COLOUR IN DESIGN EDUCATION

MSc. Margarida GAMITO
UNIDCOM/IADE - Design and Communication Research Centre
CIAUD - Research Centre in Architecture, Urban planning and Design

PhD Fernando MOREIRA DA SILVA
CIAUD - Research Centre in Architecture, Urban planning and Design

ABSTRACT
This paper presents the outcomes of a joint research in the Colour area, mainly about the colour knowledge in a scientific basis, in a way to fill the existent gap on educational programmes that use colour on design projects. It pretends to be a contribute to colour education, especially for Design Courses, in which must be present a awareness and conscientiousness of colour use and applications.

KEY WORDS
Colour | Design | Education

INTRODUCTION
The experience of the authors as designers and design teachers, awakened the necessity to structure colour knowledge in a scientific basis, to fulfil the deficiencies present on educational programmes and contribute to a more conscientious and adequate colour application on design projects.

Designers frequently use colour in an intuitive and random way. Colour is usually considered a taste option and a secondary element associated with styling, and not essential to function.

In Communication Design colour is usually applied without a real knowledge of its harmony and contrast properties, and colour interaction. Often, there is no concern about the legibility and integration factors, or the form/ground contrasts; and even more, the fact that colour expresses sensations, emotions and feelings is generally ignored.
In Interior Design, colour may control dimensional and distance relationships. By means of its psycho-physiologic, physic and thermodynamic effects, colour will interfere with the users comfort; and its harmony and contrast characteristics can make the same elements stand out or disappear.

In Industrial Design, colour is an element directly connected with the objects skin, making them stand out from the environment, or be integrated to the extreme limits of camouflage. On tools and machines, it is colour that differentiates functional elements, and gives instructions for their correct use. In a commercial application, colour symbolism contributes to sell the products, attracting different kind of buyers, according to cultural, age, or geographic variables, among other.

However, on every Design specialities, there are common problems, which need the knowledge of colour characteristics and properties, as well as the new presentation and chromatic constancy technologies that imply the knowledge of the various colorimetric systems.

**COLOUR THEORETICAL FRAME**

Colour has always been a concern of every civilization. Therefore, the comprehension of the colour phenomena has been a research objective for philosophers, theorists, artists and scientists.

We may consider that the first Colour Theory has been expressed by the Greek philosopher Empedocles (492BC/431BC) who made the statement that colour was not a property from objects, but an eye perception. Other Greek philosophers, as Democritus, Plato and Aristotle went on trying to explain colour phenomenon; and the last made the greater contribution for colour theories that remained till Newton findings.

Aristotle’s theory considered vision as an object to eye action, lead trough air. His primary colours were white, gold, and black; intermediate colours were red, violet, green, and blue or gray (that could be a variation of white), which were grouped in a seven colour scale, similar to the musical one, with a numeral relationship.

This theory was accepted without conditions, and was the subject of countless studies from philosophers of different cultures. Among them we may highlight the Arabs Alhazen (965/1039) and Avicenna (980/1037) who profound Aristotle’s theory, and during Renaissance, Leon-Battista Alberti (1404/1472) and Leonardo da Vinci (1452/1519), who studied the laws of perception and contrast on light and shadow studies.
The various attempts for decomposing white light in its chromatic components contributed to Newton's discoveries, which made a revolution to the physics colour studies on the XVII century, and opened a way to a rational and scientific study of the colour phenomenon.

Newton (1642/1727) was the first researcher that achieved the decomposition of white light on its chromatic components, with each own wavelength, using a triangular prism. In addition, Newton reconstructed the white light, passing the chromatic light through an inverted prism; and established the notion of chromatic complementarity, which conducted to range the colours in a circular diagram, arranged by wavelengths order.

At the beginning of XIX century, Goethe (1749/1832) presented the results of his research, which constituted a new approach to colour studies till then dominated by Newton theories and experiences. These studies did not receive great credibility, because the human eye was the only tool and he didn't use a scientific method; however they were very close to the modern approach of a scientific theory about the human perception of colours, and colour phenomenon.

