THE JUSTIFICATION FOR TEACHING COLOUR

by

BARBARA GAIL SHELLY

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ABSTRACT

This thesis attempts to justify an intensive course in colour for Fine Arts students at the university and art school. The teaching of colour is justified from a theoretical and a practical standpoint.

In the first section, the various disciplines concerned with the subject of colour are examined for evidence of colour's effect on the life of the human organism. This evidence is compiled from reports of research in educational and psychological journals, from the theories and discussions available in books on the physical and psychophysical evaluation of colour and the physiology and psychology of colour vision. The hypothesis that colour influences man's life pattern is substantiated in this compilation.

The phenomenon of colour is not only a significant aspect of man's environment, it is also an element of art. The responsibility for its teaching lies with the art educator. The second hypothesis that the presentation of colour to university and art school students is incompatible with practical needs is supported by an evaluation of contemporary pedagogy of colour in Vancouver. Interviews with teachers of Fine Arts in the Faculties of Arts and Education, The University of British Columbia, in the Vancouver School of Art and the Vancouver Art Gallery revealed that for the most part, the method of teaching colour perpetuates the instructor's own background in colour wheel theory and the mixture of pigments. Interviews with student colourists, and questionnaires distributed among Fine Arts majors in the Faculty of Education revealed that

the theoretical presentation of colour has little application to the practical needs of art students.

This thesis concludes with a proposed revision in the approach to colour with students of Fine Arts. The outlined course is designed to develop the ability to manipulate colour through problem-solving experiences.

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INTRODUCTION

The purpose of this thesis is to justify a more intensive and extensive teaching of colour to art students at the university or art school, and, having done this, to propose a suitable course in colour. The justification is in two parts. The first section presents research from history, physics, psychophysics, physiology, and psychology illustrating the interdependence of man and colour. The second part assesses the present pedagogy of colour in one institution to determine whether or not a need for revision exists. The theoretical and practical studies provide substantial evidence that there is a place for the proposed course. The outlined procedure for teaching colour is an experimental, problem-solving method, based on the principle that colour is the most relative medium in art. The purpose of the course is to promote a sensitivity to colour in the environment, and to capitalize on this awareness in developing dexerity in the personal use of colour.

PART I

THE EFFECT OF COLOUR ON MAN

The ensuing eight chapters will attempt to substantiate the hypothesis that man is affected by colour. Chapter I discusses the role of colour in relation to man's technological development. Colour as the objective physical stimulus for vision is the topic of Chapter II. Chapter III points out how the physiological functioning of various parts of the visual receptor depends on pigments. For example, the pigments in the rods and cones transform radiant energy into nerve activity. The psychological aspects of colour are contained in Chapter IV through Chapter VIII. These aspects include the variability of the conscious response to colour, the effect of colour on the emotions and physiology of man, the evidence of man's learned associations with colour, the link between colour vision and other senses, and finally, the deception inherent in the visual sense itself. It is hoped that this theoretical compilation will indicate that man is affected by colour in diverse and limitless ways.

CHAPTER I

THE HISTORICAL ROLE OF COLOUR

Many centuries ago, the value of minerals, plants, and animals was partially determined by the colours they produced. The artistic expression of early man was limited in colour to indigenous flora, earthen colorants, and charcoal. As his desire for colour expanded, man discovered that minerals could be ground and mixed with a vehicle such as fat. Because orange-red cinnabar was a desirable hue, mercury sulphide became a valued mineral. Similarly, azurite and malachite crystals of copper carbonate, and lapis lazuli increased in worth. In ancient Tyre the gland of the murex snail was esteemed because thousands of snails were required to produce a small portion of purple dye. This scarcity is directly related to purple's prerogative as the hue of royalty. The craving for colour also promoted exploration for new sources and trading connections. During the age of exploration new colours were brought to Europe from the East. Spanish conquistadores returned from the New World with a vivid carmine red, derived from the cochineal.

As man's technology advanced, colorants emerged as an important commodity. In 1858, quite by accident, William Henry Perkin created the first anilene dye, Perkin's Mauve. Since then, many synthetic colorants have been produced from chemicals such as anthracene, cobalt phosphate, cobalt arsenate, barium, and phthalocyanine. The discovery of new colorants becomes economically essential when standard sources for a hue are depleted. A new colorant must be found to replace the cadmiums being exhausted by the space programme. Scientists strive to produce colorants to fill diverse demands, such as fast dyes, washable inks, and non-poisonous pigments. Chemical research profits from man's search for new colour resources.

Discoveries involving colour have frequently led to technological advancement. Certain plants and substances have been found to react differently to light of opposite wavelengths. Plants will perish in rooms painted certain colours, although light, heat and nourishment are ample.[1] The oxidation of sodium sulfate is retarded by violet light, but accelerated by reddish-yellow light. E. H. Land, whose invention of the Polaroid camera employed principles of colour technology, is now proceeding from Hering's statement, "one and the same ray can be seen, according to circumstances, in all possible hues."[2] Land has produced green from a red filter plus black and white. He submits that colour vision depends not only on the stimulus of wavelength and intensity, but also on whether or not the patterns presented are acceptable renditions of the objects. For example, brown cannot be perceived until contrast, pattern, and preferable interpretation of areas of light as surfaces of objects are all present.[3] Land's investigations will no doubt enlighten the puzzle of colour perception, making possible further strides in man's continuous probe for the new and the better.

In summary, colour has been an important factor in the evolution of human technology. The desire for colour has provided the motivation to

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[1]Hilton Brown, "Color," Lecture (Chicago: Art Institute of Chicago, October 8, 1964).

[2]Ewald Hering, Outlines of a Theory of the Light Sense, trans. Leo M. Hurvich and Dorthea Jameson (Cambridge, Mass.: Harvard University Press, 1964), p. 289.

explore and investigate. Man's understanding of the chemical and physical properties of colour and their inherent working principles has been crucial in such discoveries as photography, spectrophotometry, and the laser beam.

CHAPTER II

THE VISUAL STIMULUS

Physics

The physical basis of colour is light, and life is inconceivable without light. In addition to his dependence on colour for life itself, man is affected by colour in specific ways. Physics is the one scientific discipline considering the subject of colour from an objective viewpoint. The physicist studies the stimulus qualities of colour, without any reference to an observer. The physical characteristics of colour, namely wavelength and intensity, determine the manner in which colour reaches the human receptor.[1]

Wavelength, the first physical property of colour, determines hue. The visible spectrum is produced by wavelengths between 390 mμ and 710 mμ. F. A. Taylor writes, "The spectra of natural sunlight is the basis on which a knowledge of colour for the practical colourist is founded, and it will thus be realized that a sound knowledge of colour theory based on scientific principles is the only sure guide to the artist . . ."[2] Because light travels in waves, it behaves in specific ways affecting human vision. Refraction, diffraction, diffusion, and polarization all determine the manner in which colour is presented before the retina, but they are seldom acknowledged by man as affecting him to the extent that they do. The countless

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[1]Neil Brearley, Interview (Vancouver: B. C. Research Council, Feb. 15, 1967).

[2]F. A. Taylor, Colour Technology (London: Oxford University Press, 1962), p. 6.

phenomena such as the colour of the sky and the transparency of water occur because of wavelength behavior. Similarly, reflection and absorption, permitting colour to be seen as a surface, depend on the wavelength composition of light. The predominant wavelength in the illumination alters the wavelength distribution reflected from the surface. Red paper illuminated by green light will appear black because the green light lacks red wavelengths for the colorant to reflect. Determining the hue of a surface is just one way that wavelength affects colour vision.

The second physical property of colour is intensity, that is, the rate of the incidence of energy of each wavelength reaching the visual receptor. The intensity necessary to make a wavelength visible to the human eye is adequate between 400 mμ and 700 mμ. Although it is theoretically possible to increase the intensity of invisible wavelengths in order to make them visible, the amount of energy required to make 1500 mμ visible would cook the eye.[3] Thus, intensity, the second characteristic of colour, affects man by determining which wavelengths will be visible, and how much light each wavelength will radiate.

Psychophysics

Before the effect of these physical properties can be realized, man must respond to colour. This involves the realm of psychophysics, where the reaction of the visual mechanism to a specific set of stimulus condi-

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[3]James R. Gregg and Gordon G. Heath, The Eye and Sight (Boston: D. C. Heath and Co., 1964), p. 119.

tions is investigated. Man's reactions to the three dimensions of colour--hue, saturation, and brightness--are separately measured. First, hue refers to a scale of perceptions ranging from red through yellow, green and blue. Psychophysicists state that although wavelength changes regularly from one end of the spectrum to the other, the perception of hue does not change accordingly. The ability to distinguish hue peaks at 500 mμ and again at 570 mμ, then diminishes towards the ends of the spectrum. All reds beyond 650 mμ look the same to the human observer.[4] Saturation, the second dimension of colour, is related to the purity and strength of the hue. Psychophysicists find that the ends of the spectrum have more intrinsic saturation than the center. The amount of wavelength required to produce a hue from white light decreases as the intrinsic saturation increases.[5] As the third dimension of colour, brightness is the mental evaluation of luminance.[6] Psychophysicists studying the relative amounts of energy in each wavelength region can predict that the yellow region of the spectrum will cause the most luminous sensation in man's visual receptor. Hue, saturation and brightness cannot be separated from wavelength and intensity, their physical determinants.

In summary, the physical concept of colour, characterized by wavelength and intensity, determines the quality of light reaching the visual receptor. The reaction of the eye to the pattern of radiant energy can be measured in separate terms of hue, saturation and brightness. Colour

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[4] Gregg, p. 116.

[5] *Ibid.*, p. 118.

[6] *Ibid.*, p. 116.

affects man through these three dimensions. From now on, when the noun 'colour' is used, it refers to the conscious reponse, the perception of colour. Strictly speaking, all visual appearance depends on colour.

CHAPTER III

THE PHYSIOLOGICAL ROLE OF PIGMENT IN VISION

Vision via Pigment

The eye does not see the energy distribution of light directly. It sees only the relative effectiveness of the light on its own receptor system. The evaluation of radiant energy in terms of visual perception rests squarely on the properties of the human eye. Support for the hypothesis that colour is important to the human organism lies in the examination of the visual mechanism. Pigments play an indispensable role in colour vision. "The radiant energy penetrating the cornea is . . . modified in spectral composition by pigments (lens, macula), transformed to nerve activity by pigments (rods, cones), and most of it is finally absorbed by pigment in the choroid coat."[1]

The first pigments necessary for colour vision are contained in the rods and cones of the retina. The photosensitive material used by the rods to absorb radiant energy is called 'rhodopsin'. Because rhodopsin is bleached by light, the rods are insensitive during the day. Sailors often prepare for night watch by wearing red goggles half an hour before duty, to allow the rhodopsin time to become active. There is some speculation that the rods act as the blue channel in colour vision, because night vision is blind to all hues but blue. "We ourselves create the silver hue of moonlight by looking at it with our colour-blind rods."[2] Rhodopsin, then, is

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[1] Deane B. Judd, Color in Business, Science, and Industry (New York: John Wiley and Sons, Inc., 1963), p. 13.

[2] Wolfgang von Buddenbrock, The Senses (Ann Arbor: The University of Michigan Press, 1964), p. 80.

the known pigmented component of the rods. The work of Wald indirectly indicates the existence of one cone pigment, 'iodopsin', but the existence of others is speculated.[3] Scientists theorize that the cones are composed of pigments corresponding to the hues to which they are sensitive. The retina is divided into colour zones according to the distribution of rods and cones (cones predominate in the foveal centralis, rods in the periphery). The sensation of most chromatic colour appears to change from strong red to weak yellow to pure gray during the slow movement of the stimulus from the fovea to the periphery.[4] Buddenbrock observes that in order to see a star, a person must glance to one side for rod vision.[5]

The second pigment necessary for colour vision is the 'melanin' in the choroid coat. This brownish-black pigment absorbs radiant energy to prevent the image cast by the lens from being overly degraded by stray light. Haemoglobin, another pigment, assists in the absorption of light.

The 'macula lutea', composed of brownish-yellow pigment called 'xanthophyll', is located on the retina. It protects the central cones from overstimulation by short wave energy, known to cause long-lasting after-images.[6] The understimulation supersensitizes the cones to short wave energy, so that the uniform field of vision is never interrupted by the macula spot. In addition to preventing uncomfortable after-images,

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[3]Judd, p. 17.

[4]Committee on Colorimetry, Optical Society of America, The Science of Color (Washington, D.C.: Optical Society of America, 1963), p. 103.

[5]Buddenbrock, p. 80.

[6]Judd, p. 15.

this valuable pigment also increases the resolution of fine detail.[7]

Finally, pigments contribute to colour vision by tinting the lens of the eye. The lenses of children are relatively pigment-free. With increased age, a melanin-type of yellowish-brown pigment develops in the lens, acting as a yellow filter preventing short wave energy from reaching the retina. This, like the macula lutea, protects the retina from overstimulation by ultraviolet rays.

Colour, then, in the form of pigment, is vital to the visual process. Pigments in the rods, cones, lens, macula lutea, haemoglobin, and choroid coat enable vision to take place.

Variations in Sight Due to Pigment

Variations in the kind and amount of pigmentation cause discrepancies in colour vision. The first variation in sight caused by a pigment is related to age. Although the melanin in the lenses of older people prevents overstimulation of the retina by ultraviolet rays, the macula lutea provides the same service. In persons of advanced age, when both factors are operating, the sensitivity to violet and blue light diminishes. In colour-matching tasks, older people have been found to be less sensitive to blue. Industries requiring employees to discriminate between hues are alert to this unavoidable decline. In general, the quality of colour vision increases to the age of twenty-five years: the decrease which becomes pronounced by the age of sixty-five can be partially attributed to the pigmentation.[8]

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[7] Ralph M. Evans, _An Introduction to Color_ (New York: John Wiley and Sons, Inc., 1961), p. 99.

