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Colour Studies: Clarification and Alpha-Numeric Adaptation of Notation Systems for Artists and Designers

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Abstract

Colour studies have generated much confusion in art and design education, particularly among students of the discipline in Nigeria. This is due to the complexity of the subject matter itself, wide-range of available materials and a variety of concepts developed in its multi-disciplinarity that is not kept distinct. Therefore, this paper utilizes a qualitative approach that employs the critical, historical, and analytic examination to provide clarification on the constructive and expressive aspects of colour studies. The paper introduces the reader to the pivotal role of colour and its multi-disciplinary interest. Also, it adequately clarifies paradigms and theories in the physical, psychophysical and psychological domains with particular emphasis on areas of practical value to art and design. Moreover, it considers the numeric adaptation of the colour wheel to a set of numbers for harmonic relationship. And it ends with the need for artists and designers to comprehensively grasp the contextual behaviour of colour and develop colour originality through creative construction and effective use in order to successfully express themselves in colour.

Introduction

Every day, we see and response to colour in which nature and man-made objects are expressed. The importance of colour in our lives cannot be over-emphasised. It provides a large amount of the objective information about our environment, eighty percent of the information we receive is in colour (Khouw 1995). So, how we behave, the things we recognise and the choices we make are intertwined with the effect of colour on us. For example, our behaviour toward food intake could be grossly conditioned by colour. People put and eat less food on plate with high contrast colour while the reverse is the case with plates of low contrast (Milton, 2011 quoting Koert and Brian, 2011). So, colour plays a critical role in the way we live and interact with one another and our environment. Milton (2011) lucidly captures the vital role of colour thus:

> Color can sway thinking, change actions, and cause reactions. It can irritate or soothe your eyes, raise your blood pressure and suppress your appetite. When used in the right ways, color can even save on energy consumption….As powerful form of communication color is irreplaceable. Red means 'stop' and greenmeans 'go'. Traffic lights send this universal message.

The interest in colour as a result of its importance has made it a subject matter of study in many disciplines. These include art, chemistry, philosophy, physics, psychology and psychophysics. The colour studies in these fields have resulted in the development of a variety of theories, increased knowledge and the production of wide-range of colour media that have enlarged our experience of colour. Willard (1998) vividly describes this situation thus:

> Technology picked up color study on a serious level and because of that we now have the glowing phosphors of television and computer screens, metallic paints fractals with their repeating color sequences, holograms, and four color process printing. When intertwined with the cesia, or visual signs of flicker, sparkle, gloss, lustre, iridescence, luminosity, and filmic haze, such color experience are greatly broadened… our contemporary conceptions of color are further augmented by advertising that links color to desire for everything from the prismatic sparkle of a diamond to the amber glow of a beer. Likewise, the ease in which materials such as interference colors and fluorescents can be obtained certainly influences the range of pigments and effects artist can now use.

From the foregoing, a deluge of colour materials, notation systems, theories and relationships now exist that the artist and designer could use to advance his or her work of art and design. However, these have created a unique set of problems. It has generated much confusion in art and design education, particularly among students in the discipline in Nigeria. This is due to the complexity of the subject matter itself, the failure of the student to differentiate what is of particular concern to him or her, and the different and wide-range of colour concepts developed in various fields that are not kept distinct. These are compounded by contradictions embedded in colour semantics, the reliance by artist on non-iconic art by which the syntactic qualities such as colour of a work is brought to the fore and the lack of consensus on the true primary colours (Willard,1998).

So, the art and design student is often bewildered by a number of uncertainties-aesthetic, pragmatic, semantic, syntactic, and technical-about colour in the midst of exceedingly great variety of available colour concepts and material. Willard (1998), aptly described this situation as "a dystopia of color education in a utopia of color experience". The effect of this could be seen in the predominantly unintelligible works of students and professionals in art schools and galleries respectively across the country; whereby prevalence ignorance of the logical, expressive and effective use of colour for aesthetic and functional purposes is displayed. The wild, crude and inappropriate application of hues directly from their containers, the incompetence to balance the three attributes(hue, intensity and value) of colour and the ineptitude to strategically utilize the colour wheel in a variety of ways that could generate harmonic relationships are few examples.

Therefore, the need to resolve and beat the confusion about colour, which colour studies have yield is of prime importance in art and design education in Nigeria. In order to achieve this, we would consider the clarification of the paradigms and theories of colour studies in the traditional (physical, psychophysical and psychological) domain that are relevant to the artist and designer as well as the numeric adaptation of the colour wheel for harmonic relationship.

Clarification of Colour Concepts and Theories for Artists and Designers

Many concepts, notation systems and theories about the nature of colour have been evolved and developed over a long period of time. Wallschlaeger and Busic-snyder (1992: 244 quoting Frans Gerritsen 1975:14-16) stated four concepts that provided a historical overview that "clarifies four different directions of thought brought down through the ages (from before the birth of Christ to the middle of the seventeenth century), which gives an appreciation for the different concepts and theories about the nature of colour" thus:

> 1. No physical phenomenon takes place between the eye and the object observed 2. There is radiation from the eye in the direction of the object, 3. Sight is an interaction between images ejected by the

object and something like a fire from the eye, which sees as a spirit or soul, and 4. Objects we perceive send out 'rays' to which our eyes are sensitive.

Since about sixteen-sixty up to now, the true nature of colour has been known following the experiment of Isaac Newton that separated a beam of sunlight into its component hues through a glass prism. Many researches have been conducted in various fields (arts, chemistry, philosophy, physics, psychology, and psychophysics) that provided a robust knowledge of the nature of colour in different ramifications.

The result of the above is the development of concepts and theories that are useful to achieving different purposes but might not be relevant to all concerned with colour in the same way. For example, Isaac Newton's colour notation system is crucial for additive colour mixing of the light primaries: red, blue and green that results in white and not for subtractive colour mixing of the pigment primaries: red, yellow, and blue that result in black or grey. So, while Isaac Newton's system is useful to physicist, to some extent it is irrelevant to the artist. For this reason, Johann Wolfgang Von Goethe, who developed a useful notation system for the subtractive colour mixing of pigment colours refuted Newton's colour theory (Wallschlaeger and Busic-Snyder, 1992). However, as the interest and orientation of researchers in different fields concerning colour are different so are the relevance of the concepts they developed. To the physicist, Isaac Newton expressed colour in terms of light energy; to the psychologist, Ewald Hering directed his effort to the perception and response to colour in terms of symbolic connotations that are subjective; to the chemist, Wilhem Ostwald focused his attention on the chemical constituent of colour as a substance; and to the artist, Johannes Itten devoted his attention to the constructive and expressive use of colour as pigment, are few examples. So, not all of these concepts developed are of relevance to the artist and designer.

The concepts, notation systems, and theories of colour that have relevance to art and design to some extent are the ones that relate with the physical appearance of colour and the conditions that have bearing on it. Traditionally, these are classified under the physical approach of colour studies, whereby most of the concepts are derived from the field of physics; also, the ones that relate with the physiological perception of the physical appearance of colour and our psychological response to the behaviour of colour in a given context. Traditionally, these are classified under the psychophysical domain, which is in the sphere of physiology. And the ones that border on our psychological response to colour in terms of subjective symbolism and connotations. Usually, these are classified under the psychological approach, which falls within the field of psychology. Therefore, we are going to focus our discussion on necessary concepts and theories of colour gleaned from the fields of physics, physiology, and psychology that bear on the problem of colour in art and design.

