ABSTRACT

Every Human Being establishes a personal relationship with Color. Often we give ourselves an instinctive color treatment, just by choosing clothing of a particular color, or putting around us certain colors in our homes or gardens. Most of our reactions are, however, unaware and it is only when we begin to use color in an informed way that we can take advantage of this extraordinary life force in order to improve the quality of life and our well-being. The colors we use can provide protection against many physical ailments as well as can give us emotional inspiration. Obviously the clothes also protect us from the elements, being a form of personal expression, protecting us from the world around us and affecting the way we feel and think. ColorErg is a research project which aims to study physical, physiological and psychological color effects, in its interaction with human beings through clothing, underlining the importance of color ergonomics. The main objectives focus on the acquisition of scientific knowledge in the area serving as a projective tool for fashion designers, as well as to contribute, through the dissemination of its results, as a reference to the use of color to users in general.

Keywords: Ergonomics, Color, Fashion Design, Sustainability, User Centered Design

INTRODUCTION

“Color is a property and the language of form” (Mahnke, 1993)

Nature provided us with color to fuel our body and spirit. Color enriches our entire system, giving us vital energy as supplement which is an essential part of life.

By observing nature, color often appears as a means of defense and conservation, as with plants and poisonous animals whose showy color warns potential predators or even a function of attraction that allows plants reproduction and mating calls of certain animals. The human being, in its evolution, inherited psychological and physiological reactions to color, although they cannot be controlled nor explained objectively make color as a necessary medium for the information, communication and understanding of the environment. In this respect Michael Lancaster (1996:8) states that color has the function to attract attention, convey information add emotions and stimulate illusions. (Gamito and Silva, 2009)

As highly colored beings, our forms are made of vibrant and ever-changing Colors and the Human Being answers colors actively or passively in everything we do. Light waves affect us every minute of our lives and enter our energy system, whether we are awake, whether we are sleeping, visual or blind. Our growth, blood pressure, pulse, temperature, muscle activity, immune system, etc., they are all affected by light rays. The colored rays affect not
only our bodies but also our emotions, dispositions and mental faculties.

We all have a personal relationship with Color. Often we give ourselves an instinctive Color treatment, just by choosing clothing of a particular color, or putting around us certain colors in our homes or gardens. Most of our reactions are, however, unaware and it is only when we begin to use color in an informed way that we can take advantage of this extraordinary life force in order to improve the quality of life and our well-being. Humans are not the only ones to be affected by Color. In the animal and vegetable world, color may mean survival or extinction. Color is used to attract, camouflage, as a sign of danger or send sexual signals. Color is instinctive to life and it is so important for our species as it is for the animal and plant kingdoms. There are many ways to introduce color in our system. Through the understanding of the physiological and psychological color effects, we can select the best colors for our clothes to our home and work environments. We can all learn to use color so we may take advantage of it:

- through the power of color in the food we eat and drink;
- the color techniques as therapy to heal, maintain health or alleviate many aches and imbalances (not a new idea, since there are many ancient systems of healing by Color developed throughout the world).

Of course you cannot forget color symbolic, religious and cultural power. Always used in religious rituals, Color is the language of the soul. There is a color language which we have lost and we have to learn it again, which brings benefits to our health, happiness, and perhaps even for the survival of our planet. There are very few studies on the subject, and even these are merely descriptive of a period or time. Until now there has never been an attempt to understand the global phenomenon. Does the one who determines trends, designs and manufactures Fashion has proper training on Color and its potential (for good and for bad)? Is that when people possess more knowledge about the use of color and the effects it produces in every one of us, we will ware and use Fashion differently?

**ColorErg** is a research project which aims to continue a former study on the physical, physiological and psychological color effects, in their interaction with the human beings through clothing. Since this is closely linked to fashion, the study will also address Fashion as a variable. The main objectives focus on the acquisition of scientific knowledge in the area that can serve as a projective tool for fashion designers, as well as to contribute, through the dissemination of its results, as a reference to the use of color to users in general.