[8] Robert W. Burnham, Randall M. Hanes and C. James Bartleson, _Color: a Guide to Basic Facts and Concepts_ (New York: John Wiley and Sons, Inc., 1963), p. 91.

There are three variations in colour vision independent of age. The first is caused by the variation in size of the macula lutea. Evans found that the difference in colour matches performed by observers was due to the amount of macula pigmentation present in the foveal region.[9] Burnham, Hanes and Bartleson write, "The extent and distribution of macular pigmentation vary irregularly and significantly from one person to another, and these variations can cause considerable individual differences in colour vision."[10]

The second ageless factor contributing to discrepancies in the quality of colour vision is the lack of melanin in the choroid coat. Albinos depend on the inadequate haemoglobin to absorb the stray light within the eyeball. Consequently, retinal images are diluted by the unabsorbed light: the albino suffers from low visual acuity and photophobia.

The third ageless factor in individual colour vision differences is colour-blindness, or to be more correct, 'colour deficiency'. Judd says that colour-blindness results from cones containing the wrong pigment. Colour deficiency is explained through the three-receptor theory. Assuming that normal vision is trichromatic, deficient colour vision can be broken down into categories of mono-chromacy, dichromacy, and trichromacy, depending on whether the subject uses one, two or three primaries to produce a colour match. Many people never realize their own colour vision deficiency unless it is discovered in a medical examination, in the Ishihara Test, or in a course teaching the use of colour.

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[9] Evans, p. 199.

[10] Burnham, Hanes and Bartleson, p. 74.

To summarize, from the physiological standpoint, the pigmented parts of the eye assume a large responsibility for colour vision. Individual differences in colour vision can also be attributed to pigments. Variations are so plentiful that the perception of colour on this basis alone must be considered a totally relative phenomenon.

CHAPTER IV

THE PSYCHOLOGY OF COLOUR

VARIABLES IN THE RESPONSE TO COLOUR

The preceding two chapters have explained how colour affects man in general. Colour is the physical stimulus for vision. Pigments comprising various parts of the human receptor modify the spectral composition of light, absorb light, and transform light into messages received by the brain. Thus the effects of colour can be enumerated in physical and physiological terms, applying equally to any human organism possessing colour vision. Colour's major effect on man, however, is psychological. Of paramount concern in probing the effect of colour on the human organism is the individual conscious response of man. "Visual perception is defined as the integrated response modified or interpreted in terms of the stored physiological remnants of past experience which are brought to bear in that situation."[1] This definition emphasizes the individual element of colour perception. The psychology of colour accounts for variations in the physical stimulus, in the physiological condition of the eye, and in the psychological state of the observer's mind. Variations occurring as a result of age, the intensity of experience, and the acquired response, are noted carefully in the psychological evaluation of colour's effect on man.

Developmental Stage of Colour Perception

The influence of colour on the human varies according to age. Reaction

[1]Robert W. Burnham, Randall M. Hanes, and C. James Bartleson, Color: a Guide to Basic Facts and Concepts (New York: John Wiley and Sons, Inc., 1963), p. 49.

to colour begins at a comparatively primitive stage in perception. Patients who have been blind since birth, and who have gained sight through an operation for cataracts, are reputed to perceive colour more readily than simple form. Patients recovering from injury to the occipital lobe may be able to see colour as a soft, hazy film before they can see colour as the surface property of an object.[2] Research by Staples shows that babies can distinguish between red, yellow, blue and green at fifteen months. The colours are effective as stimuli in that order.[3] Children under three years of age respond immediately to shape, whereas between the ages of three and six years, they are more attracted to colour.[4] Faber Birren says small children are colour dominant because colour is a more immediate experience than form. Studies indicate that colour dominates over form in sorting skills. Kindergarten children will sort objects of different shapes and colours by their colour.[5] Elsewhere, Birren states, "Basically speaking, colour is more emotional in its impression than form. This is particularly true of young children."[6] Lindberg concludes that the tendency to respond to colour decreases with increasing age at the elementary

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[2]M. D. Vernon, "The Perception of Colour," The Psychology of Perception, Penguin Books (Great Britain: C. Nicholls and Co. Ltd., 1962), pp. 82-83.

[3]Ruth Staples, "The Response of Infants to Colour," Journal of Experimental Psychology, XV (1932), p. 119.

[4]Rudolf Arnheim, Art and Visual Perception (Berkeley: University of California Press, 1965), p. 324.

[5]Faber Birren, New Horizons in Color (New York: Rinehold Publishing Corporation, 1955), p. 110.

[6]Birren, "Psychology of Color for the Schoolroom," Nation's Schools, LVII (April, 1956), p. 92.

school level.[7] The majority of studies show humans being less affected by colour as they grow into adulthood.

Intensity of Experience

Harland Bopst says, "Color is a dominant idea in the consciousness of everyone."[8] In actuality, some people have intense reactions to colour, some are hardly affected at all.

> The intensity . . . varies because of the differences in affective sensitivity to colors as well as because of differences in the colors themselves. Thus, some artists and others pay a lot of attention to colors and refer to them by such terms as sober, hot, heavy, dry, juicy, voluptuous, sensual, insipid, brutal, tranquil, discordant. Such terms suggest that such people are affected by colors more than most.[9]

Most people take colour for granted unless their attention is focused upon an isolated colour in an experiment. Although they can supply an affective judgment, this response cannot be regarded as typical of their normal reaction. The intensity of experience is thought to be mainly a native response, but it can be influenced by learning, and it can fluctuate with changes in attention and mood. Colour preference can also influence man's response to colour. Intensive reactions are expected from highly liked or disliked hues, compared to those eliciting a neutral feeling.

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[7] Bengt J. Lindberg, Experimental Studies of Colour and Non-Colour Attitude in School Children and Adults (Copenhagen: Levin and Munksgaard, 1938), p. 146.

[8] Harland Bopst, Color and Personality (New York: Vantage Press, 1962), p.29.

[9] Committee on Colorimetry, Optical Society of America, The Science of Color (Washington, D.C.: Optical Society of America, 1963), p. 160.

Acquired Response

Repeated experiences with a colour usually result in an automatic colour association. A dyer, for example, may prefer fast colorants to fugitive colorants. In a test for colour preferences, he will respond more favourably to the sample corresponding to his fast dye, despite the fact that the psychologist does not intend this association to take place. Association can play a major role in determining the pleasantness or unpleasantness of a colour. Both the mention of a colour name and the actual visual perception of a colour are capable of producing a connection with a past cognition. The stimulus and the idea connect simultaneously and seem to be one. This probably accounts for the negative response an airline company received when its aircraft interiors were painted brown and yellow. The combination reminded passengers of air-sickness, and they promptly became ill. Another airline official attributed the reflection of the bulkhead green onto the passengers' faces to their feelings of sickness. Walter Sargent writes, "Our responses to colours are bound up with associations of other experiences."[10] Hospital rooms are no longer painted white because patients associate white with sterility. Mrs. P. Gouldstone, a member of the Faculty of Education, The University of British Columbia, installed a mural in a Manchester children's hospital during World War II. Before she was permitted to execute her design, she met with doctors, psychiatrists, and psychologists, who eliminated all substantial areas of

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[10] Walter Sargent, Enjoyment and Use of Colour, quoted by Robert F. Wilson, Colour and Light at Work (London: Seven Oaks Press, Ltd., 1953), p. 66.

black, purple and red from her design because of the associations they might arouse. The connections resulting from past experience can be very personal, or common among many people. The scope is limitless.

In summary, although colour is affecting every human, this effect varies between individuals, according to the stage of their colour perception, the intensity of response, and the influence of past learning on judgment.

CHAPTER V

THE PSYCHOLOGY OF COLOUR

THE DIRECT RESPONSE TO COLOUR

The ensuing discussion is based on the assumption that colour can evoke a direct response from man. No matter what degree of intensity accompanies this response, it is independent of associations with past experience. Arnheim writes, "The effect of color is much too direct and spontaneous to be only the product of an interpretation attached to it by learning."[1] The direct effect of colour on the human organism can be studied as it pertains to physiology and emotions.

The Physical Effect

One of the most common physical effects of colour is the feeling of warmth evoked from reds and yellows, and coolness evoked from blues and greens. Although the comfort zone is defined in terms of temperature, humidity and air movement, colour is also an important consideration. For example, patrons felt chilly in a cafeteria painted blue. Management redecorated in pink, held the temperature constant, and the complaints ceased.[2] Wilson tells how he changed the colour scheme of the weaving shed in Yorkshire, only to be confronted by workers returning from their

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[1] Rudolf Arnheim, Art and Visual Perception (Berkeley: University of California Press, 1965), p. 326.

[2] Committee on Colorimetry, Optical Society of America, The Science of Color (Washington, D.C.: Optical Society of America, 1963), p. 168.

holidays, demanding the temperature of the work room be raised.[3]

Speculation exists between the associative explanation and the physiological explanation of the apparent temperature of colour. Two of the explanations for the apparent thermal effect of colour on body comfort are associative in nature. One hypothesis states that because fire is warm and ice is cold, people associate red with heat and blue with cold. Another theory states that the sunny, yellow sky provides warmth, whereas the sunless, blue-gray sky obstructs radiation and is therefore associated with coolness. The apparent temperature of colour has been included in this chapter, because in the opinion of the writer the physiological explanation is more significant. In 1900 in Paris, Féré found that muscular power and blood circulation are increased by coloured lights in the following sequence of hue; blue least, through green, yellow, orange and red. This research has since been validated many times. An increase or decrease in blood circulation could certainly contribute to feelings of warmth and coolness.

In addition to warm and cool colours affecting the temperature of the body, they are also said to affect muscular activity. Nakshian finds warm colour conducive to muscular activity, whereas cool colours promote mental exercise. People exposed to large areas of red overestimate periods of time, but underestimate time in blue and green surroundings.[4] Birren writes, "Physically red is exciting and increases restlessness and nervous tension."[5]

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[3]Robert F. Wilson, Colour and Light at Work (London: Seven Oaks Press, Ltd., 1953), p. 75.

[4]Jacob S. Nakshian, "The Effects of Red and Green Surroundings on Behavior," Journal of General Psychology, XXXII (December, 1964), p. 161.

[5]Faber Birren, Color Psychology and Color Therapy (Toronto: McGraw-Hill Book Co., Inc., 1950), p. 258.

Blue is used in hospitals to minimize babies' crying and patients' anxiety because it is tranquillizing. The football coach who keeps his team in a blue room during half-time to relax, and then delivers the pep talk in a red anteroom is utilizing this knowledge of colour to affect his players.[6]

Other examples of the physical effect of colour are not nearly as abundant as temperature, blood circulation and muscular activity, but they are more sensational. One of the most incredible examples of the power of colour is related by Bernard Shaw.

> Among my many medical acquaintances was a country doctor, now dead, whose children all died within a few days of their births, leaving him prolific but childless. In desperation he tried a senseless experiment. He took the last baby into the garden and shaded it in a little tent of Turkey red. That baby survived. When I last heard of him from his father, he was flourishing in the prime of life in the Antipodes. A spot of pleasant colour had made all the difference between life and death where the most intimate doctoring had failed.[7]

In contrast, a man who was blind until the age of thirty became physically ill when he first saw yellow.[8]

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[6] The fact that cool colours promote mental activity, and warm colours promote physical activity can be compared to the correlation between personality and colour preference. Generally speaking, people who are less cultural, extroverted, and active prefer the saturated hues, and the particular hue of red. People who are introverted, sensitive, self-aware, thought-oriented, and more culturally mature prefer tints, as well as blue and green.

D. Grant Ross, "Psychology of Color Preference in Projection Slides," Journal of the Association of Medical Illustrators, No. XVI (1965), pp. 14-15.

[7] Bernard Shaw, "Aesthetic Science," published for the Council of Industrial Design (London: Sun Engraving Co. Ltd., n.d.), p. 143.

[8] R. Latta, British Journal of Psychology, I, quoted by R. A. Houstoun, Light and Colour (Toronto: Longman's, Green and Co., 1923), p. 167.

Dr. Kurt Goldstein says that colour has a strong physical effect on the emotionally unstable. The stimulation occurring as a result of exposure to a red environment is particularly detrimental. The well-known neurologist describes a patient who stumbled when she wore a red dress. Blue and green clothing restored her equilibrium to a point of being almost normal. Dr. Goldstein writes, "It is probably not a false statement if we say that a specific color stimulation is accompanied by a specific pattern of the entire organism."[9] The authors of Human Senses and Perception concur with this statement, "There is indeed psychological justification for maintaining that the quality of a particular color sensation represents a state of sensory equilibrium."[10] In research with cerbellar diseases, Dr. Goldstein had his patients look at coloured paper while they held their hidden arms outstretched. When they viewed yellow, the arm controlled by the defective brain center would deviate 55 cm. from the midline. Red caused a deviation of 50 cm., white--45 cm., blue--42 cm., green--40 cm., and closed eyes caused a deviation of 70 cm. Goldstein concluded that the colours corresponding to long wavelengths go with expansive reaction, while colours corresponding to short wavelengths accompany constriction.[11]

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[9]John E. Gibson, "How Color Affects Your Life," Today's Health, XL (September, 1962), p. 23.

[10]G. M. Wyburn, R. W. Pickford and R. J. Hirst, Human Senses and Perception (Toronto: University of Toronto Press, 1964), p. 105.

[11]Kurt Goldstein, "Some Experimental Observations Concerning the Influence of Colors on the Function of the Organism," Occupational Therapy and Rehabilitation, XXI (1942), p. 149.

Emotional Effect

Colour evokes an emotional response in the human organism.