Colour as Property of Light

The concepts of the physical appearance of colour as a property of light that stimulate our vision and the features of the stimulus condition, present a veritable source of confusion for the artist and designer. Much of the confusion emanates from the difficulty in the correlation of colour as electromagnetic vibrations of different wavelengths that are intangible with colour as pigments that are tangible in liquid, paste and solid forms. The concept of colour and light is from the domain of physics. The physicist sees colour as function of light and holds that white light is consist of all hues of the spectrum (red, orange, yellow, green, blue, violet, and all the intermediate gradation, which could be seen when sunlight is passed through a glass prism. All objects transmit, reflect or absorb light that falls on them. It is the wavelengths of light rays transmitted, reflected or absorbed that constitutes the basis for the interpretation and discrimination of colour. For example, an object that is red absorbs all other wavelengths of light rays except red that it reflects. No colour is produced when all the light rays are transmitted, reflected or absorbed. When all the light rays on an object are transmitted it produces achromatic grey, but if all light rays are reflected it produces achromatic white and if all light rays are absorbed it produces achromatic black. Achromatic means the absence of chroma or colour.

The relevance of the concept of colour as a property of light to the artist and designer is the awareness that forms do not have colour in themselves, but are able to absorb, reflect or transmit wavelengths of light rays based on the nature of their surfaces and light conditions. As the light conditions change, the colour of the form as well changes.

So, the colour of a form is invariably impacted on by the surrounding light conditions. The importance of this in visual expression would be discussed later under reflected light in colour constancy. However, it would suffice here to state that the art and design student should not get confused and worry about electromagnetic vibrations that correspond to a given wavelengths of light rays and energy as well as their units of measurements in angstroms (A) and Kelvin (K) respectively.

Another source of confusion about the physical appearance of colour and light is the variation in the number of primaries for admixture. There is significant level of awareness that a desired hue (whether secondary, intermediate or tertiary) could be achieved through the admixture of the primaries hues, but which set of primaries is the confusion. The light and medial primaries are different from the pigment primaries the artist/designer should concern him or herself with. The numbers of hues that constitute the primaries for colour mixing in various fields of colour studies are different. Examples are the light primaries of red, green, and blue, medial primaries of red, blue, green and yellow, and pigment primaries of red, yellow and blue. Willard (1998) elucidated this confusion thus:

Color and color diagrams said to be reproducible from three colors are trickily reproduced with four process colors. Further muddying up the waters are camps polarized over the true primary colors: cyan, yellow, magenta for printing process and transparent painting media: red, yellow, blue for painting and other media that operate with opaque pigments, red, green and blue relating to our trichromatic retinal processing that forms the basis for inventions like color televisions, and yellow, blue, red, green describing our post retinal coding of colors called the opponent process, which was discovered in part by paying particular attention to perceptual oddities such as afterimage and contrast effects, all of which must appear confusing to art students who lack a foundation in color theory.

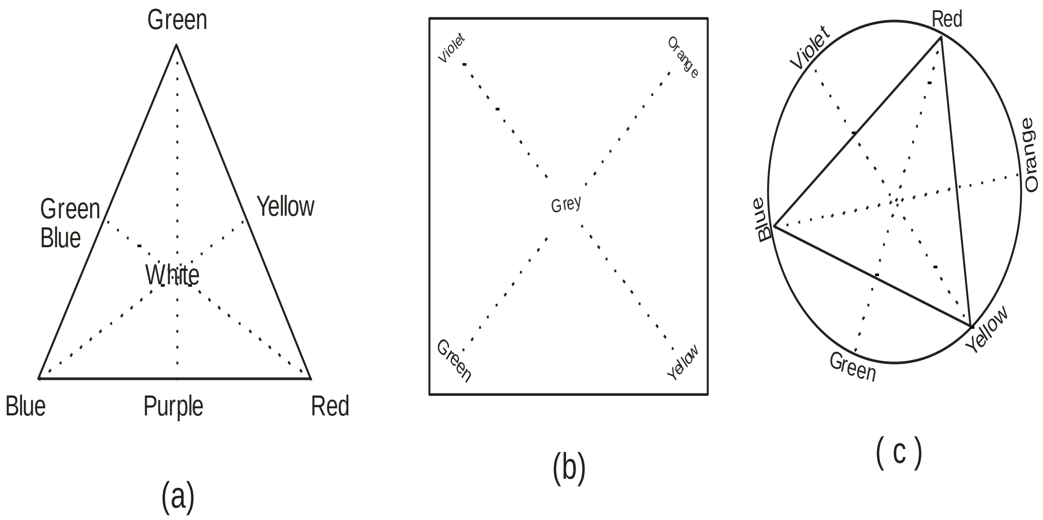


Figure I : showing (a) Light primaries (b) Medial primaries and (c) Pigment primaries by James C Maxwell, A. Hofler and Paul Klee respectively. (After Wallschlaeger and Busi-Snyder, 1992:248-251)

In addition to the above, the quality or attributes of colour: hue, intensity and value and their relationship in a visual expression often confuses the art and design student. Hue is the description of the basic colour-the specific wavelength of light rays reflected. One hue is different from another. Red is a different hue from Yellow and Blue is different from Orange as examples. Hue is the quality of colour that lay persons call colour. However, hue is modified by intensity and value. The intensity, saturation or chroma is the degree of dullness or brightness of a hue, while value is the lightness or darkness of a hue. These qualities are shown in Figure 2.

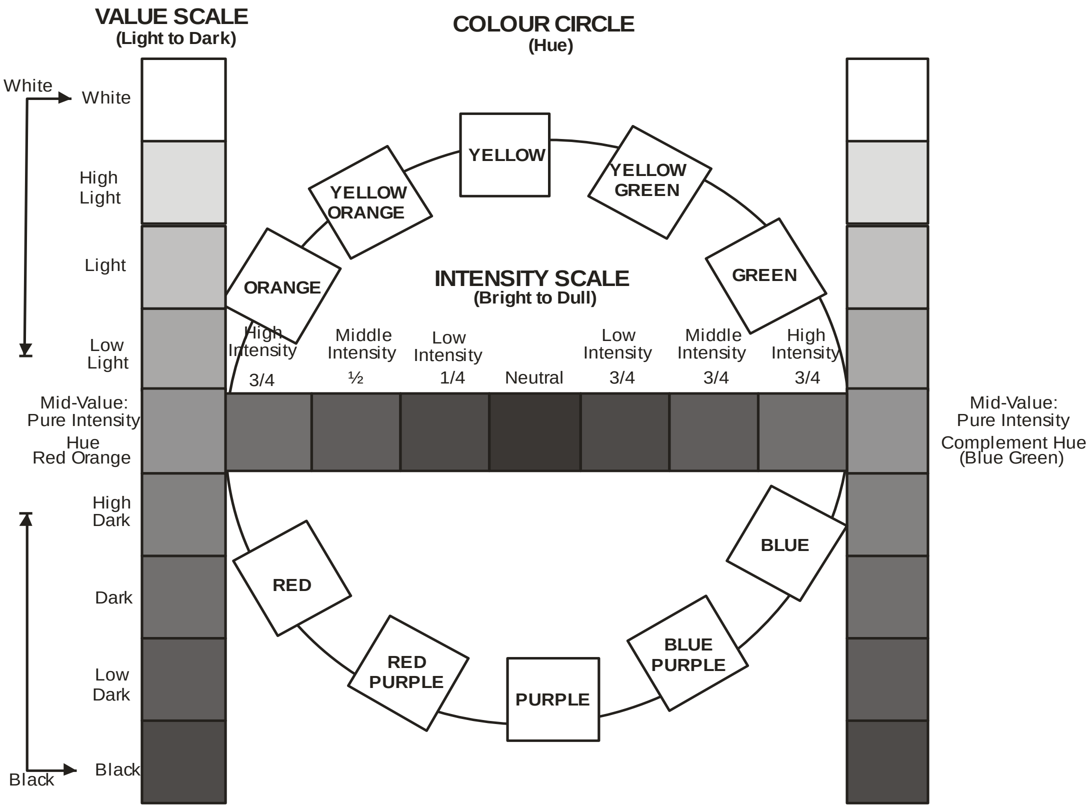


Figure 2: Showing the three attributes of colour-Hue, Intensity and Value (After Quiller,1992:25)

