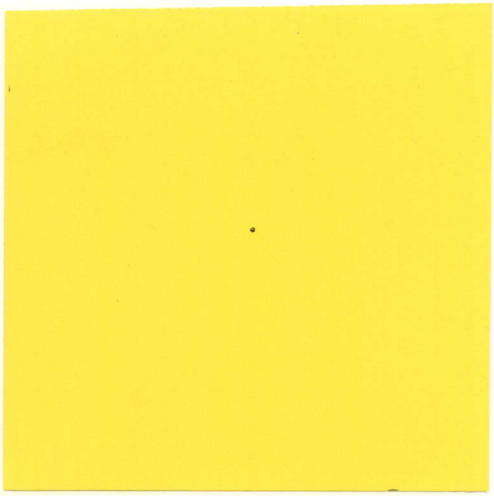
Successive Color Contrast is the perceptual phenomenon which occurs after one has gazed at a particular color, A. (Red, above) on a white ground for about fifteen seconds, then immediately changes his gaze to a blank white surface, B. (dot in square); the same shape with a complementary color (in this case, blue-green) of the first will appear soon in a much weaker, lighter image. In a few seconds, the weak image will fade and disappear. This phenomenon is sometimes called an "after-image" or "post-impressionism."

APPENDIX F

MIXED COLOR CONTRAST



A.

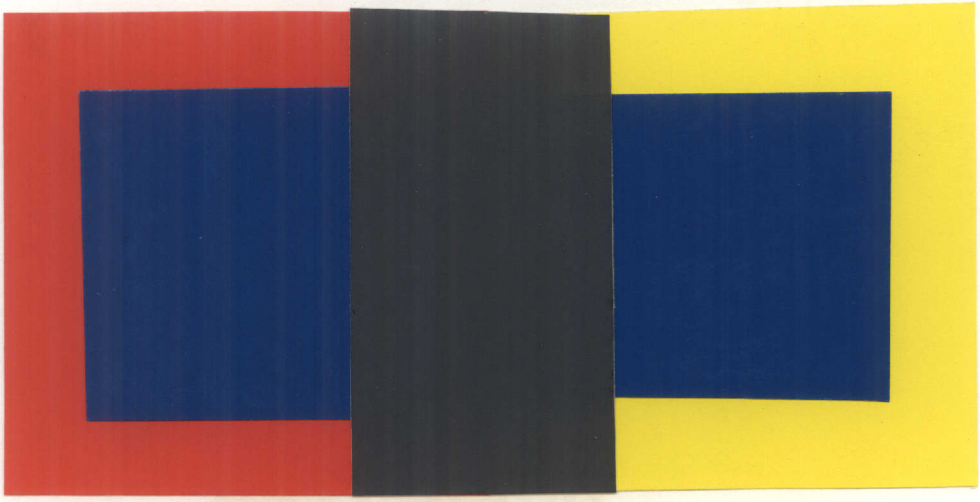


B.

Mixed color contrast perceptual phenomenon occurs after the viewer gazes at a block of color (A., above orange) on a white ground for about fifteen seconds and then transfers his gaze, not to a white ground, but to a color ground (in this case, to dot on yellow ground, B. above) resulting in a visual mixture of the "bluish afterimage" and the yellow color ground equally a greenish mixture.