> . . . all affective responses from visual stimuli must depend upon color because visual perception is impossible without some visual stimulus pattern, which, in turn, is impossible without the colors that are its elements. No one can question the reality of affective responses to visual stimuli because they are often of the most violent and unmistakable nature. Therefore, no one can question a fundamental dependence of affective responses upon color.[12]

Comparing the response to colour with the response to shape, Rorschach found that cheerful people identify colour at the expense of contour, whereas depressed people most often react to shape. People exhibiting a colour dominance are open to external stimuli, sensitive, easily influenced, unstable, disorganized and given to emotional outbursts.[13] Although Rorschach offered no explanation of the correspondence between perceptual behavior and personality, Schachtel points out that the experience of colour resembles that of affect or emotion. He says that with both emotion and colour the human is a passive observer of stimulation. With shape, a more active response is required.[14]

Psychologists at Brandeis University placed normal subjects in a gray room to find that the drab environment made them critical and fault-finding. They developed physical symptoms of headache and fatigue, and emotional traits of discontent, irritability, monotony, and hostility.[15]

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[12] The Science of Color, p. 150. [13] Art and Visual Perception, p. 324.

[14] Ibid., p. 325. [15] Gibson, p. 23.

Goethe contends that yellow-red elicits an emotional response from a few people. "I have known men of education to whom its effect was intolerable if they chanced to see a person dressed in a scarlet coat on a gray, cloudy day."[16]

When normal people react to colour with a change in emotions, it is understandable that colour evokes a strong affective response from the mentally unstable. Accounts dating back to 1875 relate how a man afflicted with a taciturn delirium became gay after spending three hours in a red room, how a violent case in a straight-jacket was calmed in one hour by blue light, and how another madman was completely cured after one day's exposure to violet light.[17] Of questionable validity, these accounts provide evidence that the effect of colour on man was being investigated in the late nineteenth century. In validated cases, the evidence of response to colour by mentally unstable patients is very pronounced. Bengt J. Lindberg observes that substable types have the greatest colour attitude.[18] On the other hand, persons who dislike colour or fail to respond to it are likely to be repressed individuals. "Failure to repond seldom goes hand in hand with a well-adjusted personality."[19] Birren states that severe cases of depression frequently reject colour, preferring a gray world and disdaining

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[16] Johann Wolfgang von Goethe, Theory of Colour, trans. E. L. Eastlake (London: Murray, 1840), p. 776.

[17] R. A. Houstoun, Light and Colour, pp. 162-163.

[18] Bengt J. Lindberg, Experimental Studies of Colour and Non-Colour Attitude in School Children and Adults (Copenhagen: Levin and Munksgaard, 1938), p. 147.

[19] John E. Gibson, "How Color Affects Your Life," p. 64.

a colourful one. According to Birren, green represents a psychological withdrawal from stimuli, suggesting escape from anxiety. Yellow promotes infantile outbursts, and red is associated with maniac tendencies.[20]

Closely akin to the relationship between colour and emotion is the power of colour to induce mood. Dr. Robert R. Ross of Stanford University allies colour with dramatic intensity and emotion. Blue, purple, and gray are best used to enforce the mood of a tragedy, whereas red, orange and yellow are appropriate for comedy.[21] In motion pictures colour is often used to support and sustain mood. Herman Darewski conducted some experiments to determine the effect of colour on his musical compositions. He looked at light through a variety of coloured gelatines and tabulated his mood reactions. Thereafter, he frequently employed gels to produce the mood appropriate for his compositions.

> . . . colour has put me in the required state of mind--given me the desired conception or else quickened or enlarged conception--for practically all the tunes which I have written lately. . . . Looking through a deep blue strip of gelatine made me 'feel' the exact music which had previously eluded me, . . . the result was what I regard as being one of the best bits of composition I have ever done.[22]

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[20] Faber Birren, Color: a Survey in Words and Pictures (New York: University Books, Inc., 1963), pp. 187-190.

[21] Ibid., p. 210.

[22] Herman Darewski, "Composing by Colour," Pearson's Magazine (December, 1916), quoted by R. A. Houstoun, p. 161.

Schail found that the influence of colour on the strength of mood and emotional tone is general and reliable.[23] Other investigations between colours and mood names have been carried out by Beck and Dunbar,[24] Ross and Karwoski, and Odbert and Eckerson[25] with the same significant agreement. Then there is the remark of the witty Frenchman, who, according to Goethe, "pretended that his tone of conversation with Madame had changed since she changed the color of the furniture in her cabinet from blue to crimson."[26]

In brief, psychologists are investigating the direct physical and emotional impact of colour on man. Physically, colour can make man feel warm and cool; it can increase and decrease his blood circulation and muscular activity. Colour is intimately connected with sensory equilibrium, and with constrictive and expansive movement. The response to colour is also manifested in emotions and in mood. A positive reaction to colour is considered emotionally healthy, whereas a failure to respond to colour is characteristic of emotional instability. Gray causes depression among normal subjects, and is preferred by the depressed. Colour and mood correlate highly. Warm hues correspond to happy, optimistic moods, while cool colours are quieter in tone. Colour is used to establish and sustain the dominant mood in

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[23]K. Warner Schail, "Scaling the Association between Colors and Mood-Tones," American Journal of Psychology, LXXIV (1963), p. 273.

Also, see "A Q-Sort Study of Color-Mood Association," Journal of Projective Techniques, XXV (1961), pp. 341-346, by the same author.

[24]Harry S. Beck and Ann Dunbar, "The Consistency of Color Association to Synonymous Words," Journal of Educational Research, LVIII (Sept.1964), p. 43.

[25]The Science of Color, p. 165.

[26]Art and Visual Perception, p. 331.

drama and motion pictures. Every human experiences some degree of direct response to colour. This response, manifested in emotions and physical functions, constitutes a noteworthy influence on the life pattern.

CHAPTER VI

THE PSYCHOLOGY OF COLOUR

ASSOCIATIVE ASPECTS OF COLOUR

The suggestive power of colour, arising from associations, affects man strongly. " . . . the processes of learning and conditioning are constantly producing colour associations with various feelings, emotions and meanings."[1] Two aspects of associative colour will be discussed; first, colour in language, and secondly, colour symbolism.

Colour in Language

Marion Milner writes, "Clearly the subject of colour is, on the evidence of language alone, very closely bound up with feelings."[2] According to Wilson, colour words came into our language to express emotions.[3] The use of colour words in the present English language is frequently accompanied by an emotional connotation. A review of colour vocabulary reveals how the communication of feeling depends to a considerable extent on the associations with colour.

Connected etymologically with the Sanscrit 'rudhira', meaning blood, red is associated with the stern qualities and the passions of man. To be caught 'red-handed' implies a feeling of guilt. When angry, people 'see

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[1]Committee on Colorimetry, Optical Society of America, The Science of Color (Washington, D.C.: The Optical Society of America, 1963), p. 99.

[2]Marion Milner, On Not Being Able to Paint, fwd. Anna Freud (London: William Heinemann, Ltd., 1957), p. 157.

[3]Robert F. Wilson, Colour in Industry Today (New York: The Macmillan Co., 1960), p. 35.

red', when showing a net loss, their position is described as 'in the red'. Confusion and delay are termed 'red tape', and a diversion is called a 'red herring'. A special day is a 'red letter day', and the celebration may take the form of 'painting the town red'. References to intoxication, prostitution, and Communism often contain the word red.

Originating as the name for the colour of the sky, the celestial qualities of blue still figure in expressions such as 'out of the blue', 'a bolt from the blue', and 'once in a blue moon'. An air of superiority surrounds the 'blue ribbon', the 'royal blue blood' and the 'bluestocking', while 'true-blue' is the Scottish description of loyalty. At the other end of the scale is the depression of 'blue Monday', 'feeling blue', and the inactivity of 'bluing time'. Inexplicable paradoxes accompany the mention of blue.

Derived from the same root as grow, green is associated with freshness, newness and youth. Taken to the extreme, it can mean inexperience, e.g. 'greenhorn'. Immaturity is understood in the expressions 'green wood' and 'green beer'. Immature emotions such as envy and jealousy cause a person to 'turn green'. Aptitude, however, is assumed in the gardener with a 'green thumb', and the person who is confronted with the 'green light'. The connotations of the word green oscillate between inexperience and confidence.

Yellow has a less than enviable emotional impact in the English language. "Looking with a jaundiced eye" is an expression of disapproval. Yellow is often associated with cowardice, e.g. 'yellow streak', or with low newspaper morality, e.g. 'yellow journalism'.

"That's mighty white of you," and "white flower of a blameless life," praise considerate actions and high morality. White enforces the unpleasant situation as well. People tell 'white lies', and are burdened with the 'white elephant'. 'White-lipped' is a description of rage: 'white as a sheet' is a reaction to fear. A 'white-livered' person is a coward, and a 'whitewash' is a cover-up.

Black has unfavourable connotations. It is associated with wickedness, e.g. 'black-hearted', and with disaster, e.g. 'Black Death', 'black Friday', 'black cats', 'black despair', and 'a black outlook'. An outcast is a 'black sheep'. Poor behavior is indicated by a 'black eye', a 'black mark' or a 'black record'. Secrecy is implied in 'black-balling', and in 'blackmail'.

Additional word associations are worthy of attention. To be angry is to be 'browned off', and the after-effect is sometimes called a 'brown taste'. Contemplation is referred to as a 'brown study'. Expressions of 'purple passion' and 'purple with rage' indicate peaks in emotion. 'Purple patches' are the high points in a 'highly coloured' or emotional statement. An optimist sees the world through 'rose-coloured glasses', and believes "every cloud has a silver lining." He anticipates a 'rosy future'. 'In the pink' refers to superb condition. The glib orator is 'silver-tongued', but 'silence is golden'. 'Golden opportunities', 'golden memories' and 'golden days of youth' are recalled with nostalgia.

In summary,

> . . . color is a power in the communication of ideas. It is definitely engaged in our simplest experiences; we use it

constantly and we know so little about it.[4]

In her book, The World I Live In, Helen Keller indicates the importance of colour association for the blind.

> Without color . . . life to me would be dark, barren, a vast blackness. . . . Thus through an inner law of completeness my thoughts are not permitted to remain colorless.[5]

The associations and emotions aroused by the use of vocabulary in the English language influence man through his speech and writing. Although colour words in other languages will have different connotations, they will undoubtedly serve the same purpose, that of implementing the communication of emotions. "Color is used in daily expression to heighten and clarify meaning."[6]

Colour Symbolism

The associative power of colour is evident in symbolism as well as in language. There are many instances where these categories overlap, where a colour word becomes a symbol, e.g. 'Red' signifies a member of the Communist party. Just as the emotions associated with colour words vary from one language to another, so the symbolic meaning of colour fluctuates between cultures. For instance, the purity symbol of the bride is white in

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[4]Harland Bopst, Color and Personality (New York: Vantage Press, 1962), p. 15.

[5]Quoted by Faber Birren, Color: a Survey in Words and Pictures (New York: University Books, Inc., 1963), p. 190.

[6]Donald M. Anderson, Elements of Design (New York: Holt, Rinehart and Winston, 1961), p. 185.

western nations, yellow in China and Israel, and red in India. "Colour means exactly what society says it means."[7] In most cases, symbolic use of colour adheres closely to the inherent characteristics of each colour.[8] Symbolism created by the church is more arbitrary.

Yellow, the colour nearest the sun, is characterized by splendor, radiance, warmth and happiness. In the shape of a circle, yellow spreads out from the center, markedly approaching the spectator. Yellow, emblematic of the sun, is the hue of the ancient German sun god, Baldur. In ecclesiastical symbolism, saffron denotes the confessor. When blue, green or black are added to yellow, the intrinsic optimism reverses to pessimism. The so-called 'cuckold' colour has been the sign of the bankrupt, the traitor, the criminal, the Jew, and the plague.

Red is glowing, solid and masculine. Light red is gracious and charming, whereas dark, intense red is dignified. Red is a symbol of charity and the life-giving qualities of blood. It is associated with sacraments in the Greek, Roman and Anglican churches, and symbolizes martyrdom for faith in Occidental religions. Red can signify beauty, bashfulness and love. On the other hand, it is symbolic of strength and bravery (Hannibal's shield). Red can represent fire, anger, hate, war and danger. Graves claims it is favoured by anarchists and terrorists as an emblem of

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[7] Anderson, p. 183.

[8] The characteristics of each colour have been derived from Goethe and Kandinsky, who have been instrumental in describing the impressiveness and expressiveness of each hue.

Johann Wolfgang von Goethe, Theory of Colour, trans. E. L. Eastlake (London: Murray, 1840), pp. 763-801.

Wassily Kandinsky, On the Spiritual in Art (New York: Solomon R. Guggenheim Foundation for the Museum of Non-Objective Painting, trans. Hilda Rebay, 1946), pp. 61-62.

defiance and violence.[9] The symbolic function of any colour can vacillate with the connotations of the situation or object in question.

The symbolism of purple varies. On the cool side, violet is withdrawn, hard and melancholy. Appropriately, it is the colour of mourning in China, and the symbol of sorrow, suffering and penitence of the saints in Christianity. Violet is also said to be the colour of older infertile women. Reference to Queen Victoria's declining reign in the nineties as the 'mauve decade' is apt. The warmer purple is more optimistic in impression, and is associated with pomp, regality, wealth, and rule.

Blue is negative, drawing the observer into it. It is spacious, serious and calm. Blue is considered to be a feminine colour, symbolizing maternity, faithfulness, and chastity. The influence of the church has led blue to symbolize truth and faith.

Green is satisfying, beneficial, passive and restful. In Christianity green is symbolic of hope, the resurrection, and everlasting life. Pale green symbolizes baptism.

White represents a paradox because on one hand it is the integration of all colours, and therefore symbolic of supreme fulfilment, while on the other hand, it is the absence of hue, and therefore of life, thus symbolizing the emptiness of the dead. Hebbel once wrote in his diary, "We freeze if we see a white mass, we shiver before a white figure. Snow is white. We think of ghosts as being white."[10] Melville's memorable description of

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[9]Maitland Graves, The Art of Color and Design (Toronto: McGraw-Hill Book Co., Inc., 1951), p. 405.