An understanding of the three attributes of colour is important for the artist and designer in order to create exciting and dynamic visual expressions in colour. The three attributes: hue, saturation and value need be employed to achieve drama. Reid (1993), states that a key challenge in the production of good colour work is to strike a balance among the attributes.

The approach to achieving purity of colour through mixing creates confusion. This is due to the difference in concept of colour mixing using light and pigment. The mixing of light primaries is additive while that of pigment is subtractive. In physics, where coloured light is mixed, the more different hues are mixed together, the purer the outcome. The combination of different amount of light primaries-red, blue and green would result in white and other colours in the spectrum. Any two colours in the spectrum that are far from each other (yellow and blue as an example) are complement and their mixture would produce white. This is different from working with pigments. The difference in relationship between working with light and working with pigment hues is much. Clair (1993:22) aptly describes the relationship in the light mixture chart as “utterly bizarre” and went further thus:

> It is hard to imagine creating blue from green plus violet or mixing yellow from red plus green! Nor do we find familiar primary and secondary relationships here. Since any of the colors can be produced by a blend of its neighbors, none is ‘unique’ and ‘unmixable’ like the pigment primaries. Instead in this purely additive system, combining colors strengthens rather than weaken them-the opposite of what is in pigment mixing. The effect is like that of turning on a series of lights in a dark house. Each newly switched-on lamp…..increases the overall brightness of the room (p. 22).

In art, where pigment hues are mixed, the more different hues are combined the more white light is absorbed or subtracted in order to reflect their distinctive hues. A hue in pigment form absorbs a segment of white light in order to reflect its hue. So, when combined the colour that is derived from the combination of two hues would be less brilliant than each of the hues combined. This implies that the fewer the number of pigment hues that are combined the more brilliant the outcome. Therefore, the artist and designer should have a wide-range of hues that are not a result of admixture. Clair (1993) succinctly expresses this thus, “a green mixed from blue and yellow is less vivid than the colors you start with- or for that matter, than a tube of unmixed green paint made from a substance that was bright to start with”. This explains the reason for the avoidance of unnecessary mixture of pigments by artists and designers. In order to achieve vibrancy, unmixed colours are applied in dots, which are optically mixed together at an ideal distance that produces vibration or lively and exciting effect. For example, the juxtaposition of red and yellow of a given size would produce orange.

The number and proportion of colour to be employed in a mixture and work of art and design often confuse the art and design student. The number of colour used at a time in a given work should not exceed five because the human capacity to effectively process the interplay of elements diminishes as the element increases. So, two to four would be appropriate. Lidwell et al (2003:38) provided an excellent advice in this direction when they state that colour should be used conservatively and the palette should be limited to what the eye can process at a glance “about five depending on the complexity of the design. Do not use color as the only means to impart information since a significant portion of the population has limited color vision”. Moreover, equal proportion of colour in a mixture often does not give lively result. For example, an approximately equal amount of warm and cold colours at opposing end create tension that is unresolved and lifeless. Since the temperatures are equally balanced they clash. Dobie (1992:36) in comparing lifeless and luminous grays states that equal amount of colour in a mixture create lifeless result (Gray) and in order to create lively luminous result, “the secret is to keep the ratio of pigments in the mixture unequal”. So, it is often more interesting to have one colour dominate in a mixture. It is this unequal relationship, the interplay of large and small amount of hue, chroma and value contrast that generate visual interest.

Closely related to the above is the bias of colour. Every colour has a bias or undertone, which affects colour. For example, using oil colours manufactured by Newton and Winsor, a blue hue have either a red undertone (as in French Ultramarine) or a green undertone (as in Cerulean); a red hue have either a blue undertone (as in Alizarin crimson) or a yellow undertone (as in Cadmium Red); and a yellow hue have either a red undertone (as in Cadmium Yellow Deep) or a green undertone (as in Lemon Yellow). Therefore, a pair of the primaries with different undertone provides a wider base for colour mix. An admixture with primaries of complementary undertone would not produce clean result. For example, a clean green would result from a green undertone yellow (Lemon Yellow) and a green undertone blue (Cerulean Blue), but a combination of a redundertone yellow (Cadmium Yellow Deep) and a red under toned blue (French Ultramarine Blue) would produce an unpleasant and dirty green hue. For this reason, the six colour system was prescribed for practical purposes (ColArt Fine Art and Graphics Limited, 1997:6).

So far, we have looked at the attributes of colour and to some extent the interactions of these attributes in the phenomenon of additive and subtractive mixtures. While the physicist interest is on additive light mixture, the artist and designer should concern him or herself with the subtractive pigment mixtures and glean from the additive approach the benefit of keeping colours lively through juxtaposition of hues that are not excessively neutralized.

However, neutralised colours, particularly luminous greys that are achieved by unequal admixture of the pigment primaries or two complementary colours (chromatic grey) are essential to achieving desired effect. Artists and designers use chromatic and achromatic greys to balance and weave together the effect of light and other elements in order to create an aesthetic whole. Achromatic grey results from the mixture of white and black. White is used to neutralize, brighten or tint chromatic hues while black is used to darken or shade a chromatic hue. The use of complementary colours or achromatic greys to neutralize or tone the saturation of a pigment is preferred to the use of black which kills or creates unpleasant hollow.

The structure upon which additive and subtractive colour mixture is guided for the physicist and the artist/designer is the light mixture chart and colour wheel respectively (figure 3a and b

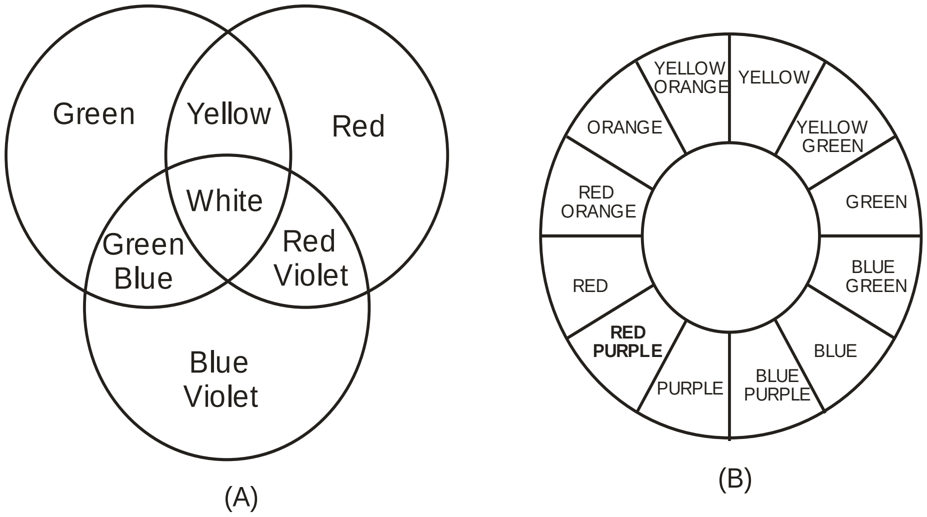


Figure 3: Showing the Light Mixture |Chart (A) and Colour Wheel (B)

The artist and designer should use the colour wheel in a variety of ways to achieve the different appearancesin which colour is seen. These ways include combination of hues adjacent to one another in the colour wheel (analogous), colours opposite each other on the wheel (complementary) or colours at the corners of a symmetrical polygon: equilateral triangle and rectangle/square-circumscribed in the colour wheel (triadic and tetrad/quadratic). This combination would be discussed later under numeric adaptation of the colour wheel.