APPENDIX G

SIMULTANEOUS COLOR CONTRAST

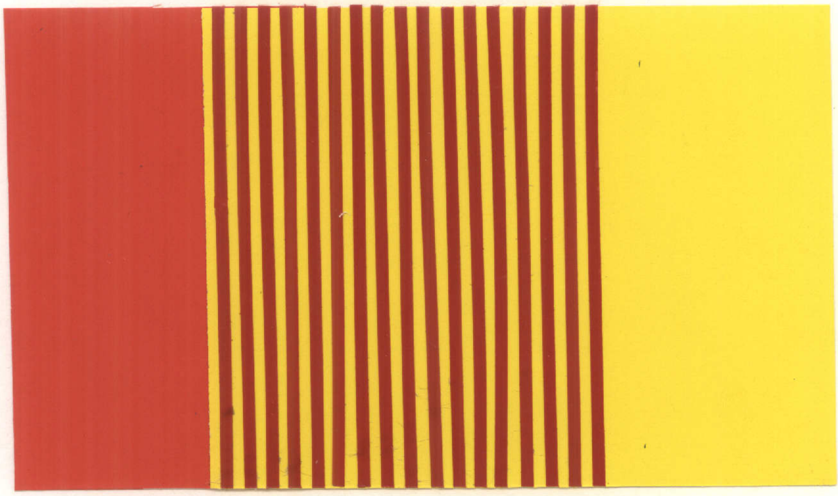


A. B.

Simultaneous color contrast occurs when colors are juxtaposed and specific modifications take place. Colors will simultaneously evoke their exact complements and the juxtaposed colors will react upon each other. Notice the blue hues in A. and B. above. The hues seem to differ in all characteristics, but in reality they are the same. The red and yellow grounds are altering the blues with their complements.

APPENDIX H

THE BEZOLD EFFECT

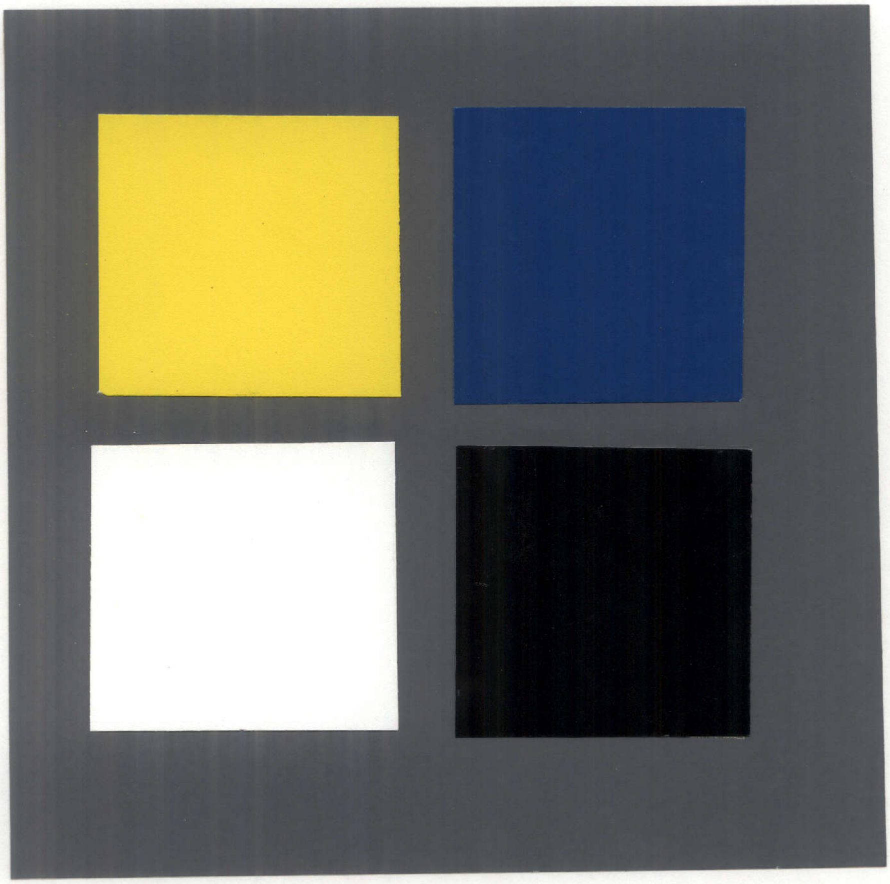


A. B. C.

The Bezold Effect is the perceptual phenomenon of two or more colors being mixed in the eye and effecting a new color. Red (A., above) and yellow (C., above) are juxtaposed in vertical stripes (B., above) which effects a new, third color--orange. Viewing distance plays an important role here. From close range B., above, will read red and yellow, but from a further distance, it will read orange.

APPENDIX I

ADVANCING-RECEDING COLOR EFFECT



Advancing-receding color phenomenon is the perceptual effect which seems to make warm (yellow) and light (white) colors and values advance toward the viewer while cool (blue) and dark (black) seem to recede.