Other scientists and colour experts made contributions to colour knowledge, such as Otto Runge (1777/1810), who created a colour tri-dimensional system representing the three colour characteristics. Also, Chevreul (1786/1810) ranged colours in a hemisphere and made an important scientific contribution to the study of chromatic contrasts and harmonies, with his book *De la loi du contraste simultané des couleurs*.

A very important development was made by two related theories that established the scientific explanation for colour vision: the *Trichromatic Theory of Colour Vision*, by Thomas Young (1773/1829) and Herman Helmholtz (1821/1894), explaining colour vision through three different retinal receptors; and the *Opponent Colours Theory*, by Ewald Hering (1834/1918) that explained colour vision at brain level.

Albert Munsell (1858/1918) created a system, published on his book *Color Notation*, describing colours in its variables: *hue*, *value*, and *chroma*, arranged in an irregular diagram, the *Munsell Tree*.

It is essential to mention the Bauhaus, where some teachers dedicated their studies to colour theories. Among them Joseph Albers (1888/1976) who, in his book *Interaction of Color* (1963), considered the way as colours present themselves within a continuous flux, being always related with contiguous colours in changeable conditions.
Kandinsky (1866/1944) wrote about colour psychological effects, synaesthesia, and established relationships between colour and music. Paul Klee (1879/1940) explored, in a large sense, surface design laws and colour theory.

Johannes Itten (1888/1967) by his qualities as educator and theoretician is the one who influenced the most the art and design world. He defined colour as a range of contrasts and opposite forces, and organized his diagram similar to Goethe’s chromatic circle and to Otto Runge’s colour sphere. In his works it is implicit the belief in a colour spiritual and subjective feeling, and its psychic and emotional values.

Frans Gerritsen wrote *Theory and Practice of Colour* and *Colour Evolution*, where he established the interrelation between the subtractive and addictive synthesis, and between the Young-Helmholtz and Hering theories. He defined eye perception as the departing point of colour theory. His tri-dimensional colour diagram is based on the systematic representation of the three colour characteristics (hue, saturation and luminosity) in a circular disposition around a luminosity vertical axis, identifying colours from a numbered position with a correspondence to their wavelengths. Gerritsen eliminated the confusion between the different colour theories, establishing the human eye and the light primary colours as the basis for all future colour theories.

**COLOUR VISION**

Colour perception is directly related with light and its reflection, but is processed through a complex system that includes eyes and brain. The human eye is the main organ for colour vision, receiving the light radiations and convoying them to the brain, where they are processed. Therefore, all colour studies should begin with the mechanism of vision system, highlighting the colour vision processus.

**I. Human Eye**

The light enters the eye trough the conjunctive and cornea. Behind them the iris controls the light quantity and the profundity of the visual field, and the crystalline lens, by its accommodation, allows the image formation at the retina.

Internally, the ocular globe as a fine layer of nervous cells interconnected – the retina – responsible for the radiations detection. When the optic radiations reach the retina receptive cells they are transformed in electric impulses and sent to the brain for interpretation.
The retina receptive cells are of two kinds: cones and rods. The rods are not sensible to colour, with the exception of some wavelengths of green colour, but envosys stimuli to the brain which allows the eye light adaptation. The rods forming big groups, mainly situated on the retina peripheral zone, have high capacity to perceive the minimal light intensity, and are responsible for the eye adaptation to chiaroscuro and to night vision - scotopic vision.

Cones, have less sensibility then rods, but can distinguish colours and work in good visibility conditions, being responsible for day vision - photocopic vision. Cones are mainly grouped at the central and more sensitive retina zone - fovea - responsible for vision with greater detail and colour resolution.

The function of sending information to the brain is fulfilled by the optical nerve, and the point where all its nervous fibres are gathered, has no rods or cones and is called blind spot.

II. Brain

The eye attracts and selects the luminous wavelengths, but it is in the brain where the visual stimuli are transformed into perception.