[10]Martin Koblo, World of Color, An Introduction to the Theory and Use of Color in Art, trans. Ian F. Finlay (Toronto: McGraw-Hill Book Co., 1963), p. 19.

the panic and terror accompanying the white whale in Moby Dick illustrates the psychological power of the absence of colour.[11]

Characteristically, black is solemn, subdued and depressing. In addition to symbolizing mourning, it signifies night, secrecy and evil. In the case of black, as with the other colours, symbolism and colour words revolve around the inherent characteristics of the colour in question.

The Development of Colour Symbolism

A few examples of colour symbolism will illustrate how colour has long been a part of man's concepts. Of the four elements constituting the Greek concept of matter, earth was green, fire was red, air was yellow, and water was blue. During the Elizabethan era, it was customary to compare the four major hues with four human temperaments. Elizabethans spoke of sanguine yellow, choleric red, phlegmatic green and melancholy blue. Another example of colour symbolism occurs in the medieval tradition of heraldry. Early in the development of heraldry, each man chose his identifying colour, signifying a virtue, which was knit into a design worn over his armour or on his shield. Later, it became the king's prerogative to assign armorial bearings and colours to reward valour. In this way, red became the attested colour of courage. The notion of a stain on one's escutcheon derives from the punishment of incorporating an abased colour into the coat of arms of a knight.[12] Another form of early visual symbolism was the

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[11] Herman Melville, Moby Dick (New York: The Macmillan Co., 1962), pp. 198-203.

[12] Thomas H. Wolf, The Magic of Color, illustr. Ned Seidler (New York: The Odyssey Press, 1964), p. 19.

custom of painting actor's faces in the Chinese theatre. Through a long tradition, certain colours and designs came to symbolize the personality of the character. Body decoration, sand paintings, and hex designs all employ the symbolic use of colour. Colour symbolism has always pervaded man's life.

When man began to notice that colour symbolism was consistent in a group of people with similar customs and learning, he realized it could be employed for a beneficial purpose. He considered the characteristics of colours, and set about making his own symbols. The colours of traffic lights were originally chosen for distinguishability. Bright lights are most easily seen, but where intensities are kept uniform, red lights are easiest to recognize, followed by green and yellow. Red is used for the most pertinent aspect of traffic control, stop lights. People have learned to associate red with the command to stop, so that the "mere perception of the stimulus can suffice to set off the fear response."[13]

In 1944 Faber Birren collaborated with du Pont to create a colour safety code for industry. He utilized the characteristics of colour to best advantage. Yellow, the most luminous colour, denotes stumbling or falling hazards, such as low beams or an alteration in floor level. Orange carries the message of attention and danger, and designates acute hazards likely to cut or shock. Green, the combination of yellow's 'attention' and blue's 'caution', is the colour of first aid equipment. Red, the most insistent, shouting colour, is used to identify fire alarms and apparatus. In industry, caution signals are usually blue, while traffic control and

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[13] The Science of Color, p. 166.

housekeeping are governed by white, gray and black. Men like Birren incorporate the characteristics of colour into effective codes of colour communication.[14] Factory workers gradually become conditioned to respond to these colours as safety measures. This is how the colour code becomes symbolic of warning against various hazards.

Safety, then, whether in industry, or in traffic control, is in part dependent upon colour. The characteristics of the colour, including the visibility factor, are considered prior to symbolic codes, but through continued association the colours become symbols of utmost efficiency. For instance, following the introduction of the du Pont safety code, the U. S. army Service Forces reported that the frequency of accidents in some government plants fell from a rate of 46.14 to 5.58. In one Quartermaster Depot, disabling injuries were cut from 13.25 to 6.99. The colour employed in the safety code installed in the New York Transit System was considered the most important factor in reducing the frequency of accidents 42.3% over a period of 18 months.[15]

Individual Colour Symbolism

> Some color situations elicit considerable agreement in emotional response because of the underlying similarities in custom, learning and association. On the other hand, many individual differences in emotional responses to color are ascribable to individual differences in environment and association.[16]

16Faber Birren, Color Psychology and Color Therapy (Toronto: McGraw-Hill Book Co., Inc., 1950), p. 259.

17Robert F. Wilson, Colour in Industry Today, pp. 131-132.

18The Science of Color, p. 166.

Colour symbolism can be a very personal matter. On of the few places in art with any symbolic colour consistency is the religious paintings of the Middle Ages. Objects and figures assume their significance through their colours, e.g. Judas is portrayed in yellow. In the realm of creativity, colour seldom has one meaning. Seurat saw gaeity in warm hues, calmness in cool hues and sadness in dark hues.[17] Where Gaugin thought yellow symbolized fear, his contemporary, van Gogh, said it symbolize hope. Here van Gogh describes his symbolic use of colour in painting.

> I exaggerate the fairness of hair, I take orange, chrome, dull lemon-yellow. Behind his head, in place of the ordinary wall of the room, I paint infinity. I make a simple background of richest blue, as strong as the palette can produce.[18]

In a letter to his brother Theo, van Gogh wrote,

> In my picture of Night Cafe I have tried to express the idea that the cafe is a place where one can ruin one's self, run mad, or commit a crime. So I have tried to express as it were the powers of darkness in a low drink shop, by the soft Louis XV green and malachite, contrasting with yellow green and hard blue-greens, and all this in an atmosphere like a devil's furnace, of pale sulphur.[19]

In this aggressively simple language the reader sees and feels the strong imagery intended in the use of colour. The communication of colour symbolism is direct.

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[17] Birren, Color: a Survey in Words and Pictures, p. 185.

[18] Quoted by Koblo, p. 18.

[19] Quoted by Graves, p. 348.

In summary, words and symbols contain major associations with colour. Emotions are expressed by colour vocabulary, and messages are conveyed by colour symbols. Both are a prevalent and vital part of communication in our society. The artist's symbolic use of colour enhances his kind of communication in a forceful manner. Considering the prevalence of colour in language and in everyday symbols, the importance of man's associations with colour cannot be overstated.

CHAPTER VII

THE PSYCHOLOGY OF COLOUR

THE LINK BETWEEN COLOUR VISION AND THE OTHER SENSES

Colour is intimately connected to the senses other than sight; to touch, smell, taste, and hearing, as well as to certain mental concepts. Inasmuch as colours are warm and cool, heavy and light, colour is aligned with touch. As far as smell is concerned, red, orange, and pink are associated with sweet odors. These examples of the sensory connection to colour are followed by startling connections in the realm of taste and hearing.

Taste

Colour affects the appetite. Consumers in British Columbia became aware of this connection when oleomargarine was coloured yellow to resemble butter. Sales increased substantially. Few people realize that butter is naturally white in winter, and is coloured to please the customer. Further, this colouring is carefully controlled because too light a yellow does not appeal to the appetite, whereas too deep a yellow makes the butter appear rancid. If the skin of an orange in injected with an even rich orange dye, the orange will sell better. Psychological studies of colour's appetite appeal reveal a specific food palette. "Although not all persons will 'feel' the same about colors or have the same reactions, by and large there are common denominators worthy of attention in the food industry."[1] Red-

[1]Faber Birren, "Color and Human Appetite," Food Technology, XVII (May, 1963), p. 45.

orange and orange arouse the most agreeable sensations. Peach, pink, tan, brown, yellow and green also stimulate the appetite. Appeal to the appetite also depends on variety. A meal consisting of steamed sole, mashed potatoes and cauliflower, served on a white plate, followed by rice pudding and a glass of milk would be less than mouth-watering. A manufacturer of chocolate candy learned that sugar coating in a variety of hues, all of the same flavour, sold better than one hue. The appeal of foods not only depends on their colour, but also on the colour of the packaging and display facilities. Green-blue is rated the most favourable background colour for food. Birren points to one instance where a school cafeteria doubled the sale of salads by putting them on green plates.[2] Thus, the role played by colour in the appetite appeal of food is established.

Colour has a direct relationship to the taste of food. Researchers have found brown chocolate has a stronger chocolate taste than white chocolate when the subject can see what he is eating, but there is no difference in flavour when the subject is blindfolded. The introduction of new food colours has been known to fail completely. People dislike the flavour of pink and green bread used in dainty sandwiches, whereas colouring in cakes, frostings, and cookies is acceptable. The most outlandish test of the reaction to unfamiliar colour in food was conducted by S. G. Hibben, whose dinner party is now famous. Although the food was excellent, many guests lost their appetites, and some became violently ill. The reason? The steaks were coloured whitish-gray, the celery was pink, the salads were

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[2]Birren, p. 47.

blue, the peas were black like caviar, the milk was "the unwholesome color of blood," the coffee had a "sickly yellow tinge," and the peanuts were scarlet.[3] Colour is a determining factor in the appetite appeal and the taste of food.

Synesthesia

Another connection of colour with the senses occurs in less prevalent instances of synesthesia. The ability to distinguish between primary modes of sensation develops with age. When the sensory links of infancy persist into later life, one kind of stimulus is likely to arouse imagery of another quite spontaneously. Colour and taste, odor, touch and hearing have a formal connection in this phenomenon. "It appears that stimuli of different sensory modes, vision, hearing, etc., are somehow linked together, so that in 'coloured hearing', for instance, auditory stimuli are perceived in conjunction with images of colours so vivid that they almost resemble percepts."[4]

The connection between colour and other sensations or percepts in the phenomenon of synesthesia is not directly due to colour. Rather, colour is the sensation that arises simultaneously with the other sensations or percepts. Therefore, synesthesia cannot be considered as having an effect on the human organism unless the organism depends to some degree upon the additional imagery. Indeed, this is the case in people who experience synesthesia, because they come to depend on this enrichment of their perception. A case is reported of a man who had been blind since the age of eleven.

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[3]Birren, p. 45.

[4]Maitland Graves, The Art of Color and Design (Toronto: McGraw-Hill Book Co., Inc., 1951), p. 408.

Before he became blind the connections between colour, touch and sound had maintained their original childhood link. This continued after his loss of sight.

> . . . colours appeared to be an integral part of his perceptions of . . . sound and touch. . . . Their meaning . . . was not fully apprehended until the appropriate colour imagery had developed.[5]

Similarly, composers who possess the synesthesic faculty depend on the connections between sound and colour. Scriabin associated the keys from C to F sharp with hues from red to purple.[6] Composer Liszt supplemented his conducting directions with such pet phrases as "More pink here." "I want it all azure." "This is too black."[7] People possessing the synesthesic aptitude find it helpful in remembering the music of certain composers, and the sounds of certain instruments. After describing the fastidious colour connections experienced with letters and words, one women wrote,

> Occasionally, when uncertain how a word should be spelt, I have considered what colour it ought to be, and have decided in that way. I believe this has often been a great help to me in spelling, both in English and foreign languages.[8]

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[5] R. H. Wheeler and T. D. Cutsforth, "Synaesthesia in the Development of the Concept," Journal of Experimental Psychology, VIII (1925), p. 149.

[6] C. S. Myers, "Two Cases of Synaesthesia," British Journal of Psychology, VII (1914), p. 112.

[7] Quoted by Faber Birren, Color Psychology and Color Therapy (Toronto: McGraw-Hill Book Co., Inc., 1950), p. 163.

[8] R. A. Houstoun, Light and Colour (Toronto: Longman's, Green and Co., 1923), p. 169.

Even though some people are dependent on the synesthesic connection of colour with other sensory perceptions, so few people possess this aptitude that it cannot be considered a significant factor in the total effect of colour on the human organism. For the majority of the population, however, the sense of taste is intimately connected with colour vision. Colour has been shown to affect both the appetite and the flavour of foods.

CHAPTER VIII

THE PSYCHOLOGY OF COLOUR

VISUAL PHENOMENA

The final chapter in the consideration of colour's effect on man is based on the primary sense of colour perception, vision. The effect of colour on the human organism through the illusion of visual phenomena is major. A visual phenomena

> is usually not identified at all unless it is actively looked for. Furthermore, by definition, subjective phenomena are not obviously correlated with external physical events, which makes them difficult to 'prove' on a common sense basis. . . . All perceptions are real whether or not they happen to have obvious correlates outside the organism; . . .[1]

There are many kinds of visual phenomena deserving attention for their effect on man. A number of these can be attributed to one of three kinds of adaptation--general, local and lateral.

General Adaptation

General adaptation phenomena are due mainly to the adjustment made by the eye to see under different conditions. As the eye jumps over the visual field, different objects occupy the center of visual attention. As the eye stops at each one, the sensitivity changes up or down to an appropriate level. Accordingly, each area is viewed with a sensitivity determined by

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[1]Committee on Colorimetry, Optical Society of America, The Science of Color (Washington, D.C.: Optical Society of America, 1963), p. 121.

the previous area. In brightness adaptation, the eye is exposed to a given illumination level until it accepts this level as normal, then all other intensities are seen relative to it. In other words, the phenomenon of brightness adaptation means that the brightness dimension of all colours seen by man is determined by the brightness of the previous stimulus. W. D. Wright found that exposure of the eye to light almost instantly causes the sensitivity to drop. For brief exposures, the eye recovers almost immediately, but for longer exposures, the recovery takes longer.[2] Due to brightness adaptation, estimation of absolute brightness is vague. Errors become apparent only when the subject returns to the original situation. The estimation of relative brightness, however, is exceedingly precise. The eye supercedes the camera in ability to distinguish grays.

In the same way that brightness perception is influenced by the light intensity of the previous field, so the perception of colour is partially determined by the colours previously seen by the eye. 'Colour adaptation' or 'colour constancy' is a phenomenon experienced by anyone who wears sunglasses, but soon forgets that everything is tinted green. Similarly, white paper seen in yellow candlelight is assumed to be white, although in physical fact, the yellow light reflected from the white paper makes the paper yellow. Although stimulus changes alter the sensation of colour, the unconscious, with its store of past experience, reinterprets these changes to maintain the apparent constancy of the colour. Colour constancy tends to make colour a property of the object, rather then the variable it would

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[2]W. D. Wright, Researches on Normal and Defective Colour Vision (London: Henry Kimpton, 1946), pp. 149-150.

be if the receptor sensitivities were unfixed. 'Object' or 'surface' colour has been investigated by Thouless. Perception, he states, seems to deviate from its stimulus, showing "regression toward the real object."[3] This phenomenon is important in daily life because it helps the individual identify object colour under adverse conditions such as dusk and deep shadow.