APPENDIX J

CORRELATION COEFFICIENTS OF VARIABLES IN THE NON-ART MAJORS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Grade Level	---	.0763	.2314	.066	.1728	.1489	.3579***	.0017	.0415	.2470	.2470	.0661	.0535	.2024	.1453	.0613	.2393
2. Sex		---	.1213	.1741	.1222	.1511	.3037	.2037	.1399	.0925	.0925	.1876	.1957	.0166	.0399	.1521	.0957
3. Art Hours Completed			---	.1126	.0043	.2405	.2067	.1619	.2564	.1233	.1233	.1532	.0584	.0451	.0830	.0748	.0992
4. Corrected Vision				---	.0924	.1858	.1492	.5560*	.0568	.1448	.1448	.1131	.1163	.0640	.0311	.0578	.2720
5. Seating Distance A					---	.3001	.3026	.0507	.0733	.0	.0	.3930**	.4590*	.1020	.3571***	.1837	.0319
6. Seating Distance B						---	.6002*	.0375	.1495	.0	.0	.0393	.0751	.1235	.0355	.0376	.0150
7. Seating Distance C							---	.1423	.0430	.0	.0	.0361	.1451	.2574	.2040	.1014	.0421
8. Visual Acuity								---	.0774	.0685	.0688	.0704	.1072	.1987	.0495	.0391	.1176
9. Color Deficiency									---	.1337	.1337	.1010	.1282	.0172	.1109	.2062	.0461

*Significant at the .01 level
**Significant at the .02 level
***Significant at the .05 level

APPENDIX J--Continued

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10. Consecutive Color Identification											1.000*	.5004*	.4003**	.4353*	.1012	.4506*	.0678
11. Simultaneous Color Identification											---	.5004*	.4007**	.4353*	.1012	.4506*	.0678
12. Successive Color Identification												---	.4836*	.4446*	.2000	.5706*	.0161
13. Mixed Color Identification													---	.1339	.3023	.2918	.1085
14. Simultaneous Color Comparing on Black-white Ground														---	.1164	.7985*	.1222
15. Advancing-receding Color on Grey Ground															---	.0888	.1996
16. Simultaneous Color on Color Ground																---	.1065
17. Bezold Effect Identification																	---

*Significant at the .01 level
**Significant at the .02 level

APPENDIX K

CORRELATION COEFFICIENTS OF VARIABLES IN THE ART MAJORS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Grade Level	---	.2733	.4750*	.2130	.2139	.1809	.3809***	.3035	.0663	.1385	.0037	.0916	.2852	.0424	.0582	.1490	.0410
2. Sex		---	.1095	.0504	.1459	.0486	.0498	.1391	.1310	.0076	.2182	.3638*	.2678	.0291	.1442	.0051	.0875
3. Art Hours			---	.2599	.0948	.2693	.1509	.0179	.2862	.1102	.1520	.3916*	.2945	.0984	.2149	.1136	.1063
4. Corrected Vision				---	.2713	.0318	.0735	.1801	.1136	.3128	.2308	.0859	.1984	.0456	.2105	.0117	.0329
5. Seating Distance A					---	.4405*	.3201***	.2948	.0596	.2178	.1605	.1687	.2040	.0022	.0149	.0119	.1930
6. Seating Distance B						---	.2891	.1732	.0351	.2521	.1857	.2038	.0418	.0748	.0484	.0865	.1951
7. Seating Distance C							---	.0863	.1175	.0622	.2902	.0508	.1096	.3537***	.0492	.2793	.0645
8. Visual Acuity								---	.3733**	.1289	.0304	.0361	.0363	.0177	.3357***	.0870	.1417
9. Color Deficiency									---	.0524	.0386	.1907	.1405	.1216	.2804	.0486	.0963

* Significant at the .01 level
** Significant at the .02 level
*** Significant at the .05 level