Nevertheless, the textural qualities of a surface depicted by the artist/designer using pigment should not be confused with texture of the physicist. The physicist sees texture as a function of the degree of diffused light reflected or transmitted by an object's surface. When most of the diffused light on a surface is reflected, it is seen as a mat surface but when most of the diffused light is transmitted, it is seen as a translucent surface. And when little of the diffused light is reflected the surface texture is described as glossy or smooth and when little of the diffused light is transmitted then it is classified as a transparent surface. However, the realization and depiction of these surface qualities using pigments that is inherently subtractive, albeit, not as bright or dazzling as the diffused light the referent reflects or transmits, is a source of aesthetic pleasure rather than frustration in visual expression. This brings us to how colour appears and how it is experienced by our physiological being.

Psychophysical Response to Colour and Light

The way our body reacts to colour and light is another important subject the artist and designer should be conversant with in order to employ colour towards achieving a desired end. The physiologist is concerned with how colour is processed by our visual make-up and neural reactions: the organ of vision, the optical pathways, and brain process and colour vision theories. These would not be our concern in this article, however, our focus would be on "the stimulus situation and subjective response in visual experience because these are essential to an understanding of colour in the context of the art" (Osborne, 1970:260).

Colour influences one another within a given space and impact on the perception of the object depicted. The way colour affects one another when juxtaposed creates fugitive sensation. This sensation arises as colour seems to change in accord with the predominant colour environment or background on which it exists. There are two principles of this sensation-simultaneous contrast and successive contrast.

Simultaneous contrast is concerned with how the attributes of colour (hue, intensity and value) are enhanced or reduced when juxtaposed with one another in a given space. Osborne (1970:260) aptly describes this phenomenon thus:

> When areas of high brightness are juxtaposed with that of low brightness, they appear to become increased in brightness and darkness respectively than when they are not seen together side by side. Also, saturation varies in accord with the background or juxtaposed areas. Areas of adjacent hues that are juxtaposed appear more different than when seen apart. And objects of complementary hue appear to be more saturated when juxtaposed than when seen in separation.

Successive contrast is another fugitive sensation, whereby the complementary colour of an object that is focused on for a given period registers on the eye and the image of the object is remembered and sustained for a period when the direction of the gaze is shifted and focused on another neutral ground. For example, a gaze at a red square on a white circular ground for about two minutes, when shifted to a neutral field, a green square on black circular ground would be experienced. Wallschlaeger and Busic-Snyder (1992:276) provided a vivid physiological explanation for this phenomenon thus:

> In the eyes there are color receptors on the retina called cones. These cones can adjust to a specific hue when a viewer looks at an area for one minute or more and then looks at a blank, neutral field. The viewer then sees the complement of the original hue…. The complementary color also appears when the eyes are closed.

The background on which a colour is placed affects its hue, intensity and value as well as the size and luminosity of the object the colour depicts. For example, when a white square is placed on a black background, it appears larger and brighter. In contrast, when a black square of the same size is placed on a white ground, the black square does not appear as large or as bright (see figure 4).

Figure 4: Showing Simultaneous Contrast

The above phenomenon is called irradiation. The luminosity and intensity of colour is affected by its background. For example, a colour decreases in luminosity on white ground, but appears to increase in chroma. While on a background, light colours appear to have a higher chroma whereas dark colours appear to have less chroma and greater luminosity. These are topics for the artist and designer because it affects the perception of the on-looker. Wallschlaeger and Busic-Snyder (1992:280) state that:

> changes in luminosity and chroma affect how the viewer perceives the size and depth of figures. With composition on a black background, the color light appear larger and seem to advance

> towards the viewer, whereas on a white ground, the dark hues will appear larger and would seem to advance toward the viewer.

Furthermore, hues, intensity and value are modified by the variable of space which has been discussed to some extent. Osborne (1970) pinpoints these spatial factors that affect colour thus:

> A large area appears brighter and more saturated than a smaller area of the same hue. But a small light area in a large dark field appears brighter than an area of similar brightness of an uncontrasted field. Also, when the contrasted area is made up of intricate linear patterns, the phenomenon of assimilation reverses the foregoing effect of simultaneous contrast. Moreover, brightness and saturation are enhanced by defined outline or distinct shape. And an area seen as a single conformation seems uniform despite contrasting backgrounds in different parts of its extent.

Another issue is the tendency to see the colour of objects the way they appear in normal daylight or local colour and not the actual light that is reflected upon the eye. In addition, there is also the tendency to compensate for changes in illumination and viewing condition. These tendencies make up the phenomenon of colour constancy. For example, a yellow cloth illuminated by sunlight under a red roof may appear orange but its local colour remains yellow. One could depict colour reflected upon the eyes if one is interested in illumination, atmosphere and colour rather than the object. In doing so, objects depicted are often broken up and absorbed into unfamiliar areas of colour.

Most objects are illuminated by a main source of light and light from neighbouring objects (reflected or accidental colour), which modifies local colour. Since pigment colours does not have the brightness of natural light but can match all hues and intensity, the artist and designer must subdue all brightness contrast to a reduced key in order to match the limit of his or her pigment. Compromise, distortion, adjustments and the employment of effects that best convey the scene depicted should be made in order to produce veritable visual structures. Creative manipulations, selectivity and exaggeration as well as seeking colour harmony with a limited range of colour are superior to slavish copying and naturalistic matching of referents.

The seeking of harmony with a limited range of colour is a crucial aspect of the psychological approach that is indispensable for the artist and designer. We are going to consider this in more detail under numeric adaptation of colour wheel for harmonic relationship. However, let us consider next our perception and subjective response to colour in the psychological domain.

Psychological Perception and Reaction to Colour and Light

Colour is perceived in different modes and dimension and has derivative qualities that influence our reaction in terms of preferences and subjective symbolism.

Colour appears in three modes: film, volume and surface. Film colour appears in uncertain distance from the viewer and the eye could penetrate through into it to some extent, for example, as seen in a grey sky. Volume colour permeates the space they occupy and object can be seen through them, for example, as seen in a transparent glass of wine. And surface colour, which appears to lie on the surface and the eye, cannot see through it. The appearance of colour as light is also described as lustre, luminosity and glow, but these are derived from the three modes of colour already mentioned. Lustre describes brightness that exceeds the surface colour and seems to break up the surface texture, while the brightness of an object that exceeds the surrounding visual fields and emit light is describe as luminous. And an object that is luminous throughout its mass is described as glow.