The brain is constituted by a grey matter, formed by cellular corps, interlinked by fibres. The superficial part of the cortex has various circumvallations with different functions of stimuli reception and interpretation that are essential to the perception of the five senses. The vision function is located at the visual cortex, on the brain occipital zone.

The brain nervous cells are grouped in two symmetric and complete hemispheres, linked by two fibres groups: callous corps, thicker, and a minor one, optic chiasma.

III. Vision mechanism

Vision mechanism involves eyes and brain. For a correct vision it is necessary the two eyes cooperation to compare information. The visual mechanism unifies retina’s two images, slightly different, in order to perceive solid objects in tri-dimension. Each eye retina, and its retinal fibres, is vertically divided in two equal parts. The extern eye fibres are directed to the same side of the cortex and, otherwise, the internal eye fibres (nasals) cross behind the eyes, at the optic chiasma, and head to opposite sides of the brain. Coming from the optic chiasma, the optical fibres go through the geniculate lateral body of each hemisphere, and end on the visual projection area.
IV. Colour vision

Chromatic vision may be considered as the main part of the human vision study, because it distinguishes humans from most animals, and contributes to a better comprehension of what surrounds us, as well as it affects our emotional state.

It is also very important to perceive how the differentiation of colours is processed.

The Young-Helmholtz was the first theory that explained colour vision by the differentiation of three kinds of retina receptors: cones $S$, sensible to short wavelengths of blue colour; cones $M$, receptors to medium wavelengths of green colour; and cones $L$, which attract long wavelengths of red colour. However, cones sensibility is extended to other wavelengths.

Other researchers admitted the idea of the existence of four different sensibilities on the photoreceptors. Ewald Hering (1834/1918), on his opponent colours theory established that any colour may be represented by a coordinate axis that varies between a colour and its opponent, or complementary. Hering considers that, at the retina level, the visual system creates signs of opposite pairs (Yellow/Blue, Red/Green and White/Black) which are sent to the brain. Also, the secondary colours result from the combination of the sent information by each opponent colour channel.

David Hubel and Torsten Wiesel identified on the lateral geniculare nucleus, three cells groups that demonstrate the Hering theory. From these cells, two groups function as colour opponent systems, while the third one functions as special opponent system.

The tri-chromatic and the opponent colour are now considered complementary theories. The first one is eye processed, at cones level, while the last is processed on the brain virtual cortex.

COLOUR PERCEPTION

Colour perception includes all colour characteristics and proprieties, and the different colour effects, which are essential to a good comprehension of colour and a adequate colour application.

I. Colour Characteristics

Colours have their own characteristics, or attributes, which allow an objective description, and contribute to a good perception and identification. The colour characteristics
usually considered, are: hue, luminosity (value), and saturation (chroma). To these three fundamental attributes we may aid temperature.

- **Hue**

Hue is a universal variable present in all colours (Munsell 1976), and is defined by its wavelength that places it on the visible spectre. On common language, it is confused with the colour name.

The eye primaries hues activate only one eye sensibility. However, as the other sensibilities are activated in higher or less intensity, appear other hues, each of them pure, without mixing with white, black or grey, and with their own wavelengths.

- **Luminosity or Value**

Luminosity is the lightness graduation of a hue: is the distinction between any colour and a lighter or darker one (Munsell 1976). It may be changed by addition of white or black.

By the perception laws, when all the eye sensibilities are activated similarly and simultaneously, to the higher luminosity corresponds white, and to the less sensibility corresponds black. On the neutral luminosity axis, going from white to black through the greys, the three sensibilities are activated in various degrees, but no one is dominant.

- **Saturation or Chroma**

Saturation defines the purity state of a colour. All pure colours have their saturation at 100% corresponding to their wavelength. When saturation is non-existent, the colour is achromatic and belongs to the neutral luminosity axis.