APPENDIX K--Continued

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10. Consecutive Color Identification										---	.4287*	.0906	.2427	.0731	.0063	.0438	.3336***
11. Simultaneous Color Identification											---	.0057	.0756	.1099	.2708	.0688	.0638
12. Successive Color Identification												---	.4458*	.1430	.2546	.1871	.0325
13. Mixed Color Identification													---	.1472	.1815	.0306	.0356
14. Simultaneous Color Comparing on Black-white Ground														---	.0806	.8618*	.0739
15. Advancing-receding Color on Grey Ground															---	.1322	.2569
16. Simultaneous Color on Color Ground																---	.0827
17. Bezold Effect Identification																	---

* Significant at the .01 level
*** Significant at the .05 level

APPENDIX L

SNELLEN VISUAL ACUITY CHART SCORES FOR NON-ART MAJORS N=40 RANGE=35-61 M=49.85

Subject	Snellen Score	Subject	Snellen Score
1.	42	21.	39
2.	51	22.	48
3.	51	23.	59
4.	45	24.	58
5.	51	25.	61
6.	47	26.	51
7.	48	27.	53
8.	40	28.	51
9.	53	29.	49
10.	35	30.	51
11.	55	31.	52
12.	51	32.	58
13.	44	33.	56
14.	49	34.	58
15.	54	35.	29*
16.	54	36.	58
17.	49	37.	53
18.	49	38.	44
19.	41	39.	51
20.	50	40.	56

* Less than 20/20 vision

APPENDIX M

SNELLEN VISUAL ACUITY CHART SCORES FOR ART MAJORS N=40
RANGE=22-57 M=46.78

Subject	Snellen Score	Subject	Snellen Score
1.	52	21.	46
2.	43	22.	44
3.	55	23.	49
4.	35	24.	51
5.	44	25.	51
6.	53	26.	52
7.	49	27.	32
8.	52	28.	42
9.	35	29.	56
10.	22*	30.	54
11.	52	31.	40
12.	51	32.	48
13.	41	33.	52
14.	27*	34.	51
15.	52	35.	54
16.	49	36.	48
17.	55	37.	57
18.	49	38.	50
19.	50	39.	41
20.	47	40.	40

* Less than 20/20 vision

APPENDIX N

PSEUDO-ISOCHROMATIC PLATES FOR
TESTING COLOR PERCEPTION FOR
NON-ART MAJORS N=40
RANGE=4-14 M=12.45

Subject	P.I. Score	Subject	P.I. Score
1.	12	21.	14
2.	13	22.	12
3.	14	23.	14
4.	12	24.	14
5.	14	25.	12
6.	14	26.	11
7.	12	27.	14
8.	14	28.	11
9.	12	29.	11
10.	11	30.	10
11.	4*	31.	14
12.	14	32.	13
13.	14	33.	11
14.	14	34.	13
15.	10	35.	12
16.	14	36.	14
17.	13	37.	12
18.	13	38.	14
19.	13	39.	13
20.	11	40.	11

* Red-green Color Deficient

APPENDIX O

PSEUDO-ISOCHROMATIC PLATES FOR
TESTING COLOR PERCEPTION
FOR ART MAJORS N=40
RANGE=8-14 M=13.3

Subject	P.I. Score	Subject	P.I. Score
1.	13	21.	13
2.	14	22.	14
3.	12	23.	14
4.	13	24.	12
5.	14	25.	12
6.	13	26.	13
7.	14	27.	14
8.	14	28.	14
9.	13	29.	8*
10.	14	30.	12
11.	14	31.	13
12.	12	32.	14
13.	14	33.	14
14.	14	34.	14
15.	14	35.	12
16.	14	36.	14
17.	12	36.	13
18.	14	38.	14
19.	14	39.	14
20.	13	40.	14

* Red-green Color Deficient

APPENDIX P

BINOCULAR VISUAL ACUITY AND COLOR DEFICIENCY RATING SCORES OF SELECTED NON-ART AND ART MAJORS

Subject	Visual Acuity	Color Deficiency Rating	Color Phenomena Consensus
Non-Art Major #11	55	4**	83%
Non-Art Major #35	29*	12	87%
Art Major No. 14	27*	14	90%
Art Major No. 29	56	8**	86%

* Less than normal visual acuity
** Less than normal color deficiency

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