The descriptions above relate with the real mode of appearance of colour and brightness an object emits. This degree of brightness can only be simulated at a reduced key by the artist or designer. This is because pigment colour is limited in brightness when compared with what is obtainable in real life. The artist/designer has to produce film, volume, surface, lustre, luminosity and glow effect using pigment colour. Understanding these modes of colour appearance in real life and reflecting such within a given picture plane contribute to the aesthetic qualities that produce salutary effects.

Although, we have already discussed to some extent the dimension or attributes of colour (hue, intensity and value), here, we will just mention some other terms used to describe colour experience for the purpose of clarity. These are brilliance, saturation, tone and shade. Brilliance describes the combination of intensity and value. Saturation or intensity describes the purity of a colourin the sense of the amount of hue in a given sample. Shade and tone describes the reduction of the brightness of hue using black and grey respectively.

Furthermore, colours have derivative qualities with which they are described. They could be described in terms of temperature and mass-having weight and size. Colours could be classified as warm or cool. Red, orange and yellow are warm while blue, blue-green and violet are cool. However, within the various hues the temperatures are different. For example, a red-orange is warmer than a red-violet as blue-green is cooler than yellow-green.

Temperature is assigned to hue based on real life experiences such as hot red pepper or flame, cool blue sky, exciting yellow sun flower and fresh green leaves. Nevertheless, it is more appropriate to consider the temperature of colour as descriptive of the position of hues on the colour wheel. Other implication/interpretations should be ignored because of their different connotative meanings in different contexts. In addition, colour is modified and affected by changes of the light conditions in the environment. So, its temperature is determined by context, saturation, value, size/shape and texture. For example, orange appears warmer when surrounded with cool colours than it does when surrounded with warm colours. Osborne (1970), states that it is a useful generalisation to say that in most situations cold colours will appear recessive and contractive, while hot colours are emergent and expansive. Also, cool colours are more restful than warm colours.

Furthermore, colour has weight and size. Dark colours are heavier than light colours. Lighter objects tend to look larger than darker object of the same size. This is critical to artists and designers in order to create expressively coherent structures. Equally important is the use of colours to generate the sensation of space on the basis of one's subjective colour preferences.

The sensation of space could be created by the use of colour through the contrast of light and dark, juxtaposition of hues, cold and hot contrast, simultaneously contrast, complementary contrast, contrast of proportion, contrast in the shape of colour areas, degree of saturation and texture of the colour areas (Maurice, 1978; and Kreutz, 1997, and Raybould, 2011). The more contrasted two colours are the more space they seemingly generate. Examples are, a pair of complementary colour is a balancing of warm and cool colour that enhances the strength and vividness of each other. For this reason, it is advocated that complementary colour contrast be used for focal point saturation (Raybould, 2011:122). The size of an area occupied by a colour affects its energy and spatial position, so the energy of a colour appears to increase with the reduction of its size - a result of the principle of compensation. Also, a triangular shape and a circular shape of the same area and colour do not take the same position in space this is because shape affects spatial functioning. And when colours and forms are placed at the lower part of a picture plane they appear heavier and nearer than when placed at the upper portion showing that the position of colour in relation with the picture field impact on its spatial behaviour. The contrast between the degree of intensity of pure colours and diluted colours affect colour space, while the diluted colour gains in intensity the pure colour decreases when they are juxtaposed.

The contrast of degree of saturation between pure colours and diluted colours affect colour space. Diluted values seem to gain in vitality while pure colour loses some of their brilliance when juxtaposed. All these are affected by the way one colour is laid over another. The contrast in texture of pigment colours as in thin wash next to an impasto and pigment applied with painting knife side-by-side with brush change the position of a colour in the context of space.

Finally, the study of one's own subjective colour preferences and the field of colour symbolism is of fundamental importance to the artist and designer because personal preferences is the basis of true Individual expression. Maurice (1978), states that this can be developed by personal involvement in painting and design activities with little external guidance, using combination of colours at random and selecting those that are exciting and satisfying (Table 1).

	Y	YO	O	OR	R	RV	V	BV	B	BG	G	GY
V		V YO	V O	V OR	V R	V RV	V	V BV	V B	V BG	V G	V GY
BV	BV Y		BV O	BV OR	BV R	BV RV	BV V	BV	BV B	BV BG	BV G	BV GY
B	B Y	B YO		B OR	B R	B RV	B V	B BV	B	B BG	B G	B GY
BG	BG Y	BG YO	BG O		BG R	BG RV	BG V	BG BV	BG B	BG	BG G	BG GY
G	G Y	G YO	G O	G OR		G RV	G V	G BV	G B	G BG	G	G GY
GY	GY Y	GY YO	GY O	GY OR	GY R		GY V	GY BV	GY B	GY BG	GY G	GY
Y	Y	Y YO	Y O	Y OR	Y R	Y RV		Y BV	Y B	Y BG	Y G	Y GY
YO	YO Y	YO	YO O	YO OR	YO R	YO RV	YO V		YO B	YO BG	YO G	YO GY
O	O Y	O YO	O	O OR	O R	O RV	O V	O BV		O BG	O G	O GY
OR	OR Y	OR YO	OR O	OR	OR R	OR RV	OR V	OR BV	OR B		OR G	OR GY
R	R Y	R YO	R O	R OR	R	R RV	R V	R BV	R B	R BG		R GY
RV	RV Y	RV YO	RV O	RV OR	RV R	RV	RV V	RV BV	RV B	RV BG	RV G	

Table 1: Showing a colour mixing grid (After Maurice, 1978: 87)

In these diagram, the letter –symbol are as follows:

Y = Yellow,	BV = Blue-Violet	YO = Yellow-orange	B = Blue
O = Orange	BG = Blue-Green	OR = Orange-red	G = Green
R = Red	GV = Green-Violet	RV = Red-Violet	V = Violet
W = White	BL = Black	X = ‘neutral’ grey	

However, a random selection of colour hinged on ignorance would always not produce the desired result. Johannes Itten’s advice to his students at the Royal college of Art to seek knowledge if they could not produce masterpieces as a result of the lack of knowledge is indispensable (Ward, 2003). So, in order to successfully express a given idea in colour, fundamental knowledge is often a prerequisite. This includes harmonic colour relationships that we would consider next under numeric adaptation of notation systems.

Alpha-Numeric Adaptation of Notation Systems (The Colour Wheel)

The adaptation of ideas, processes, structures or systems to a set of numbers in art is not new. Since the renaissance period, for example, simple, rational, irrational and sequence numbers have been employed in solving problem of art e.g. composition. These include the Fibonacci sequence- a sequence of numbers whereby every number is the sum of the preceding two (1, 2, 3, 5, 8, 13 etc.), the Euclid Golden ratio- a ratio within the elements of form, such as height to width that approximates 0.618 and the Golden grid- whereby a surface is divided into thirds that is similar to the Golden ratio but resulting in an approximation of 0.666, to mention a few. These numeric approaches were attempts to establish mathematical models aimed at creating aesthetic positions for the elements of prime importance in a composition.

The use of model (functional, graphical, mathematical, structural or verbal), which is a consciously simplified description of a piece or reality, seeks to show the main elements of any structure or process and the relationship between these elements (McQuail and Windahl, 1986:2). Furthermore, they state the advantages of model thus:

> Firstly, they have an organizing function by ordering and relating systems to each other and by providing us with images of wholes that we might not otherwise perceive. Secondly, they help in explaining, by providing in a simplified way information which would otherwise be complicated or ambiguous to key points of a

processor system. Thirdly, the model may make it possible to predict outcomes or the course of events.