A user-centered research methodology has been used, with participatory design, using survey methodologies, direct observation and active research, supported by mechanical means, in laboratory.

**COLOR SYMBOLOGY**

Juan Eduardo Cirlot (1958) in the "Dictionary of Traditional Symbols" presents a summary of various symbolic images of color in the human communication - "the color symbology is the most universally known and used consciently, in liturgy, in heraldry, in alchemy, in art and in literature". He also quotes as examples: "the generic division established by the optical and experimental psychology in two groups of colors, the hot and spare ones, which correspond to processes of assimilation, activity and intensity (red, orange, yellow and, by extension, the white), and the cold and re-entrant ones which correspond to processes of disassimilation, passivity and debilitation (blue, indigo, violet and, by extension, black), having green as an intermediary hue of transition and of communication between the two groups" ... "The co-ordination of colors with psychical functions, changes from one culture to another, from society to society and also from individual to individual. However, as general rule:

- blue, the color of space and the light sky, is the color of thought;
- yellow, the color of the sun which comes from afar, comes through the darkness as a messenger of light and disappears again into the dusk, is the color of intuition, i.e., of a function which illuminates the origins and tendencies of events;
- red, the color of the palpitating blood and of the fire, is the color of life and fiery senses;
green, the color of the directly perceptive vegetations, is the color which represents the perceptive functions" ... "The positive color and the negative color: Frequently in symbols, the opposition of black and white, as being positive and negative, either as a simultaneous polarity or as a successive and alternated mutation".

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

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 color 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.

Wolfgang Goethe (1989) interpreted the colors according to expressions and symbolisms creating a language which, according to his view, should be applied to the use of color:

- "red - indicates force (power) : the higher manifestation of color; it expresses the ideal satisfaction.
- green - indicates weakness: the color of simplicity; it expresses real satisfaction".

Between green and red, which set them as poles, he defines two groups of variations:

- "hot colors, indicating : active, agile, vigorous, ambitious
  . yellow / red : the vigorous, the convulsive
  . red / yellow : the splendid, the pleasant, the happy, the lively
  . yellow : light
- cold and dark colors, indicating : passive, turbulent, soft and distant
  . blue / red : the turbulent
  . red / blue : the vigour, the joy, the gloomy, the shady, the dichotomy open / closed
  . blue : the cold

hot colors give grace and enchantment, cold colors are an incentive to sternness and dignity “.

**COLOR CODE**

“Code is a system of principles which grants a certain value to certain signals. Value is mentioned and not signification, in order to give a more general character, because signification is only used in respect to the communication between human beings; however, a communication system can be operated between machines. The relationship between machines is done by codes of values because they don’t understand the meaning of signals. In human communication, the receiver has a voluntary act of comparison between message and code and decodifies the message” (Eco 1967).

The message one deals with is a visual one and the signs must correspond to one’s own perceptive necessities, which belong to human beings. Therefore, the system of principles must grant a certain value to certain signals to become a code and this certain value has a significative basis.

In terms of color, particularly of color / space language, the organisation of codes obeys general rules which are strictly connected to the possibility of manipulation of the language of color, to the boundaries and differential thresholds of perceptive capacity in general, be that of signals, be it of the visual field, and to the categories of signification which are embraced by the language of color, as analysed before, according to color / space signs which are communication of color, and those which communicate by color, or with characters of simple signs, of superimposed signs or of supersigns.
Therefore, the chromatic codes are organised as having the repertoires of color / space signals as a basis, programmed according to categories and shade classes, and they are dependent on the range of repertoires of signs of the individuals who participate in the communicative process, in consideration of the environment and common experience context.

The primary and principle codes of color / space are organised according to solicitations of types of harmonic shades, extension of boundaries and levels of differentiation between shades.

By these codes, which are applicable to the programming of languages to all project fields, one can define the chromatic harmonisation types which, from a group of color / space signs constitute a new sign indicator of a certain communicative situation which is characterised as a message by the tonal quality and by the quantity of visual vibrations between shades that it transmits.