'Memory colour' refers to a similar phenomenon. Memory colour tends to accentuate the dominant colour characteristic. For instance, when the shape of a leaf and the shape of a horse are cut from the same cloth, the observer will usually think the leaf shape is greener. Memory colour also influences night vision. Few people realize that there is no perception of colour in night vision, because their memory of object colour from photopic vision persists into scotopic vision. When reproduction is the purpose of an illustration or photograph, accurate colour matching is not essential. The greatest satisfaction is obtained by matching the corresponding memory colours. Thus man's judgment allows his perception to take the path of least resistence, inaccurate though it may be.

Local Adaptation

The second group of phenomena are due to local adaptation, and are best represented by after-images. The majority of after-image explana-

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[3] R. H. Thouless, "Phenomenal Regression to the Real Object, I," British Journal of Psychology, XXI, p. 359.

tions are based on trichromacy.[4] Adaptation to any one colour decreases the sensitivity to the receptors involved. This makes the eye relatively sensitive to the other colours, whose corresponding receptors are not 'fatigued'. When the viewed stimulus is changed, the fresh receptors govern the sensation. After-sensations start forming from the very moment of fixation. The intensity of the after-image increases with the length of fixation on the stimulus.[5]

After-images are classified as positive and negative. The original after-images seen in the contemporary hue are termed 'negative'. They have a latency of one second and a duration of half a minute.[6] The hue of an after-image viewed on a neutral surface deviates from the strict complementary towards reddish -blue.[7] Viewed on a coloured surface, the after-image will appear as the subtractive mixture of the complement and the colour of the surface. The hue of the after-image influences the colour perception of any number of things.

In positive after-images the brightness relationships remain the same as those found in the original response to the stimulus. The original

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[4]C. A. Pagham, "After-Images as a Means of Investigating Rods and Cones," Colour Vision--Physiology and Experimental Psychology, Ciba Foundation Symposium, ed. A. V. S. de Reuck, and Julie Knight (London: J. and A. Churchill, Ltd., 1965), p. 263.

Pagham states that no theory of after-image is satisfactory at present.

[5]R. W. Pickford, Individual Differences in Colour Vision (London: Routledge and Kegan Paul, Ltd., 1951), p. 20.

[6]Rudolf Arnheim, Art and Visual Perception (Berkeley: University of California Press, 1965), p. 348.

[7]Robert W. Burnham, Randall M. Hanes, and C. James Bartleson, Color: a Guide to Basic Facts and Concepts (New York: John Wiley and Sons, Inc., 1963), p. 70.

process continues after the stimulus has ceased to exist. The latency is a small fraction of a second. In fact, the positive after-image may even merge with the terminal lag of the original sensation, accounting for the fact that this type of after-image is also affecting man's vision in an unobtrusive manner, seldom pin-pointed as interference, because it is seldom recognized. Other after-images are more complex in nature, but they also occur less frequently in daily circumstances. Examples of complex after-images are the 'flight of colours' and the 'recurrent vision', taking in the Hering Image, Bidwell's Ghost, the Purkinje Image, and the Hess Image.[8]

A great number of after-images occur in everyday situation, e.g. walking into a dark room and turning on the light. Many after-images are best brought to the attention of people in demonstrations with controlled means. Most people have unconsciously learned to ignore after-images because they interfere with more useful perceptions. Also, under normal conditions, the eyes shift so frequently that there is insufficient time for an after-image to develop to full strength. "After-images are important principally because of their implications for the functioning of the visual mechanism, they are one manifestation of the general process of visual adaptation."[9]

After-images represent one kind of local adaptation. A closely related phenomenon is successive contrast, occurring when the subject looks in succession from one stimulus to another. A red stimlus exhausts the red-sensitive cones so that the subsequently fixated surface is mixed visually with blue-green. According to Linksz, the whole experience is

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[8] Burnham, Hanes, and Bartleson, p. 71.

[9] *Ibid.*, p. 72.

plainly a sensorial process with no judgment process.[10] All successive contrast demonstrates that the effect of a stimulus does not abruptly end the moment the stimulus ceases to exist.

Lateral Adaptation

The third adaptive phenomenon is lateral adaptation. It is the major factor in simultaneous contrast. Whereas the after-images and successive contrast result from a previous stimuli, simultaneous contrast is a product of present stimuli. The illusionary effect of simultaneous contrast can be seen in both brightness and colour contrast.

In brightness contrast, the value of a colour is determined to a large extent by the value of its surround. It also depends on the size and placement of the ground. Colour contrast or colour enhancement is the second type of simultaneous contrast. "Color contrast produces an enhancement or intensification of the perceived difference between neighbouring colors."[11] Ward summarizes the phenomenon this way, "Contrast of colour is due to the modifications in the appearance of colours that are caused by differences in hue, brightness and purity of adjacent or contiguous colours."[12]

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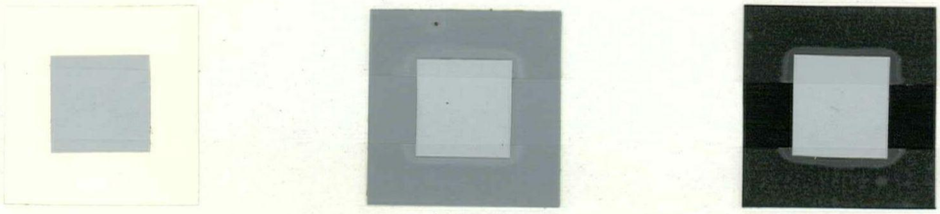
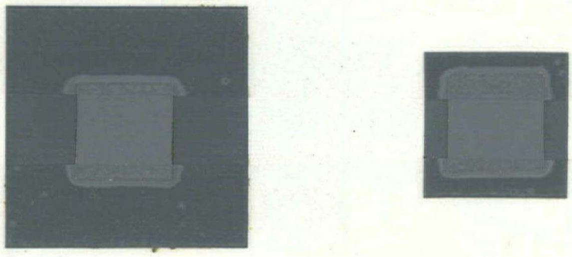
[10] Arthur Linksz, Vision--Physiology of the Eye, II (New York: Grune and Stratton, 1952), p. 196.

[11] The Science of Color, p. 117.

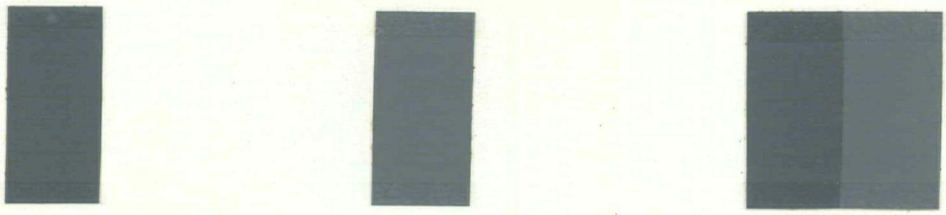
[12] James Ward, Colour Harmony and Contrast (London: Chapman and Hall, Ltd., 1932), p. 54.



Three identical squares of gray placed separately on white, gray and black grounds appear to change their brightness.



The magnitude of the apparent change in brightness depends on the size of the neighbouring stimulus.



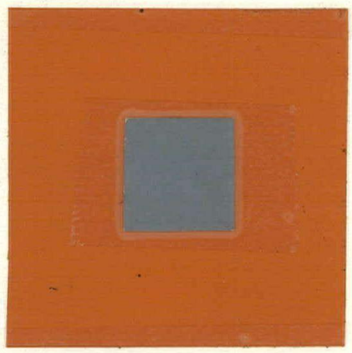
The magnitude of the apparent change in value also depends on the distance between the two fields. In juxtaposition, simultaneous contrast accentuates even small differences.

Brightness contrast also emphasizes the value difference between two colours. The small red square looks black and colourless when placed on a white ground, whereas the same red is more brilliant and colourful on the black ground.

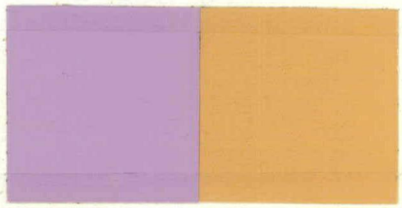
FIGURE 1

BRIGHTNESS CONTRAST

Juxtaposed colours of relatively high and low purity appear saturated and desaturated respectively.



When a chromatic hue is contrasted with an achromatic hue, it induces a complementary hue in place of the hueless sensation.

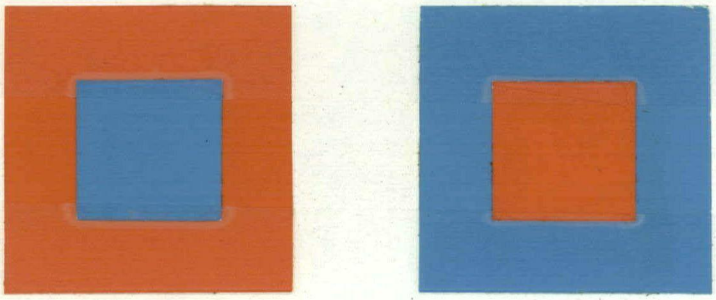


The tendency of each colour to induce its after-image complementary into its neighbour increases the existing hue difference of non-complementaries.

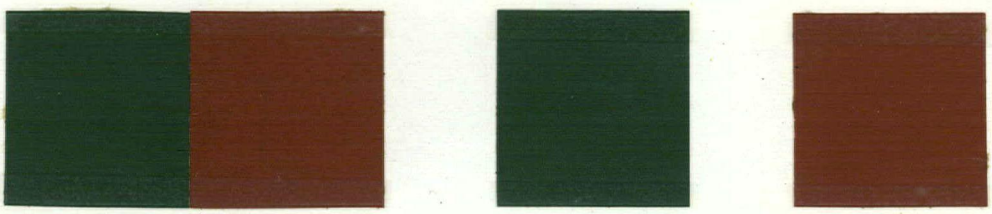
FIGURE 2

COLOUR CONTRAST

COLOUR CONTRAST CONT'D.



The simultaneous contrast of complementary colours of equal light intensity produces illusionary colours vibrating at the boundary. They often appear as a shadow on one side of the boundary and as light reflected on the other, or as a duplication or triplication of the boundary line. When the figure and ground are reversed, the vibrating boundaries make a corresponding quality alteration.



Complementary colours of equal light intensity tend to enhance each other. Chevreul writes, "My experience tends to show: that the effect is a radiating, setting out from the line of juxtaposition; that it is reciprocal between two equal surfaces juxtaposed; that the effect of contrast still exists when these two surfaces are at a distance from each other, only it is less evident than when they are contiguous; finally, that the effect exists when we cannot attribute it to fatigue of the eye."[13]

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[13] M. E. Chevreul, <u>The Principles of Harmony and Contrast of Colours, and Their Application to the Arts</u> (London: George Bell and Sons, 1890), p. 419.

Albers underlines the vital less of adaptive colour phenomena. He says the fact that the after-image and simultaneous contrast are psycho-physiological phenomena

> . . . should prove that no normal eye, not even the most trained one, is foolproof against colour deception. He who claims to see colors independent of their illusionary changes fools only himself, no one else.[14]

Non-Adaptive Phenomena

Phenomena not ascribable to adaptation also affect the human organism, but in more isolated circumstances. A few such effects will be mentioned to give the reader a hint of the deceptive quality of colour vision. First is the enigmatic Bezold effect, where a black outline darkens the enclosed hues, and enhances their saturation. This technique is exploited by manufacturers changing the appearance of designs with the least alteration in production. Secondly, the spreading effect, or 'halation', causes most grid patterns to be incorrectly perceived because the lighter component of the grid, whether it be the lines or the ground, tends to spread and appear larger. Thirdly, as illumination is increased, colours tend to appear more blue or more yellow. This phenomenon, called the Bezold-Brucke effect, is experienced by people buying furniture and other merchandise where colour is an important consideration, only to be dissatisfied with the colour on delivery. (Needless to say, the colour of illumination contributes to the deception.) Fourthly, the Weber-Fechner Law states that the visual perception

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[14]Josef Albers, Interaction of Color (New Haven and London: Yale University Press, 1963), p. 31.

of an arithmetic progression depends on a physical geometric progression. For example, the steps in a swimming pool deepen in arithmetic progression, but do not appear to be evenly spaced. Any many who has tried to lighten house paint, and has been amazed at the amount of white required, has had first-hand experience with the Weber-Fechner phenomenon. The fifth enigma, that of disappearing boundaries, is the concern of anyone depending on the accuracy of colour perception for his safety. Colours of similar hue and equal light intensity tend to merge. For example, the underside of a cloud is often indiscernible from the sky. In another natural phenomenon, radiant energy does not provide the stimulus for colour sensation. Accidental colours, resulting from pressure on the eye, have an amusing, though ephemeral effect on man. Finally, yellow has the greatest light-producing capacity in daylight vision. In scotopic vision, governed by the rods, the wavelength of 507 mμ (green) is seen as the brightest hue. This phenomenon, the Purkinje effect, causes the leaves and grass to take on an unnatural brightness in night vision. Other non-adaptive phenomena can be illustrated with simple apparatus. Fechner's colours, produced by presenting an achromatic stimulus intermittently, and 'marginal contrast', produced with black and white rotating discs, are convincing examples of the illusionary qualities of colour.