By the perception laws, to brighten up a colour it is necessary to activate partly the sensibilities that don’t belong to this colour, although, when the colour becomes lighter, it becomes also less saturated. To darken a colour its sensibility must be less activated, and the colour looses luminosity and saturation.

- **Temperature**

Colour temperature may be considered in comparison with other colours or by its effects. However, it can be also considered a colour characteristic having a correspondence to its wavelength. Colour measurement by electronic sensors shows that surfaces covered with a range of reds, orange, or yellow are warmer than surfaces covered with blues or green colours. The temperature decreasing scale of the principal colours are: red, orange, yellow, blue, cyan, magenta, and white.
Dark colours are warmer than lighter ones, absorbing more incident light. So, within a hue, temperature may change with its luminosity. In a composition or environment, the human eye is spontaneously attracted by warm colours, and need more concentration to perceive cold colours.

Pigment mixage implies mixing their temperatures. Also, the relative colour temperature makes that a colour may seem more or less warm in comparison with other colours.

- **Colour/Space Unity**

It is common to represent colour through a tri-dimensional form, known as “colour solid” and adopted by several authors, in chromatic systems used in arts and in sciences, following the fundamental relation between the three original dimensions. Judging colour in spatial issues and when comparing it with the perception of space regarding the light, one positions in first place the attribute of luminosity or value. Nevertheless this characteristic, or attribute, in terms of chromatic definition evolves into an integrated dimension to the attribute of hue, which in terms of an informative meaning of colour is the one that characterises it the most. So, in the tri-dimensional conception, when getting together the three attributes, the following relationship is established:

\[
\begin{array}{c}
\text{Luminosity (or value)} \\
\text{Hue} \\
\text{Saturation (or chroma)}
\end{array}
\]

So, combined stimuli of luminosity and saturation belong to a certain hue in the perceptive chromatic whole. So, Moreira da Silva (1999) proved that there is a tri-dimensional relation of colour/space, which forms a unity, and is represented by the following expression:

\[
C/S = (h^{\text{value}}) / S
\]

This relationship becomes the perceptive unity which is the basis for the other possible formations in colour/space relationship.

**II. Colour Complementarity**

Newton established the concept of colour complementarity, but it was Ewald Hering's opponent colour theory that related this concept with the vision mechanism.
The perception of a colour hue and luminosity is activated by the reaction of the eye sensibilities to the emission of certain wavelengths. The wavelengths that would activate the eye sensibilities, not yet activated, constitute the complementary colour. Therefore, the complementary colour is the same as light rays absorbed, and the addition of the two colours rebuilds the white light.

Complementarity to white is black, and primary colours are complementary to secondary colours. However, the totality of complementary colours is not limited to these colours and every colour from the visible spectre has its complementary colour, its pair to the white colour reconstruction.

III. Colour Interaction

"The character and effect of a colour is determinate by its position in relation to the colours accompanying it. A colour is never seen alone, but always in relation with its environment" free translation (Itten 1985:144)

This relation between colours, or the colour relation with the environment, with which it interferes, provoking and suffering alterations, was named Colour interaction by Josef Albers (1971), in his book.

- After image

After image is a complementarity relationship provoked by eye tiredness and by visual memory. This phenomenon consists in, after observing one colour insistently, seeing the complementary colour over a white background. This reaction is more immediate when the observed colour has great intensity, and it happens because the cones sensible to this colour become saturated and, when the eye moves to the white background, are temporarily impeached and can only activate the complementary sensibilities.

The complementary after image is usually called negative after image. Nevertheless, after image can be positive when it happens under the stimuli of an intensive light, and is similar to the observed colour.

Every hue form an after image with its complementary hue, and the after image of white is black.

The after image effect can be neutralized by a complementary background colour, it can also be diminished or neutralized, applying a white or black contour.

- Successive contrast

Successive contrast is the reaction to after image provoked by colours, observed one after the other. When the eye is moving rapidly over a coloured surface, it observes the
colour in which it focus and also, the after image from the previously observed colour. This phenomenon happens because the eye, trying to activate all the sensibilities, tints the adjacent colours with the observed complementary hue.