Having as a base the formation of sign repertoires, the codes of superimposed color / space signs, for designation of communicational intentions of something more than color / space, are defined according to the solicitation of the context.

These codes follow the common communicational structure of the languages being applied to them, beyond the chromatic reference given by the previous code, the qualification established by the communicative structure.

Selections of unities of interest in the codification are applied to the sign repertoires and for the whole a system of rules for the message transmission is established.

**COLOR BIORHYTHMS**

One can also associate colors to the Seasons. There are personalities more connected to a particular season, in detriment of others.

If we see the case of the Traditional Chinese Medicine that associates each of the seasons to a color and an element and these, in turn, are associated with different body parts and organs.

Even if we have our favorite colors, there are also many colors to which we are attached, depending on our mood and emotions. These changes in our color preferences can give a valuable indication of the changes in our energy levels, disease and areas of our lives where it is developing an imbalance that needs attention.

Our preference colors and its changes may be associated with health changes or changes in life (as is the case of the holidays).

Knowledge of Color and its potentialities can lead us to try to find balance, including colors for protection.

There is also the case of colors that displease us. We may be concerned about the fact of looking at some colors and feel disgust. These can reveal hidden diseases or areas of our own image that need more attention.

The colors that displease us can lead us to determine our own vulnerabilities. For example, if we do not like Pink, that might mean we hate being in situations where we feel in dependence on others; if brown displeases us, we may feel resentful of others.

If we want to create balance and harmony in our lives, we need to appreciate the importance of giving natural rhythm to our life. The realization that life is not constant and that our activity and energy levels should change through the seasons, help us to be gentle with ourselves and to develop a sensitivity to nature and, once again, to the nature cycles.

The colors we chose to use and there are around us, tell us if there is an imbalanced area that needs our attention and to be cured. The ideal for a balance in our biorhythm is to build our own biorhythm colors chart. If we find that certain colors are missing, it is possible we feel the lack of its energy in our own system.
COLOR NEUROSCIENCE

An understanding of the brain and nervous system functions is important in the overall understanding of color. It is intended to underline the involved key process within sight and brain. Neurology is the study of the nervous system, particularly with regard to humans. This field is meaningful for the study of color since it allows an understanding (as far as medical science allows) of the process involved between the arrival of the light wave and the physical reactions which result inside the human body.

The eye structure is a complex one. In the spirit of this document, the function of each element cannot be described in detail, but a brief reference will be made. The cornea (positioned in front of the eye) allows light to enter the structure. The size of the pupil is defined by the extension of the iris, which determines the amount of light entering the eye. The lens refracts the light, which passes through the vitreous humor before focusing on the retina.

The retina structure itself is very complex, and acts as the function of the first level of light interpretation. The most important receptors are the rods and cones, which respond to non-color and color respectively. The central fovea is the most sensitive part of the retina where the concentration of the cones is maximum. The optic disc (or white spot) is the area where the blood vessels enter the sight and nerves are in and out of the eye as the optic nerve. This region has no rods or cones and is often referred as the blind spot.

As the color of a particular wavelength reaches the retina, all photoreceptors able to respond do it. The combination of the receptors that respond allows the brain to interpret the exact color of light. For example, if light with a wavelength of 600 nm reaches the retina, 30% of the green photoreceptors respond in conjunction with 55% or 64% of the red receivers. From this information the brain will calculate the color in question is orange. The reason why there are two possible red responses is due to the fact that 60% of the population has the amino acid at position 180 of the opsin protein, whereas the rest have alanine in that position. Therefore, although all of them describe red and its variations the same way, it is likely that there might be a difference in color perception.

From the retina, visual information passes to the optic nerve, joining in the optic chiasma. Here, the images are organized in a way that the information that one or both eyes see in the left side of the sight is directed to the left half of the brain, and vice versa.

With the help of both eyes focusing on the same object, the human being can realize the depth and the distance, while each eye produces a slightly different image of the same object. The visual cortex of the brain completes the task of organizing visual information, which began in the retina. As previously mentioned, the processes in the brain are poorly understood, although the brief description above reflects current medical studies.