In conclusion, colour has apparent distance, temperature, size and weight. The maxim that warm colours advance, while cool colours recede is well-known. Pillsbury and Schaefer have reinterpreted the older view that the stimulus basis for the advancement and retreat of colour is luminance rather than hue.[15] Whereas brightness determines colour distance, hue determines colour temperature. The maximum wavelength for warmth has been pin-pointed to 610 mμ, and the maximum coolness ranges through green and blue.[16] Mueller[17] and Arnheim[18] claim that warm and cool colours do not refer to specific hues, but to the deviation of a given colour in the direction of warmth or coolness. (They would have to concede that hues are initially warm or cool, in order to determine whether the direction is warm or cool.) Both the apparent distance and temperature of a colour depend on the neighbouring colours. A green will recede when placed on a warm red ground, but it will not recede when placed on a cooler blue ground. Similarly, green will seen cool when juxtaposed with red, but warm when juxtaposed with blue.

Size and weight are also closely related to colour. Gundlach and Macoubrey found that the apparent size correlates 0.86 with luminance. They demonstrated that lighter objects look larger than darker objects of the same dimensions.[19] There is general agreement that the apparent weight

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[15] W. B. Pillsbury and B. R. Schaefer, "A Note on 'Advancing and Retreating Colors'," American Journal of Psychology, XLIX (1937), pp. 126-130.

This has an interesting correlation with Chevreul's classification of warm and cool hues according to their luminous or sombre qualities. The luminous colours are yellow, orange, red and light green, the sombre colours are blue, violet and deep green.

[16] The Science of Color, p. 168.

Also, refer to the theoretical explanation for colour temperature on p. 21 of this thesis.

[17] Conrad G. Mueller, Sensory Psychology (Englewood Cliffs, New Jersey: Prentice-Hall, 1965), p. 328.

[18] Art and Visual Perception, p. 329.

[19] C. Gundlach and D. Macoubrey, "The Effect of Color on Apparent Size," American Journal of Psychology, XLIII (1931), pp. 109-111.

of colours varies according to brightness. Dark colours appear heavy and light colours appear less heavy.[20] Isay Balinkin describes these factors in the following excerpt.

> Suppose you're a foreman in a factory and ask one of your men to move two large boxes, exactly the same size and weight. One is pale green and the other is dark brown. He's almost sure to pick up the green one first because it looks lighter. Now you ask him to put the box on either of two workbenches some twenty feet away. One is painted red and one is blue. He'll probably put it one the red one. It looks a good step closer.[21]

In summary, phenomena produced by adaptation have their impact on all visual appearance, whereas phenomena not ascribed to adaptation occur intermittently, or with specific conditions, and are often transient in effect. Regardless of the explanation and the degree of the effect, the fact is clear that these phenomena influence man through his vision. "What you see is your best guess as to what is out front."[22]

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[20] E. Bullough, "On the Apparent Heaviness of Colours," British Journal of Psychology, II (1906-08), pp. 111-152.

Also, J. E. DeCamp, "The Influence of Color on Apparent Weight. A Preliminary Study," Journal of Experimental Psychology, II (1917), pp. 347-370.

[21] Isay Balinkin, The Color Tree (New York: Interchemical Corporation, 1965), p. 11.

[22] Professor A. Ames, Jr. of Dartmouth College, quoted by Deane B. Judd, Color in Business, Science, and Industry (New York: John Wiley and Sons, Inc., 1963), p. 23.

CONCLUSION TO PART I

Research discussed in the preceding eight chapters provides evidence to support the hypothesis that man is affected by colour. Colour is the physical stimulus for sight. Physiologists have shown how pigments implement the response process in the visual receptor. The way that man is intellectually, emotionally, and unconsciously bound up with colour experiences is the concern of the psychologist.

Merchandising and advertising utilize the qualities of colour to produce a calculated response in the consumer.[1] Man can be made to feel bored, indignant, or physically ill by colour. He can be shocked or delighted. Colour determines the reaction. But these business-oriented endeavours are gaints among the disappointingly few instances where the potential of colour is being realized. The constructive approach of the following excerpt makes an apt conclusion to this section.

> The value of color is determined in significant part by what people come to think, or are made to think, of its value. This being so, it is worthwhile to know how to make people think that color is valuable. The most effective way to do that is to arrange for them to discover that color produces the effect which can satisfy their wants and needs . . . . that greater satisfaction can be derived from the use of color; and that perceptions and decisions having to do with color tend to have a higher affective valence.[2]

In short, this has been the aim of these eight chapters.

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[1]See Vance Oakley Packard, The Hidden Persuaders (New York: McKay, 1957).

[2]Committee on Colorimetry, Optical Society of America, The Science of Color (Washington, D.C.: The Optical Society of America, 1963), p. 167.

PART II

EVALUATION OF THE PRESENT SITUATION

The profound effect of colour on the human organism has been established in the preceding presentation of research. If colour is important to man, it is of major concern to the artist, because colour is a major element of art. In addition to motivating the artist through its direct visual impact, colour can affect his emotional state of mind and his rate of motor and mental activity. It provides him with an element capable of producing moods, space, tension, and symbolism. The question arises as to how an artist learns to control and utilize the powerful scope of colour, and how any person becomes aware of the richness of colour in the environment.

The responsibility for teaching colour rests with the art educator. It is assumed that the layman and natural colourist alike can improve their expressive use of colour. It is further assumed that both the layman and artist can become more sensitive to colour around them. Art educators are obligated to employ their best resources to assist man in seeing and using colour.

The most efficient way to do this is to teach colour in a meaningful manner to future teachers and art majors at the university, and to students at art school, because these people have the potential of creating a sensitivity to colour in their own pupils, in architectural and interior decorating clients, and in the art-conscious public. It was hypothesized that colour is not being taught in the most effective manner to students at this level.

CHAPTER I

INTERVIEWS WITH TEACHERS

To determine how colour is being taught, interviews were conducted with teachers of art during February and March, 1967. The subjects included 10 members of the Art Department of the Faculty of Education, 3 members of the Fine Arts Department of the Faculty of Arts, both at The University of British Columbia, in addition to one teacher of the Vancouver Art Gallery docents, and 3 teachers employed by the Vancouver School of Art.

The 17 teachers answered the interview questions (see Appendix A) with reference to their present teaching assignments. The results are summarized according to the number of the question, and are followed by a comment on their significance.

1. a) Sixteen teachers separate the elements of design, justifying the division with three general reasons. First, the discussion of the separate elements and their interrelationship provides a means of approaching works of art for understanding and appreciation. Secondly, this approach facilitates the definition of vocabulary. Finally, it allows the inexperienced student to explore and discover for himself the principles of art in manageable amounts, where a total involvement might be overwhelming.

1. b) The emphasis placed by 7 teachers on one or more elements is dictated by the nature of the subject, e.g. form and texture in ceramics, colour and tone in painting, line in drawing and in graphics. Ten subjects said they do not emphasize any element, maintaining that all the elements contribute to the total form or concept. One teacher of painting believes

that creativity is restricted when an element such as line or texture is emphasized, because the students tend to forget the other elements.

Comment: No teacher is more enthusiastic about colour than the other elements, yet a deep love for colour was suggested as part of the ideal background of the teacher of colour. (See No. 9.) All teachers are teachers of colour in that the opportunity to mention colour arises in all classes.

2. Eight teachers attributed their awareness of colour to a general development, highlighted by a van Gogh or optical painting. Four teachers recalled experiences with colour in early childhood, 4 remembered school exercises such as the mixing of pigment, and one described a recent synesthesic experience.

Comment: No pattern emerged suggesting an approach to awakening a sensitivity to colour in students. Only one subject was conscious of having experienced the overwhelming effect of colour.

3. Twelve teachers, including all 10 from the Faculty of Education, recommended that instruction in colour begin immediately, because the sooner mechanics are taught, the sooner an awareness of the relationships and possibilities of colour will develop into a dexterous handling of this element. Two teachers said they time the introduction of colour according the need and readiness of the individual. Two teachers reserve the second half of their courses for colour.

Comment: Because of its immediate impact, colour is more easily distinguished as an element of art than line, form or texture. It provides a logical place to begin the identification and explanation of the art elements. Although the majority of teachers introduce colour immediately, they cover mechanics such as the spectrum and the mixing of pigments. Teaching a student to mix tones and tints does not not ensure the development of an adept manipulation of colour to suit personal needs. In the opinion of the writer, the teaching of colour should stress the interacting characteristics of this element in vision, because colour is seldom perceived in isolated conditions.

4. a) The instructors all said they deal with colour to some extent.
4. b) In the Faculty of Education, the level and purpose of the course determines the approach to colour. In courses designed to introduce students to media and methods, or to the pedagogy of art, the following aspects are covered in two or three lessons; terminology, theory (colour wheel, harmony and discord), and experimentation in the mechanics of mixing. In advanced courses such as those dealing with painting or design, the student is assumed to have mastered the basics, and colour is brought to his attention through motivation and evaluation. Activities such as the matching of tones, mixing of pigment, and optical exercises are assigned to help the student. The fact that colour is taught in a prerequisite course saves one teacher from "going into the boring details."

In the Faculty of Arts, teachers of art history deal with the artists' use of colour, pointing out any emphasis on colour that occurs in a work of art. In design classes, the systems of colour notation are the main component of the second term. Colour is reserved for the last half of the docent training at the Vancouver Art Gallery.

At the Vancouver School of Art, the first-year student is exposed to colour as part of his orientation to painting, itself on of the four areas receiving equal emphasis. Students are introduced to the seven colour contrasts of Itten, and they also explore the relationship between colour and music. In the ensuing years of specialization, the student is assumed to have mastered the basic use of colour, and the teaching of colour becomes a matter of individual attention and timing.

Comment: The details of colour theory are as boring to the student as they are to the teacher. The teacher of advanced courses should go beyond this point with his students. The Ostwald and Munsell systems of colour notation were designed as references for science and industry. The production of inflexible models of painted cardboard does not enhance the ability to use colour. The Vancouver School of Art is the only institution utilizing coloured paper to eliminate the tedious chore of mixing. The range of colours available in the colour pack is inferior when compared to a similar supply available in the United States. No attempt was being made to supplement the inadequate range with collection of paper from magazines. A give-and-take atmosphere of experimentation involving the teacher and students would be an improvement over the lecture and assignment structure of most classes.

5. Teachers found the following methods successful in heightening the students' perception of colour: collecting objects of one colour to illustrate variations in one hue, mixing variations of one hue in pigment, working with a limited palette such as black, white and ochre, freely experimenting with paint, then explaining the theory involved, studying the use of colour in works of art, and using the colour wheel to explain the nomenclature.

Comment: The methods declared to be the most successful mirror the present approach to teaching colour. There is little focus on the changeable, adaptive qualities that contribute to the excitement and mystery of colour. Students at this level would be stimulated by such an approach.

6. All the teachers recommended a free, subjective approach to colour with elementary pupils, moving into an objective approach including theories and formulae with the secondary students. The more advanced the level, the more intellectural an approach was recommended.
Comment: Most university and art school students have learned colour theories in high school. A review of the material will be ineffective if the material is not practical to begin with. Formulae no longer satisfy the student searching for an individual expression. The recommendation that the teaching of colour become increasingly abstract with advanced levels, contradicts the opinion of the majority of teachers that colour should not be taught as a thing in itself.

7. All teachers were able to name a colour base in their work, but they avoid personal demonstrations that might influence students. Although the art instructors denied seeing their own colour base in the work of students, they readily perceived the influence of other teachers on students.
Comment: The objective onlooker is able to perceive influences the teacher is unable to detect. These influences could be harmful or beneficial.

8. The teachers named their theoretical training in colour, their experience and discoveries in the use of colour, and their efforts to keep abreast of current trends as contributing to their use of colour and the background and preparation they bring to teaching.

Comment: Teachers tend to perpetuate the mechanical training in colour they themselves received, e.g. tonal painting, matching tones, limited palette. The introduction of a new approach to colour would counteract this stagnancy. Although the teachers are dedicated and familiar with current movements in art, not one is seeking a new way to teach colour.

9. The subjects considered a command of all aspects of colour, including the physical qualities of light, the chemical composition and behavior of pigments and dyes, the psychology of perceptions and affective response to colour and the use of colour by masters to be components in an ideal colour teaching background. This background would ideally be enriched with a love for colour, a sensitivity to colour, and an ability to handle it well.
Comment: Together, the teachers' suggestions make a composite description of an ideal teaching background. Few teachers expressed an interest in acquiring the knowledge they lack, or in strengthening the weaker aspects in their teaching of colour.

10. A workshop equipped with physical, chemical, psychological and literary resources, models and machinery, and staffed by a lab assistant, would facilitate student's personal exploration of colour. A course in colour should comprise theory, including the physical, chemical and psychological aspects of colour, supplemented with experimentation and practice with problems involving the concepts introduced, and appreciation of the use of colour in nature and in painting. Lectures by resource people such as physicists, physiologists, etc. could put the students in contact with specialized colour experts.

Comment: Suggestions for the ideal course in colour vary considerably from the responses to the fourth and fifth questions, implying that the teachers of art realize that colour is not being taught in an ideal manner. Although many teachers named resources such as books, chemicals, coloured light equipment, films, colour systems models, reproductions, and psychological testing apparatus as being ideal but out of the question, it is the opinion of the writer that these resources are readily obtainable, and that their use can be implemented in present classroom facilities without employing a lab assistant. This would require time and initiative on the teacher's part.

11. Finally, members of the Faculty of Education were asked to name any outstanding student colourists, so that the background of the students could be determined. This is the topic of the next block of interviews.

CHAPTER II

INTERVIEWS WITH STUDENTS

The 5 most frequently mentioned student colourists were interviewed to determine the influence of their university art background on their use of colour. (See Appendix B.)

1. Three students learned about the colour wheel in high school; nothing was applicable to their work. Two students found their high school training valuable; one learned to mix water-colours, while the other investigated the visual phenomena in op art.

2. All students emphasized that the repetitive presentation of charts and wheels at the university level is useless. One student said, "I didn't talk to any who liked it. The best students were most sick of it."
Comment: If the background of colour theory has been taught to most students in high school, it can be reviewed independently if the need is felt, leaving the teacher and student more time to experiment and explore in depth some of the principles of the interaction of colour.