The successive contrast is provoked only by hues, independently of their luminosity. If two colours with a great luminosity contrast are placed side by side, when they separate the lighter colour darkens and the darker one lightens.

- **Simultaneous contrast**

Simultaneous contrast is the result of an after image which alters the appearance of a colour, by the influence of the adjacent colours, having the influenced colour a minor area than the influent colour. This reaction occurs on saturated, or less saturated hues, and neutral colours, and may affect an object shadow.

Neutral colours are the most affected by the simultaneous contrast, and in consequence, a grey background makes the other colours look more intense. Being a form/ground contrast, it can happen in relation with all colour characteristics.

- **Optical mixture**

Optical mixture is the after image that happens when the eye, after fixing for some time on a high saturated colour, moves to a background of a different hue equally saturated. The brain interprets this colour as a mixture from the first colour and the new one, with a higher luminosity than the one corresponding to pigments mixture. The optical mixture works differently when it is a light or direct colour mixture, a pigment mixture, or an indirect mixture from reflected rays.

**IV. Colour Mixtures**

- **Additive synthesis**

Colour additive synthesis is a direct mixage process of luminous coloured beams. In this colour combination, to the light flux received by the eye, luminous energy is added of one or more wavelengths zone of the magnetic spectre. One or more receptors, sensible to the various wavelengths, are activated and the mixed colour will be lighter and more luminous than the component colours.

When the three receptors are activated similarly, the result is white light; if they are activated in a different way, a tertiary colour will appear; when two receptors are activated in a similar way, the lights will be of secondary colours; and when only one receptor is activated, will appear a primary light.
• Subtractive synthesis

Colour subtractive synthesis is the overlapping process of transparent colours or pigment mixage, which are seen as reflected light. On these colours formation, light energy is taken off from the luminous flux reflected by the object in one or more wavelength band.

In theory, secondary colour (cyan, magenta and yellow) overlapping eliminates all light reflexion, resulting in black but, in practice, there will be some light reflexion, and the colour perceived will be a dark grey. Also, the subtractive mixture is always darker than any component.

V. Colour contrasts and harmonies

• Colour contrasts

«We speak about contrasts when, between two colour effects, we may establish differences or sensible gasps. When these differences reach a maximum, the contrasts are polar or opponents. So expressions like big-small, black-blue, hot-cold on their higher degree are polar contrasts.» Free translation.² (Itten 1985:36)

The colour contrasts may be organized in function of the colour characteristics, complementarity and temperature, and quantity or proportion.

• Colour harmonies

Harmony in a colour composition is considered when the totality of its colours activates, in more or less quantity, all eye sensibilities. Also, it is possible to achieve harmonious ensembles combining hues and neutral colours.

Colour harmonies may be monochromatic or polychromatic, with several varieties such as: analogue colours harmony; complementary and double complementary harmony, which can be square, rectangular and trapezoidal; tri-colour harmony, with the variants corresponding to the different kind of triangles.

VI. Colour special effects

The colour temperature, saturation, and luminosity, influence its position on space, placing it at a near, far away, or middle distance. For the same luminosity level, warm hues advance or stand out, and cold ones withdraw, showing a sensation of profundity. However, these effects may be inverted if the warm hues have little saturation, and the cold ones are highly saturated.
The luminosity influence is more evident on the form/ground relation. Over a high luminosity ground, dark hues stand out and light ones tend to melt with the ground; and have the inverse effect over a dark or black ground.

Concerning saturation, highly saturated hues seem bigger and near, than less saturated ones, with the same luminosity.

When colour saturation and luminosity values are equals or nearer, the composition becomes flat, and the dimension differences disappear.