Therefore, consciously simplifying the description of a sure method of utilizing the colour wheel to achieve harmonic colour relationship, using mathematical approach that could be easily internalised and made intuitive through practice is needful. It would give the much needed knowledge to handle a range of different particular circumstances in relation with the use of colour for visual expression and communication. Also, it would serve as a framework that would guide the student and professional artist/designer to key points of the colour wheel in order to harmoniously use colour to achieve a desired result.

Harmonic colour relationships consist of utilizing the three attributes of colour (hue, intensity and value) in a way that creates visual balance with salutary effect. These three attributes have been discussed (see figure 2). The hue is the fundamental attribute on which the rest attributes are based, so, the colour wheel presents only the hue (figure 5).

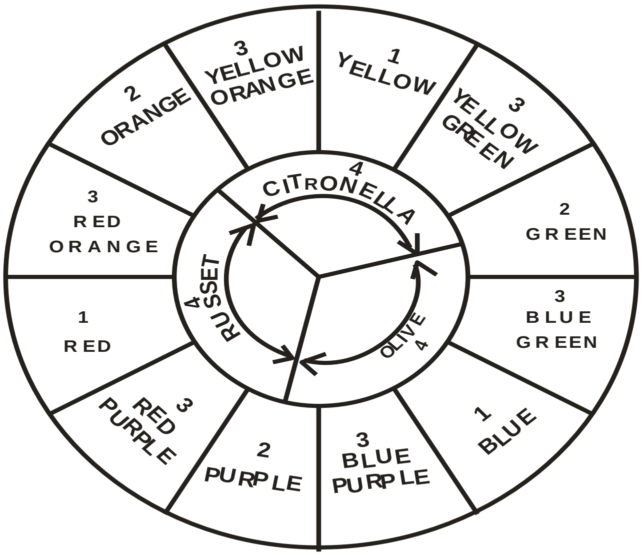


Figure 5: Showing the Colour Wheel– 1 Primary, 2 Secondary, 3 Intermediate and 4 Tertiary hues

The attribute of hue is often combined and modified with the other two attributes, intensity and value in a harmonious colour piece. So, we are going to subject the use of the colour wheel to a set of numbers, which represent a described/prescribed harmony type. This is in order to attempt to provide a mathematical model that would simplify the description of the use of the colour wheelfor a variety of harmonic colour relationships. Therefore, our basic formula for colour harmony is nH(I+V)=1, where nH=number of the hue on the wheel, I=intensity and V=value, which results in a harmonious whole=1.

Generally, harmonic colour relationship could be classified into two: related and contrasted. Specifically, monochromatic and analogous colour schemes are related harmony while complementary, triadic and tetrad/quadratic colour schemes are contrasted harmony. So, we would order our discussion on these two broad categories with focus on the specific types of colour harmony and their numbers.

Related Harmonies

Related harmonies include monochrome and analogous colour schemes. Monochromatic scheme is the use of tints, tones and shades of a hue. And analogous scheme involves the use of two to four colours adjacent to one another on the colour circle.

Monochromatic Scheme (M: 1)

The number for the monochromatic scheme is 1 (figure 6).

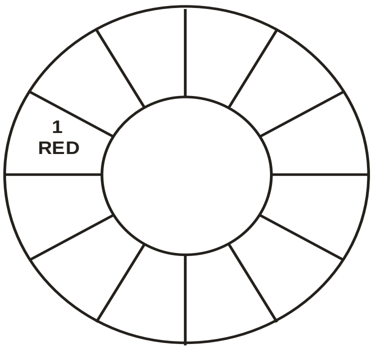


Figure 6: Showing the monochromatic colour scheme

The number, 1 represents any hue selected on the colour wheel. The hue could be then combined with its modifiers -intensity and value scale. For instance, if the hue selected from the colour wheel is red. Red is 1. Red is combined with its modifiers (intensity and value scales). The modification of red using the intensity scale would produce-neutral, ¼intensity, ½intensity and ¾intensity. The neutral is achieved by admixture of red and its complement green at equal proportion, and then the intensity is continuously increased by a quarter volume of red until it becomes 1-

full intensity - the pure hue. Also, the modification of red using value scale would produce high light to low dark values of red that range from white through red at medium value to black (see figure 2).

The combination of the hue, its four tonal variations in terms of brightness and dullness as well as its nine variations in value in terms of lightness and darkness present a wide-range of possibilities in expressing an idea with monochrome. The possibilities assume a limitless range when organised according to the principles of organisation. For example, the principle of dominance; imagine making one visual expression of every value of red in the value scale and every tonal value in the intensity scale as the predominant red. This would provide a minimum of thirteen visual expressions of red. So, using the monochromatic scheme, applying the principle of dominance alone, of all the hues in the colour wheel would result in varied one hundred and fifty-six visual expressions.

Analogous Scheme (A: 1, 2, 3)

The number for the analogous scheme is 123 (figure 7).

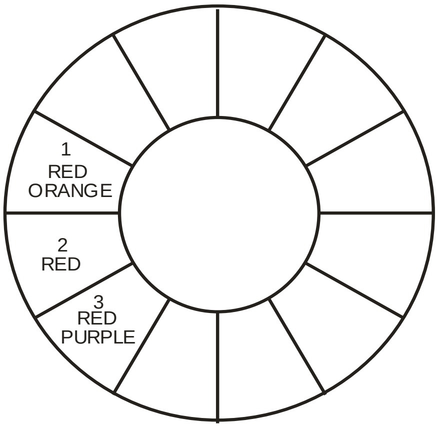


Figure 7: Showing the analogous colour scheme

The number, 1 represents any hue selected on the colour wheel and the two colours that are adjacent to it, 2, and 3 respectively. Using our general formula of nH(I+V)=1, the analogous scheme could be expressed thus 1H(I+V)+2H(I+V)+3H(I+V)=1. If number 1 is red orange (RO) then 2 would be red (R) and 3 would be red purple (RP). So the formula when applied on palette would be RO(I+V) + R(I+V) + RP(I+V) = 1. A visual expression that is derived from the combination of red orange, red and red purple and their intensity and value scales would be harmonious. The number of visual expressions that could be generated with this scheme from the colour wheel without repetition of colour far exceeds one hundred and seventy four in a given round.

Contrasted Harmonies

The contrasted harmonic colour relationship is the use of hues form different part of the colour wheel. These include complementary harmony, which is the use of hues at opposite sides of the colour wheel, triadic harmony-the use of three hues equidistant from one another in the colour wheel and tetrad/quadratic harmony- the use of four colours that form a rectangle or square circumscribed in the colour wheel.

Complementary Scheme

There are many complementary schemes (direct, double/paired, split, adjacent and analogous). Some- double/ paired complementary are treated under tetrad, but for our purpose we would consider three: direct, split and near complimentary.