3. Two students found free experimentation with colour stimulating. The 3 remaining students were unaffected by the methods to which they were exposed.
Comment: This is probably because they were bored with repetition.

4. Every student learned about the use of colour through independent study of works of art.

Comment: An individual, self-direct approach is more effective for the student who feels a need to develop a personal dexterity in colour. The review of theory will seldom motivate a student to explore the field of colour.

5. The students were indebted to teachers who either allowed freedom to discover about colour, or who praised the colour qualities in student work.
Comment: Students sense the attitude of the teacher. The teacher supports the student just by understanding that discovery in the field of colour is highly personal and requires persistence. Enthusiasm for colour is contagious.

6. The subjects named the colour base of several instructors, but said the instructors were not biased towards this use of colour in students. One subject reported overhearing a number of students say they could not help being influenced by a certain instructor's use of colour.

7. When asked for their views on how colour is presently being taught, 4 students replied that colour is not being taught, and 1 student said her feelings on that matter were vague because she herself has not been taught about colour.

8. All students though a course would be beneficial to the majority of students. They would like to see the study of light, and colour in films included. Three mentioned that personally, they did not feel a need for such a course, while 2 said they would enrol.
Comment: Although 3 students are satisfied with their handling of colour,

they have few ideas on the extensive areas of colour that could be presented in a course. It was not expected that any student would be interested in a course, because each is a skilled colourist.

9. The background of the teacher of colour should include an ability to verbalize on the visual, a sensitive eye for colour, and an involvement and inquisitiveness in the field of colour.

Comment: Again, it appears the teacher should be a specialist in the field of colour.

CHAPTER III

RESULTS OF THE QUESTIONNAIRE

Interrogation of the student colourists revealed that the theoretical approach to colour has little application in practice. It was decided to circulate a quesionnaire amongst a more representative group of Fine Arts majors to derive the general opinion on the present methods of teaching colour in the Faculty of Education. (See Appendix C.) The questionnaire was distributed on an anonymous and voluntary basis to students who have commenced their majors.

1. A total of 49 replies have been tabulated, including 22 Elementary single art majors, 6 Secondary single art majors, and 21 Secondary double art majors. Differences occurring in the answers are insignificant because they can be attributed to the variety and number of courses taken. The results are combined to form a composite picture of the teaching of colour in the Fine Arts Department.

2. The description of what has been learned broke down into four manners of response. To begin with, 4 students gave no answer. Secondly, 6 students checked the box but did not describe what they learned. Fifteen students made evaluatory comments such as: "very little," "not in any detail," "a very basic introduction (i.e. practically nothing)," "learned nothing about colour that I had not known before." Some description of colour presentation was written by 24 students. The following figures and descriptions amalgomate the three latter modes of response. Thirteen students learned how the old masters used colour in F.A. 101. Twenty-eight

students learned about colour in F.A. 300. The most frequently mentioned facets of colour were mixing and experimenting with poster paint, colour charts and terminology, warmth and coolness, harmony, and clash. Two students mentioned learning about collage in F.A. 301. Nineteen subjects learned the following information in F.A. 302: colour wheel and mixing shades, tones and transparencies to achieve various relationships such as discord, and distance. Seven students learned about the use of natural dyes in the design courses. Twenty painting majors, the majority of whom referred to F.A. 401, mentioned the use of colour in composition. Specifically they named the theory behind tones, shades and tints, the apparent distance and the mood of colour. Ten students checked the elementary art education categories, referring to the use of colour themes, music as a stimulus for painting, and the limited palette for children. Two students mentioned learning how to give colour assignments in secondary schools.

Comment: Students described theory and mechanical details of mixing most frequently. No students mentioned that an evaluation of the use of colour had motivated them to enquire into the field in any depth.

3. Twenty-four students were able to apply what they had been taught about colour to their own work. They spoke of the use of colour in composition to achieve tone, form and harmony. Fifteen said the information has no value to their work. The 10 students who did not reply to this question are assumed to have the same opinion.

Comment: Only half the students were able to apply their learning, suggesting that the presentation of colour be revised to suit their needs.

4. The following chart tabulates the results of the definition question.

TABLE I

STUDENT SCORES ON DEFINITIONS

TERMS	RESULTS Correct	Semi-Correct	Incorrect	Omitted	Total
Colour	8	10	22	10	49
Hue	5	14	23	7	49
Saturation	2	4	25	18	49
Brightness	4	13	23	9	49
Shade	21	5	16	7	49
Tone	12	5	19	13	49
TOTAL	51	51	128	64	

Comment: Students were able to define 'shade' and 'tone' better than the other terms. Ability to define terms does not necessarily indicate an ability to use colour, but nevertheless, all students have been exposed to some terms in F.A. 300. Less than half the subjects correctly defined 'shade' and 'tone', indicating that either the teaching of terminology is a waste of time, or it is not taught in a meaningful way that can be practised by the student. The concepts involved in shade and tone are confusing, and can be better explained in terms of brightness and saturation. No student knew that hue, saturation and brightness are the three dimensions of colour. Terms from the previous questions were borrowed with no demonstration of the comprehension of their meaning, and used in an attempt to define the subsequent term. Many students tried to deduce the meaning from connotation.

particularly in the case of 'saturation'. In fact, saturation was the most poorly defined term, indicating that students are not familiar with it in this context. Sarcasm flavouring 4 responses might indicate that some students felt guilty at demonstrating an inferior ability to cope with the basic terms in their field of specialization. Many felt the need to rationalize or explain their failure.

5. Six students were able to describe the interaction between gray and green. Four were partially correct, 29 were incorrect, and 10 did not attempt to answer.
Comment: More than half the students did not know the visual result of a simple colour interaction. In view of the fact that colour is almost always seen surrounded by other colours, a weakness in the teaching of colour is suspected.

6. Thirty-seven students knew about the advancing-receding phenomenon. Nine answered incorrectly, and 3 did not attempt the question.
Comment: This is one visual property of colour that has been brought to the attention of this group of students. Their ability to grasp the relative nature of the apparent movement of colour indicates a readiness to delve into the total complex of colour's relativity.

7. Eighteen students felt competent in their use of colour. Thirty-one said they did not feel competent in manipulating colour to fulfill a specific need.
Comment: This is considered a more valid evaluation of a student's ability

to use colour than one supplied by a panel of judges, because the student can consider his handling of colour in more than one area, whereas an objective judgment would probably be based on isolated examples of work. The students also has an intimate knowledge of how this expression with colour evolved, whether the colours were determined with ease or with struggle. Furthermore, the student could dare to be honest in a situation where his evaluation would only be a statistic.

8. Forty students felt there was a need for a course in colour, while 8 did not. One student did not answer.

9. The following table presents the results of Nos. 9, 10, and 11b.

TABLE II

STUDENT CONSIDERATION OF DIFFERENT ASPECTS IN THE STUDY OF COLOUR

	EVALUATION		
TOPICS	Need to Study	Competent	Valuable Course Material
Appreciation	17	8	21
Mixing	25	1	31
Light	23	1	26
Interaction	26	4	34
Theory	24	1	24
Psychology	28	0	28
Physiology	28	2	27
Chemistry	20	2	20

Comment: As was expected, more students felt competent in the appreciation of the use of colour by old masters, than in any other field. The number was still surprisingly small. Seventeen said they felt a need to study this aspect further, and 21 would still like to have it included in a course. Similar comments can be made concerning the reaction to the chemistry of pigments, their origin and nature. It was surprising to find the number of students feeling a need for instruction in the mixing of pigments, and in the colour theory, as these are the two aspects of colour receiving the most thorough treatment at the present time. The bulk of the needs occur in categories almost totally neglected by this department. Instructors would be well advised to cater to these needs, because what is now being taught is available in books. Students are learning more about colour by studying local exhibitions than memorizing mechanics. By adopting this approach to the review of theory, teachers would have more time to help the student in learning to control the element of colour for his own purposes.

11\. a) Thirty-seven students said they would take a course in colour, 4 did not know, and 8 said they would not enrol in a course.

Comment: Of those whose response was negative, many reasoned that academic learning would not enhance their ability to use colour. The writer agrees with this opinion. The colour course proposed by the writer is not academic but experimental in approach. This was not pointed out to the students. The nature of the questionnaire, designed to evaluate the present teaching of colour, did not give an accurate impression of the writer's approach to colour. On the other hand, it was feared that an ideal description of the proposed course would be biased.

12. Students suggested that a course in colour be comprised of theory and history, followed by experimentation and practice in application to a field of specialization and independent research. The majority of subjects preferred the academic portion of the course to be considerably smaller than the practical application. Students also favoured illustrated lectures, and the display of good examples of the use of colour.

Comment: It was refreshing to find the majority of students preferring to discover rather than be told about colour. In the opinion of the writer, the students display the readiness prerequisite to a course in colour.

CONCLUSION TO PART II

Information from the interviews and questionnaire supports the hypothesis that the present approach to teaching colour does not satisfy the needs of students. This is less a criticism of the present method of teaching than an indication that teachers have insufficient time to present colour in any other way. Faced with a structured introductory course, they can only devote two or three lessons to terminology, physical and chemical theory, experimentation in pigment mixing, and the apparent temperature and distance of colour. Although this is often review material to students, this method ensures a common background from which to build. Instructors of advanced courses, however, have little opportunity to develop the study of colour because they are primarily concerned with the student's struggle to find a personal expression. The present structure of the Fine Arts programme allotts insufficient time for any course to include a probing study of the interdependence and interaction of colour. At the same time, students need and want more intensive instruction in colour. The most constructive alternative to the present dilemna is the introduction of a course in colour.

THE PROPOSED COURSE

Because colour plays an indispensable role in the functioning of the human organism, and at the same time is a vital element in art, it should be a major concern of the art teacher. The present theoretical approach is assessed as perpetuating a poor learning situation. The theoretical justification of Part I does not dictate the content of the course, it merely enlightens man to the omnipotent presence of colour in his life pattern. From the theoretical material in the justification, however, emerges a characteristic of colour--the key to a sound educational approach. Colour is a relative phenomena. Not only is there a discrepancy between the physical stimulus and the psychic effect, there is a discrepancy between each individual psychic effect. Man responds to the stimulus with his own receptor, his own past experience, emotions and personality. The ideal teaching of colour will adhere to its main characteristic, relativity.[1]

John Ruskin wrote to art students many years ago, "Every hue throughout your work is altered by every touch that you add in other places; so that what was warm a minute ago, becomes cold when you have put a hotter colour in another place, and what was in harmony when you left it, becomes discordant as you set other colours beside it."[2] Paul Renner adds, " . . . all the colors . . . are links in the whole, and the whole is vulnerable in

[1] It is readily admitted that the fields of history, physics, psychophysics, and psychology can provide a wealth of important material for the artist. Before he can use this information, however, he must be able to manipulate colour.

[2] Quoted by Rudolf Arnheim, Art and Visual Perception (Berkeley: University of California Press, 1958), p. 354.

every link."[3] The purpose of a suitable course in colour is to lead the student to understand the interaction of colour and to assist him in drawing insight from experience, so that eventually colour, the most relative medium in art, becomes a tool to be manipulated by the hands and brain of the artist.

The proposed course (See Appendix D) is essentially derived from the work of Albers,[4] with numerous extensions and modifications. It will demand initiative, patience, persistence, craftsmanship, and problem-solving ability, and in turn, these qualities will be enhanced in the student exposed to colour in this manner. The course is a step-by-step programme designed to confront the student with a colour problem requiring that he think through the situation to arrive at several suitable answers, both visual and verbal. The more a problem is practised, the more the student will learn. The exercise is never finished, but can be returned to at any time to work out new solutions and to evaluate progress. This experimental approach restores to the teaching of colour the exciting but evasive quality of education that is found in the discovery process. Discoveries can be shared and discussed in a mutual give-and-take classroom atmosphere. Personal and collective evaluation by comparison, together with discussion of reasons and conditions for each phenomenon, will accelerate growth of understanding and ability by providing insight.

The course as it is presently outlined is suitable for Fine Arts majors

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[3] Paul Renner, Color: Order and Harmony, trans. Alexander Nesbitt (New York: Reinhold Publishing Corporation, 1964), p. 42.

[4] Josef Albers, Interaction of Color (New Haven and London: Yale University Press, 1963).

at the university and art school levels. With adaptation, it can be used in elementary and secondary schools, in classes for the layman and the mature artist. Students who learn to see and use colour through this method will be able to teach it themselves with no instruction in methodology. They will also be able to adapt it to any kind of personal work. This course could be introduced on an experimental basis in the Fine Arts Department of the Faculty of Education, immediately following F.A. 300. Eventually, it could become a prerequisite for painting and design majors, because the entire course is an exercise in two-dimensional composition. It has worthwhile application in ceramics (colour and form, texture, and decoration), and in graphics (brightness and colour contrast, visual phenomena). It will be deemed a success in art education if it does nothing other than sensitize the student to colour in his surroundings. A more acute awareness of colour will breed appreciation of its complexity and flexibility. An enriched perception enhances life itself, by opening a world of resources, ideas and motivations.

APPENDIX A

INTERVIEW

Teachers of Art at the University and Art School

1. a) Do you differentiate between the elements of design such as line, form, colour, and texture in your teaching of art? Can you explain why you do (or do not) make this distinction between the elements?
   b) Do you emphasize one element more than the others? If so, which, and why?

2. Can you think of any particular time that you became aware of colour as an influence in your life and work?

3. Is there any particular time in the teaching of art at the university or art school when you feel it is important to introduce colour?

4. a) Of the art courses that you teach, which include some instruction in colour?
   b) What aspects of colour do you cover in each of these courses? Can you estimate the time this requires?

5. What methods do you find most successful in heightening the perception of colour in your students?

6. Would you recommend a different approach to teaching colour for the elementary, secondary, and university or art school teacher? What would this entail?