VII. Colour appearance

"The sensation and appearance of color is encoded through the structure of the eye and in the visual centers of the brain. A particular color may appear solid and opaque like a painted wall, transparent like a glass window, lustrous like the glaze of a ceramic vase, metallic like a holiday ornament, luminous like the beacon of a lighthouse, and voluminous like a bottle of colored ink." (Linton 1985:66)

There are different kinds of colour appearances:

- Opaque colour surface

Opaque colour surface is the most frequent visual perception for objects. Usually, solid objects under normal vision conditions communicate the sensation of coloured surface, which is a barrier impossible to overtake by the human eye.

- Transparency

Transparency happens when a surface, or an object, overlaps other element allowing it to still be completely seen. However, it is possible to create transparency illusions. Colour is a very important factor on the transparency illusion transmission, provoked by changes in hues and luminosity that occur when a surface overlaps another.

The transparency luminosity results from the mixing luminosities, and the transparency resultant hue will be a mixture of the ground and overlapping hues, with predominance to the overlapping colour. It may show the illusion of an additive synthesis, an optical mixture, or a subtractive synthesis, and transmit the sensation of distance and deepness.

VIII. Shadows colour
The shadow colour of the object depends on the incident light. Every coloured light creates a shadow in its complementary colour, which is not the effect of simultaneous contrast, but real colour.

White light, the day light, activates every eye sensibilities and its shadow is black. However, the colours of the shadows provoked by various coloured lights correspond to additive colour mixtures. On the other hand, on day light absence, the coloured light resultant shadows are different. One coloured light have a black shadow, because it is the absence of light. When the object is illuminated by two complementary colours, each colour provokes a complementary shadow and where the shadows overlap the black colour is seen, while the mixed light is the result of the two colours additive synthesis. With analogue lights, each light projects a shadow in the other incident colour, the overlapped shadow still will be black, and the mixed light will be the two colour additive synthesis. The results of the three primary colours projection are three primary colours shadows, one overlapped black shadow, and a white light mixture, because the additive synthesis of the three light beams reconstitutes the sun light.

COLOUR PSYCHOLOGY AND SYMBOLISM

The nature itself creates means of defence and species conservation. All over the times, animals and plants have developed colour and colour vision as an attraction or rejection factor which allows their reproduction and defence.

As a result of these conditionings, human beings on their evolution have inherited psychologic and physiologic reactions to colour, that cannot be objectively controlled or explained: once they were essentials to their survival.

So, colour has a visual, associative, symbolic, synaesthetic, and emotional charge which affects psychologically and physiologically the human being, and may be approached from multiple perspectives, among which is psychology.

I. Colour Psychology

Colour doesn’t depend only from the external world, neither is it only the response to a stimulus. It is part of our psyche and it is an experience that integrates the human behaviour. Being a brain perception, it is an emotion, an impression, or a sensation which activates simultaneously the mind and the cognitive system.

The definition and valuation of all the visual perception, including colour perception, is different to each individual being, depending on his emotional and mental state, on the
personal memory, suggestibility, attention capacity, and knowledge storage, which is acquired from education, environment and culture.

II. Psychophysiologic effects

"Color and light [...] have great impact on our psychological reactions and physiological well-being. Research has proven that light and color affect the human organism on both a visual and non-visual basis. It is no longer valid to assume that the 'only' significant role of light and color is to provide adequate illumination and a pleasant visual environment." (Mahnke 1996, p3)

The brain receives and interprets, provoking physic, psychic and emotional reactions. Frank Mahnke (1996:10-18) states six basic factors that influence the colour experience on human being, which are organized in his Colour Experience Pyramid: Personal Relationship; Influence of Trends, Fashion, Styles; Cultural Influences and Mannerisms; Conscious Symbolism - Associations; Collective Unconscious; and Biological Reactions to a Colour Stimulus.

III. Colour Symbolism and Association

Colour is a visual and psychologic perception, which is not identical for all individuals. But, independently from them, colour significance may change through the times, depending on the different cultures, or on its use. There are also associations of colour significances with their representation in nature or with temperature.

• Colour symbolism

The psychologic and physiologic fields are interlinked and, in the search for a colour harmony, it becomes necessary to have in account the psychologic effect in function of symbolism.