Direct Complementary Scheme (DC:1, 7)

The direct complementary scheme uses two hues that are directly opposite each other in the colour wheel (figure 8)

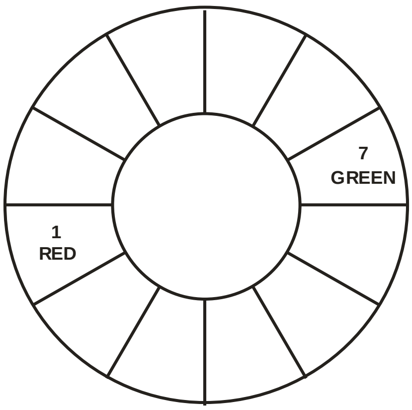


Figure 8, showing the direct complementary colour scheme

Choosing any colour to start with, 1 then the seventh colour from it is the complement. For example, if 1 is red, then the seventh is green, so using the formula ofnH(I+V) = 1. 1(I+V) + 7(I+V)=1therefore, R(I+V) + G(I+V)=1, will produce harmonic relationship. The intensity and value scales of red and green, like all other pairs of complementary colour present a wide-range of options that can be used to create a large number of visual expressions. Maurice (1978: 83), lucidly presents this in a graphic form using the direct complement of yellow and violet (as shown in Table 2)

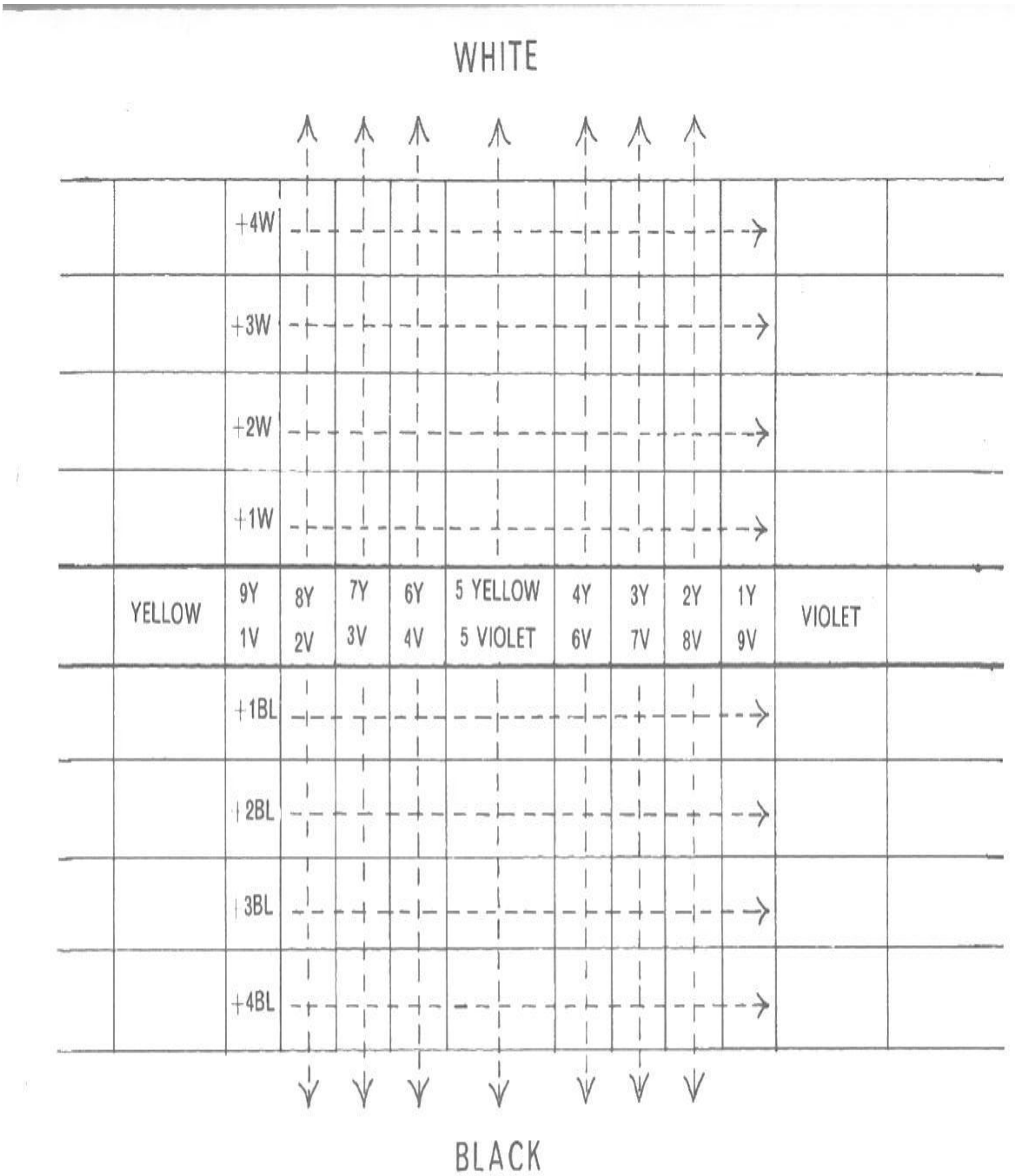


Table 2: Showing a range of admixtures with direct complements (After Maurice, 1978:83)

In these diagram, the letter –symbol are as follows:

W = White BL = Black Y = Yellow V = Violet

The numerical figures indicate the quantitative addition to each mixture

Split Complementary Scheme (SC: 1, 6, and 8)

The split complementary scheme uses three hues: any chosen hue and the two beside its complement (Figure 9).

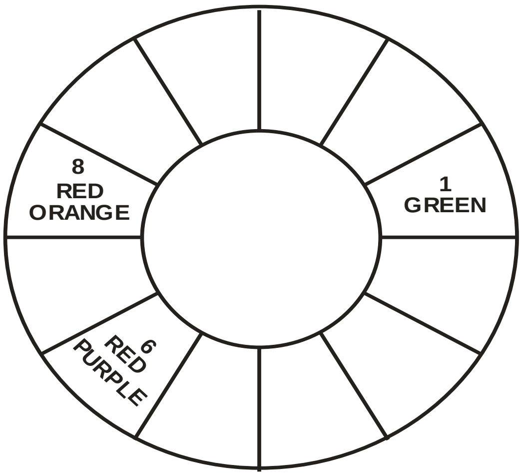


Figure 9: Showing the Split Complementary Scheme

From the above, if green is the chosen hue for example, red orange and red violets are its split complement. The complement red is deliberately omitted to afford the two hues by its left and right sides. This in mathematical order is 1H(I+V) + 6H (I+V) + 8H(I+V)=1. So, using our example– G(I+V) + RO(I+V) + RV(I+V) =1, which translates to harmonious relationship.

Near Complementary Scheme (NC: 1, 6 or 8)

The near complementary scheme utilizes two of the three hues of the split complementary scheme-the chosen hue and any of the hues by its complement. This could be expressed in numeric form as follows. 1H(I+V) + 6H(I+V)=1 or 1H(I+V) + 8H(I+V)=1. Therefore, G(I+V) + RO (I+V) =1 or G(I+V) + RV (I+V) =1.