7. a) Do you have a personal colour base in your artistic expression?
   b) Do you detect students using colour the way you do? If so, what is your reaction?

8. Would you tell me a little about your artistic training? Is there anything in your background that you find particularly helpful in your personal use of colour and/or in teaching colour to students?

9. Ideally, what kind of background (i.e. knowledge, experience), would you recommend for the teacher approaching the subject of colour with university art majors or art school students?

10. If you had the time, equipment, all the ideal resources and conditions, how would you teach colour to art majors? How would you deal with such aspects as theory, practice, and appreciation?

11. Can you direct me to any student who uses colour well, so that I may determine his background in colour and learn his views on its teaching?

APPENDIX B

INTERVIEW

Students of Art

Faculty of Education, The University of British Columbia

1. Where have you been taught about colour, other than in your university training? Can you tell me a little about what you learned and what you were able to apply to your work?

2. Can you describe what you have learned about colour in Fine Arts courses of the Faculty of Education, and what you have been able to apply to your work?

3. a) Can you describe the methods used to teach these concepts of colour?
   b) What method contributed most to increasing your awareness of colour?

4. Have you learned anything about colour on your own? Do you apply any of this knowledge and/or experience to your work?

5. Have you noticed whether any instructors are particularly sensitive to student's use of colour? If so, how do students respond to this sensitivity?

6. Are you aware of yourself or any student being influenced by an instructor's use of colour?

7. What are your views on the way colour is being taught in the Fine Arts Department of the Faculty of Education? What would you praise and what would you criticize?

8. a) Do you think there is a need to deal more intensively and extensively with colour in this department?
   b) What aspects of colour would you include in a course in colour? How should a course in colour be taught?

9. What, in your opinion, is the ideal background for the teacher approaching the subject of colour with students?

APPENDIX C

STUDENT SURVEY ON COLOUR

1. a) Division: Elementary ☐ Secondary ☐

   b) Major: Single Art ☐ Double Art ☐

2. If you have learned about colour in any of the following courses, place a check in the box, and describe what you learned.

   ☐ F.A. 101 ______

   ☐ F.A. 300 ______

   ☐ F.A. 301 ______

   ☐ F.A. 302 ______

   ☐ F.A. 303 ☐ 403 ☐ 413 ______

   ☐ F.A. 305 ☐ 405 ☐ 415 ______

   ☐ F.A. 307 ☐ 407 ☐ 417 ______

   ☐ F.A. 401 ☐ 402 ______

   ☐ Ed. 205 ☐ 305 ______

   ☐ Ed. 404 ______

3. Has this information been of use to you? What have you been able to apply to your own work?

   ______

   ______

4. Define the following terms as well as you can.

   a) colour ______

   ______

   b) hue ______

   ______

c) saturation ______________________________

____

d) brightness ______________________________

____

e) shade ______________________________

____

f) tone ______________________________

____

5. Describe what happens when a small square of gray paper is placed on a green ground. ______________________________

____

6. Do warm colours always advance? Yes ☐ No ☐

Do cool colours always recede? Yes ☐ No ☐

7. Do you feel competent in your ability to manipulate colour to fulfill specific needs in your work? Yes ☐ No ☐

8. Do you, as a student, feel there is a need for further instruction in colour in art courses in the Faculty of Education? Yes ☐ No ☐

9. Place a check in the box beside any area where you could benefit from further instruction in colour.

a ☐ Appreciation of the use of colour in paintings.

b ☐ Mixing pigments, and glazing.

c ☐ Coloured light, additive primaries, theatrical gels, and films.

d ☐ Interaction of colour, subtractive colour and complementary contrast.

e ☐ Colour theory--Chevreul, Goethe, Munsell, Maxwell, Albers, and Hofmann.

f ☐ Psychological aspects of colour, colour in language and symbolism.

g ☐ Physiological aspects of colour, how the eye perceives colour, explanation of visual phenomena.

h ☐ Chemistry of colorants, origin and nature of pigments.

i ☐ Other. (Fill in.)

10. List the letters from the foregoing categories in which you feel competent as a result of art courses you have taken in the Faculty of Education.

____

11. a) Assume that you will be a Fine Arts major in the Faculty of Education next year. Would you be interested in taking a course in colour if it was offered?

Yes ☐ No ☐

b) List the letters from the categories in No. 10 which you would like to see included in such a course.

____

12. What are your suggestions on how such a course be taught?

____

____

____

____

APPENDIX D

PROPOSED OUTLINE OF COLOUR COURSE

Motto: Colour is the most relative medium in art.

The exercises will be executed in paper and mounted on card unless otherwise specified. Verbal explanations will be written on the back. Each problem includes the design of a suitable format for the presentation of the solution.

The many advantages of paper make it the ideal material for solving the problems. It is superior to paint because it eliminates the tedious chore of mixing, and is free of textural brush strokes. Paper permits the student to choose from a variety of available colours, and to use the same colour repeatedly. Paper is inexpensive: a purchased colour pack of two-hundred fifty silk-screen colours can be supplemented by collections from magazines and paint chips. The only tools required are a cutting edge, a ruler, and glue.

Series A: How Colour Deceives

1. 3 colours as 4
   - a) brightness
   - b) hue
   - c) temperature
   - d) saturation
   - e) chromatic and achromatic

   (Alternate method--intersecting colours)

2. 4 colours as 3
   - a) brightness
   - b) colour
   - c) complementary contrast

3. 4 colours as 2 (reflection of reverse grounds)

4. 3 colours as 2
   a) brightness
   b) hue
   c) saturation

5. 4 colours as 1, expanded up to 7 as 1.

6. 3 colours as 12 (stripe problem, additive and subtractive mixture)

This series is to be followed by a display and evaluation of results, discussion of subtractive colour, and a detailed study of:

a) adaptation
b) simultaneous contrast
   i) brightness contrast
   ii) colour contrast
   iii) complementary contrast

Series B: Leaf Studies (A description of the visual result will accompany examples 1--6, and a description of theory and process will appear with examples 7--9.

1. Determine the hue of a leaf and place in on the complement.

2. Determine the hue of a leaf and place it on a more saturated ground of the same hue.

3. Determine the hue of a leaf and place it on an achromatic variation of that hue.

4. Determine the hue of a leaf and place it on:
   a) a cool ground
   b) a warm ground
   c) neutral ground of the same light intensity

5. Determine the hue of a leaf and place it on:
   a) a complement of greater brilliance
   b) a complement of lesser brilliance

6. Find two leaves that are complementary and equal in brightness. Find the corresponding hues in the colour pack and mount the leaves on the reverse grounds.

7. Pull all the hue from a leaf by placing it on some ground composed of other leaves.

8. Increase the saturation of a hue by placing it on a ground of leaves.

9. Attempt to make a leaf look transparent.

10. Free Study: destroy the shape of the leaves and mount them in a personally pleasing colour statement.

Series C: Study in the Compositional Use of Complementary Contrast.

From a coloured magazine photograph make a tracing of shapes, and transfer to cardboard. Recreate the photograph:

1. in achromatic tones, matching the value of each colour to a gray.

2. in an arbitrarily chosen theme of complementary contrast.

Series D: Gray Scales

1. From black and white magazine photographs cut thin strips of all the grays available, and arrange them in vertical, parallel stripes from black to white and back to black. Evaluate the accurate judgment of grays, place strips of white, gray and black across the exercise and describe the illusion. Follow with discussion of related pigment mixing in the Weber-Fechner Law.

2. Create eight stripes graduating from black to white. Mount them in parallel juxtaposed lines, alternating black and white at the left margin. Describe the visual effect.

Series E: Colour in One Plane (9 hues in square format)

1. Which is darker?
   a) warm
   b) cool

2. Which is lighter?
   a) warm
   b) cool

These exercises are to be followed by a discussion of apparent distance, and temperature of colours, and by a study of colour space in paintings.

Series F: Saturation

1. From several of the most saturated versions of one hue, choose:
   a) the reddest
   b) the bluest
   c) the greenest
   d) the yellowest

2. The End Effect--Place samples of one hue in two rows of increasing saturation. One row will have 4 samples. The second row will duplicate the first, but will have an additional, more saturated sample. Compare the fourth sample in each row.

This series is to be followed by a discussion of the psychology of colour perception.

Series G: Study in Complementary Mixture

1. Take saturated papers of the three primaries and three secondaries. Find the papers that show three equally spaced mixtures of the parent with its complement. Arrange in a hexagonal pattern with a grey center.

2. Repeat the exercise in pigment for one complementary pair. Paint seven equal steps from red to green, blue to orange, or yellow to purple.

3. By arranging complementary pairs in vertical stripes, create:
   a) additive mixture of complements
   b) complementary contrast.

Series H: Colour Assimilation

1. Arrange alternating vertical stripes of yellow and gray above stripes of blue and gray. Compare the grays.

2. Juxtapose two Maltese crosses of blue and yellow, with a gray centre. Describe what happens when concentration is alternated between the blue cross and the yellow cross.

Series I: Study in Vibration

1. Create grid patterns using:
   a) warm and cool colours of full saturation and equal light intensity
   b) warm and cool colours of great brilliance
   c) warm and cool colours of dim brilliance
   d) chromatic and achromatic colours
   e) two warm colours
   f) two cool colours

   Mount the six studies together and determine the principles of vibration.

2. Free study in two-colour vibration, compositional choice.

Series J: Additive Mixture

1. Find two colours and arrange them in a pattern that will allow optical mixture of the colours before they reach the retina. This will be followed by a discussions of where additive mixture is found, e.g. Impressionism, Pointillism, printing process, weaving.

Series K: Study in Spreading Effect

1. Create grid patterns using:
   a) dark on light
   b) light on dark

This will be followed by an investigation of 'halation', its reason, and its prevalence in daily vision.

Series L: Optical Ambiguities

1. Using black and white striped paper (obtainable in wrapping paper) create a design which will produce the greatest visual ambiguity.

2. Do the same with coloured stripes.

3. Find the combination of colours, which, when mounted in intersic, angular patterns, will cause the boundaries to disappear.

Series M: Study in Transparency and Space Illusion

1. 8 as 5
   a) white film over red, blue, green and violet
   b) 25% green film over four colours
   c) 50% red film over four colours

2. Create a ladder of eight brightness steps of one hue. Find one colour that, when placed between these steps, will appear to come from behind half the steps, and lie over the other half.

Follow these exercises with a discussion of volume colour, apparent weight, and distance of colour and how this affects man.

Series N: Study in Colour Harmony

1. Using four colours, create twenty-four variations of one pattern. Evaluate in terms of space, temperature, weight, quantity, colour and brightness changes.

2. Create an harmonious colour composition. Describe how this harmony is achieved in terms of quantity (how much and how often), intensity, and weight.

Series O: Symbolic Use of Colour

1. Colour and Emotion--With three colours, create a composition depicting each emotion:
   a) love
   b) envy
   c) hate
   d) depression

2. Colour and Activity--Using the same design and different colours, create one composition that is active and one that is passive.

3. Colour and Age--Using the same design, vary the colours in two compositions to depict old age and youth.

4. Colour and Personality--Free studies using different sets of three colours to depict:
   a) Hitler
   b) Toscanini
   c) Cleopatra
   d) Napoleon
   e) Doris Day
   f) personality of choice

The designs must contain no associative elements.

Series P: Analyses of Great Paintings (from good reproductions)

1. Using post card reproduction for tracing areas, analyze the following paintings in separate studies of value, dominant colour, subordinate colour, colour temperature and colour space:
   a) El Greco — Assumption of the Virgin
   b) David — Lamentation at the Foot of the Cross
   c) Degas — At the Millinery
   d) Seurat — Sunday Afternoon on the Island of La Grande Jatte
   e) Gaugin — Why are You Angry?
   f) Cezanne — The White Sugar Bowl
   g) Matisse — Madame Matisse

2. Using the same analyses of value, dominant and subordinate colours, colour temperature, and colour space, study five paintings in the Vancouver Art Gallery that exhibit outstanding use of colour.

These exercises will be supplemented with independent research on a topic of the student's choice, to be presented in written and oral form to the class, and to be accompanied by experiments and visual examples where possible.

The students will be required to read Interaction of Color by Josef Albers, "The Color Problem in Pure Painting--Its Creative Origin," by Hans Hofmann, and The Art of Color by Johannes Itten. (See Bibliography.) Student's research presentations will require considerable reading in specific fields. This course, however, does not require extensive reading because its purpose is to promote problem-solving ability with colour. This cannot be learned from reading.

Examples of solutions to the exercises in the course outline are available on request to the writer. So, too, is The Background for Teaching Colour, a two-hundred eighteen page review of research into physics, psychophysics, physiology, psychology and references, designed enrich the background of the teacher approaching the subject of colour.with art students.

GLOSSARY

Achromatic - Colour lacking a distinguishable hue.

Additive Mixture - The mixture of the light primaries--red, blue, and green--in the eye, ultimately forming white.

Brightness - The dimension of colour referring to a scale of perceptions representing a colour's similarity to one of a series of achromatic colours ranging from very dim (dark) to very bright (dazzling).

Chromatic - Colour with distinguishable hue and saturation.

Colorant - A colouring material, taking the form of a soluble dye or an insoluble pigment.

Colour - One aspect of visual experience that can be described as having quantitatively specifiable dimensions of hue, saturation, and brightness.

Hue - The dimension of colour referring to a scale of perceptions ranging from red through yellow, green, and blue.

Light Intensity - The eye's evaluation of the light reflected from a pigment.

Saturation - The dimension of colour referring to a scale of perceptions representing a colour's degree of departure from achromatic colour of the same brightness. (Sometimes called Intensity.)

Shade - A hue which has been darkened by the addition of black.

Subtractive Mixture - The absorbing action of the pigment primaries--magenta, cyan, and yellow--ultimately forming black.

Tint - A hue which has been lightened by the addition of white.

Tone - A colour which has been modified in hue and saturation by the addition of its complement.

Value - Synonymous with brightness and light intensity.

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