Symbolism represents the associations and impressions ensemble, consecrated by the traditions transmitted through the centuries, by means of civilisations and religions. As it represented in the Color Experience Pyramid (Mahnke 1996), there are colour symbolisms that belong to humanity inheritance and are the same to most cultures; and other ones, less lasting, that are characteristics of some cultures and specific groups.

The concept of symbolism and colour language may be extended to literature, fashion, folklore and ethnography.

• Colour association
Colour perception may not be associated with a physical fact; colour may be seen in the
brain, without vision contribution, only by the power of imagination and memory, or in
association with other sensorial organs, by synaesthesia.

- Colour memory and synaesthesia

Sometimes, it is more important to know the sensation, or the association, provoked by
a colour, than the difference between analogue colours.

Similarly to vision, the brain receives impulses from other senses organs, which are ana-
lysed and interpreted in other brain sections. These informations are interlinked in such
a way that an image perception may awake the memory of another perception, ac-
quired from a different sensorial organ.

However, visual perception determined by these sensorial associations, is not sufficient
for the complete identification of an object, without memory intervention that, by
analogy, evokes images already stored in the brain. The perception of an unknown ob-
ject is associated and compared, in the brain, with similar objects.

COLOUR APPLICATION TO DESIGN

In order to fully communicate the designer intentions it is necessary to fulfil the har-
mony and contrast rules, which are provoked by colour interaction. However, it is possi-
ble to establish colour relations of rhythm, balance, scale and proportion, and also to
have notions of how to make a surface stand out or be annulated.

- Rhythm

A coherent composition should present order and unity, and those may be represented
by rhythm, which can be defined by a progression or repetition of hue, or other colour
characteristics.

- Balance

The balance notion within a composition is related to the visual effect of the totality of
its components. Colour may furnish or withdraw the deepness or relief notion, by means
of its brightness, saturation, or temperature characteristics, which establish the image
placement in space.

The colour balance in a composition may be symmetric or asymmetric. The formal sym-
metric balance, is reinforced when colours are also symmetric, but these compositions
tend to be visually statics. In a formal asymmetric balance a symmetric colour place-
ment may attenuate its activity. On the contrary, a composition with symmetric forms may acquire movement with an asymmetric colour disposition.

Colour contrasts can also affect a composition balance. How bigger a form/ground luminosity contrast may be, less is the colour quantity needed to achieve balance.

- **Scales**

Scale notions include all dimension relations of colour, which may be established in function with its surface or readability.

The dimension of a colour surface influences its saturation, the brightness and saturation diminishing as its area grows. Otherwise, as a colour becomes saturated it stands out from the ground, but a change in brightness, even if it changes the colours clearness, is less drastic.

- **Emphasis**

Emphasis is related with the definition of coloured areas, which stand out in a composition. As colour is seen with priority to form, it represents an important role.

The composition visual centre doesn’t coincide with its geometric centre, and is situated slightly on the side and above. So, the geometric figures construction lines may help in the localisation of the colour to which emphasis must be given.

Other emphasis factors are saturation, contrast, form and dimension, and texture. An arbitrary or illogic colour selection is another emphasis factor that is achieved by applying to an object a colour that does not belongs to him, or using a colour contrary to the coloured form nature.

**COLORIMETRIC SYSTEMS**

Illumination sources, and the reflection power from the covering materials, can be scientifically measured and compared by its spectral reflectance.

For a correct colour use in their works, Designers must know which colorimetric system is more appropriate for a specific work.

- **RGB system**

This system combines the three light primary colours in an additive synthesis that originate all other colours. It is built in a cube, with the primary and secondary colours, and black and white, represented on its vertices, having the edges a graduation from 0 to
255, because the human eye may distinguish 256 levels on the luminosity scale. Therefore, in this system are represented more than sixteen millions colour combinations \((256^3)\). Each colour is identified by three co-ordinates \((255, 255, 255\) corresponding to RGB) that show the participation of each primary colour on its composition.