Triadic Colour Scheme (T: 1, 5, 9)

The triadic colour scheme uses three hues that are at equal distance in the colour wheel (Figure10)

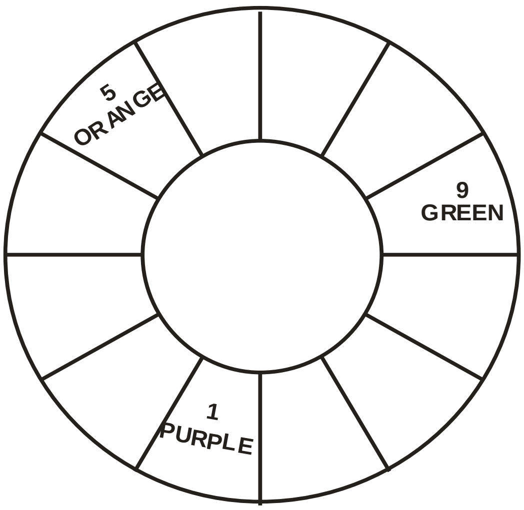


Figure 10: Showing the triadic colour scheme

The number for triadic colour scheme is 1, 5, 9 where 1 stands for any colour that is selected, albeit, randomly. Then the fifth and the ninth hue from the selected one constitute a harmonic relation when combined for visual expression. For example, were purple (1) is selected; orange (5) and green (9) would be taken as the other two hues for the triad. This translates to 1(I+V) + 5H (I+V) + 9H (I+V)=1. Therefore, purple (I+V) + Green (I+V) + Orange (I+V) =1. The range of the intensity and value scale of this combination-the triad- is enormous. The range of neutrals, resulting from the combination of the three hues and the value scale of these neutrals, and that generated by every one of the three hues is wide. Imagine the several triadic schemes is the 12 hue colour wheel and the almost limitless variations the gradation of every hue provides, it becomes clear that a great variety of harmoniously related art works/designs could easily be achieved with just applying the principles of dominance in the variation process.

Balance Colour Scheme (B: 1, 6, and 10)

The balance scheme is closely related with the triadic scheme in the sense that it uses three colours at three different sections of the colour wheel. However, it is different in that the hue are not equidistant but in a balance spacing of 4 after the first hue on the wheel has been selected and 3 after the second hue has been taken. This result in selection of hue 1, 6, and 10 in the colour wheel a shown in (figure 11)

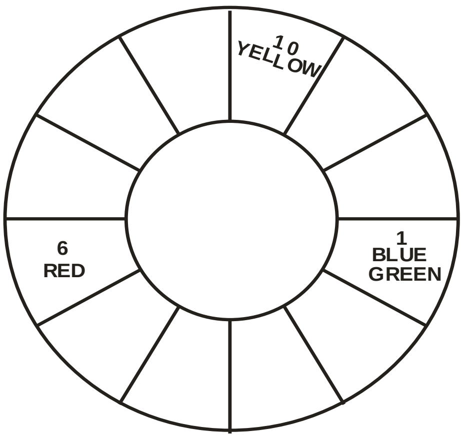
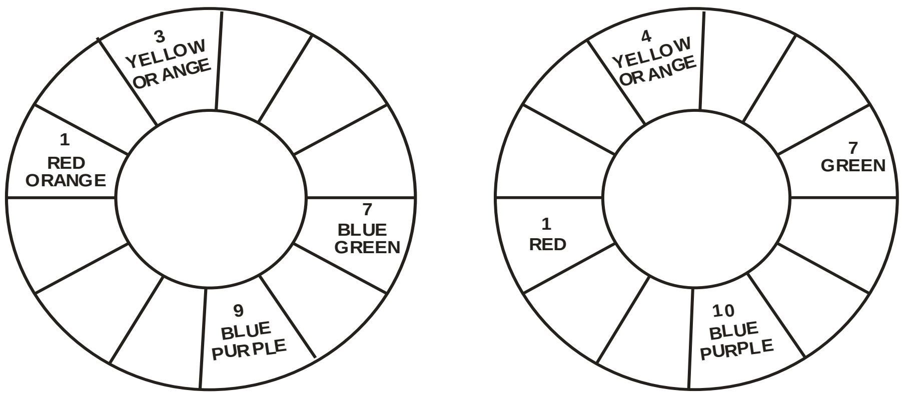


Figure 11: Showing the balance colour scheme

The application of the balance colour scheme using the formula nH(I+V) =1 is described mathematically thus: 1H(I+V) + 6H(I+V) + 10H(I+V) =1. If Blue Green is 1, Red is 6 and yellow is 10. Therefore, BG (I+V) + R(I+V) + Y(I+V) =1. The balance colour scheme is as dynamic as the triadic scheme already discussed.

Tetrad Scheme-Double or Paired Complementary (TS:1, 3, 7, 9) or (TS:1, 4, 7, 10)

The Tetrad scheme uses two sets of complementary hues in the colour wheel in two ways (Figure 12a and 12b)



12a 12b

Figure 12a and 12b: Showing the Tetrad Scheme

One of the two ways mentioned above involves the number 1, 3, 7, 9, which produces a rectangle circumscribed in the colour wheel (as shown in Figure 12a). And the other uses 1, 4, 7, 10, which produces a square circumscribed in the colour wheel (as shown in Figure 12b). The harmonic colour relationship derived is often dynamic. Expressed in mathematical order following the general formula nH(I+V) =1, the first way could be expressed thus: 1H(I+V) + 3H(I+V) + 7H(I+V) + 10H(I+V) =1. Let us make Red Orange (RO) the first hue to be used on the colour wheel, so, RO is 1, then Red purple (RP) is 3, Blue Green (BG) is 7 and Yellow Green (YG) is 9.

The second way could be equally expressed in mathematically order as follow: 1H(I+V) + 4H(I+V) + 7H(I+V) + 10H(I+V) =1. Let us assume we are starting with red on the colour wheel, so the hue Red (R) is 1, Blue Purple (BP) would then be 4, Green (G) would be 7, and Yellow Orange (YO) would be 10. Therefore, R(I+V) + BP(I+V) + G(I+V) + YO(I+V) =1

The range of neutrals, number of gradations and hue is the largest in comparison with the other schemes for harmonic colour relationship already discussed. This becomes obvious when all the hues, intensities and values are expressed. So, the number of visual expressions that could be generated using the tetrad scheme is immense.

So far, all we have discussed about achieving harmonic whole could be summed up in the following codes: M(1); A(1, 2, 3), DC(1, 7), SC(1, 6, 8), NC(1, 6 or 8), T(1, 5, 9), B(1, 6, 10) and TE(1, 3, 7, 9) or (1, 4, 7, 10). The codes represent Monochromatic, Analogous, Direct Complementary, Split Complementary, Near Complementary, Triadic, Balance and Tetrad harmony respectively. Just as acronyms and mnemonic devices that are methods of re-organising information to aid rapid recall when needed, so are these simple numbers, which are easier to remember and use in creating harmonic relationship than otherwise.

Conclusion

An adequate and clear knowledge of the dynamic energies of colour in relation with its contextual behavior is of crucial importance to successful visual expression in colour. The way colour functions in different contexts and the extent to which pigment colours can effectively depict existing realities, express emotions and communicate ideas are pivotal for the artist and designer to internalize.

In addition, the development of colour originality through creative construction and effective use of the colour wheel for effective visual expression cannot be over-emphasized. The use of simple numbers (123, 17, 159 and 1379 to mention a few), employed within the harmonious colour relationship formula nH(I+V) =1, where 1 is any number of hue on the colour wheel the artist/designer starts with, is a veritable strategy that produces salutary outcomes .This through practice becomes intuitive and forms part of one's sensibilities.

The above necessarily and sufficiently equips the artist/designer, whether in training or in professional practice, with the technical know-how that serves as a panacea for the prevalent confusion and ineptitude in terms of colour usage. From this informed standpoint, the artist/designer is enabled to proffer satisfactory resolutions to art and design tasks. Also, it gives the confidence to creatively, constructively and expressively use colour to achieve an overall desired goal.

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