This system is used whenever lights are mixed to generate colours, like computer monitors, scanners, and digital cameras.

- **CMYK system**

  The CMYK is a subtractive system that gives print indications, when used in computers. Its primary and fundamental colours are Cyan, Magenta and Yellow; and black is used to reinforce the subtractive mixture of these three colours. These colours are represented in a graduation from 0 to 100; and the other colours are defined by the percentage of each component primary colour. The various black percentages, without any other colour, are a neutral greyscale.

- **Hexachrome system**

  This system assures a higher chromatic fidelity than the CMYK system, and is destined to print. It uses six colours, adding Orange and Green to the CMYK colours, in order to increase the colours range that can be reproduced, and the colour printing quality.

- **HSV system**

  The HSV (hue, saturation, value) colorimetric system, also called HSB (hue, saturation, brightness), is represented by an inverted cone, where the hues are situated on a hexagon at the cone basis; being the saturation its diagonals. The luminosity axis starts with white, on the basis centre, and goes down to the black vertex.

  This system is solely used in digital systems, having no correspondence to the additive synthesis, or the subtractive synthesis.

- **HLS system**

  The HLS system (hue, lightness, saturation) differs from the HSV system because it is constituted by two cones unit by the basis. Its luminosity axis develops between the vertices, with white on the top and black on the bottom, while the pure colours are situated on the double cone basis. This system permits the definition of an infinite number of colours.

- **Munsell system**
The Munsell system describes colours by its three variables: hue, value (brightness) and chroma (saturation); and permits the use of decimal scale. It considers five primary colours: red, yellow, blue, green, and purple; and five secondary and complementary colours: reddish yellow, reddish purple, bluish purple, bluish green, and greenish yellow. Light gradations are present on the vertical axis, saturation gradations on the tree branches, with the pure colours on their end.

This system, used on colour definition for Industrial and Interior Design, has been adopted by the United States Bureau of Standards, and is currently applied on educational programs at UK and USA.

- **Natural Colour System - NCS**

The NCS system was create by Annders Hård and Lars Sivik, in Sweden by the final of 60s. Similar to the Munsell system, is used on Interior Design and allows the description of all colours from perception, using only NCS parameters, without needing any instrument or colour standard.

It is based on the Hering opponent colour theory, and its principal colours are: red $R$, green $G$, yellow $Y$, and blue $B$, besides white $W$ and black $S$. The tri-dimensional model is a double cone, where white is on the top vertice, and black is on the bottom one; while pure colours are placed on the cones basis. To make the consultation easier, this system is usually represented by the **NCS Colour Circle** and by the **NCS Colour Triangle**.

- **Comission Internationale d'Eclairage - CIE systems**

The *Comission Internationale d'Eclairage* (CIE) has developed some chromatic coordinated systems, which are applied to illumination.

The basis for these systems colour identification is a mechanic measurement where the three colour variables - hue, saturation and luminance - were measured by colorimeters. Its colours are represented by coordinates that depend from a **standard observer** and **standard luminous sources**.

On the first CIE system colours were represented by the coordinates $X$ and $Y$, to which were added a third one $Z$, corresponding to luminosity. Later on were developed other systems. In 1976 was adopted the CIE Lab system that is based on the Hering colour opponent theory. In this system the coordinate $L$ represents the luminosity; red and green correspond to coordinates $a^*/a'$; yellow and blue correspond to the coordinates $b'/b'$.

Endnotes:

2. «On parle de contraste quand, entre deux effets de couleurs à comparer, on peut établir des différences ou intervalles sensibles. Quand ces différences atteignent un maximum, on parle de contrastes d'opposition ou polaires. Ainsi les termes grand-petit, noir-bleu, chaud-froid à leur point plus élevé sont des contrastes polaires. Les organes de nos sens ne peuvent percevoir que par l'intermédiaire de comparaisons.» Itten, J. (1985). *Art de la Couleur*. Paris : Dessain et Tolra


References:


(1ª Publicação: 1963. Yale University)