Studies in cats have been carried out (Graham 1997) in order to determine the role of the various areas of the brain (just a little research has been done in human beings). Five areas were identified within the cat brain which control the perception of: shape; motion; color; and shape and movement coordination; and movement and Color coordination. The perception of form is therefore very important for cats, with movement and color respectively in second and third places.

Once the visual information has reached the human brain it is interpreted through the various elements present in this structure. The cerebral cortex contains 90% of all nerve cells, and it receives and interprets the sensory impulses. The brain contains the voluntary and conscious process, with the right hand side controlling the imagination and the left hand side controlling the logic. The thalamus deciphers the sight, hearing, taste and tact; the hypothalamus regulates blood pressure and body temperature, translating the emotions in physical responses (of physiological type). The pituitary gland is the largest endocrine gland of the body, controlling all other glands; the cerebellum is responsible for muscle coordination; and the straight formation regulates emotion. All these glands are interconnected and all are related to the response to visual stimuli.
COLOR PHYSIOLOGY

The context used herein this document to "color physiology" is the following one: the effect and the extension the brain stimulation (involved the process described above) has on other human body systems.

According to Mahnke (1996), the environment may be responsible for the introduction of "nervousness, headaches, lack of concentration, inefficiency, poor provisions, visual disturbances, anxiety and stress". All of these are physiological responses caused by a large number of stimuli; the effect that color in particular has in the human being has been investigated for many years. Freling (1990) points out the largest comebacks in the light of a particular color: red color is devastating; blood pressure is inconsistent, evidencing a pulse increase, it induces dryness in the throat and headaches. The subjects tend to move away from the source. The yellow light leads the subject to the tendency to move away from the source, and a subjective sensation in hands. "Yellow causes tension but at the same time releases and activates motor activity"; violet-blue light (and blue) "...leads to calm and to concentration capacity"; the green light "...has a similar effect to the stimulus of light balancing heterogeneous trends" (Freiling, 1990).

The following investigation was conducted by Birren (1982). Although not specifically related to the behavior of humans, some of the findings are particularly relevant. Different colored lights affect the rate of increase of various plants, albeit stimulating hue varies with the species. The behavior of insects, fishes, reptiles and birds is affected by the variation of wavelengths, including the end of the spectrum, tending to ultraviolet light. The hue of light has a profound effect on birth ratio of various animals, e.g. mice living under a full light spectrum reproduce at sex ratio of 50:50; mice living under blue light produce 30% of males and 70% of females, while living under the pink color light produce 70% of males and 30% females. Surprisingly these ratios also reflected in blind mice under similar lighting.

Studies carried out by Krakov, Allen and Schwartz (1942) revealed that loud noises, strong smells and tastes assets increases human sensitivity to green and reduces sensitivity to red. Blue light decreases the activity and the crying of babies (which have no cultural experience of blue).

Goldstein (1939 & 1942) suggests that time is over stimulated to red light and sub-stimulated under green light, although not all investigations have confirmed this interpretation.

In studies specifically directed to the approach of the physiological effects at direct exposure of colored light, according Birren (1982), the researcher Metzger (unknown date) used light sources directed only to one eye. The effect was that the muscles, only in the same side of the body, responded to the stimulus. Metzger also found changes "...in the superficial and deep sensations, both demonstrating a deep dependence on the optical stimulus." The subjects were asked to stay standing with arms stretched horizontally forward, placing the light source directed only to one eye. When the colored light was used, the red led the arm of the illuminated side of the body moved out. The green light caused the arm movement inside.

Ellinger (1941 & 1957) developed similar experiments directing light to only one side of the face and neck of subjects. When the red light was used, the subjects with arms stretched likewise drove to the light source, verifying the removal with the use of blue light. According to Ellinger "This reaction also occurs when the eyes are closed."

Birren (1982) concluded: "It seems clear that humans, like all other living beings react to radiation ... We can therefore generalized that color affects muscle tension, cortical activation (brain waves), heart rate , breathing, and other functions of the autonomous nervous systems - and certainly this brings defined emotional and aesthetic reactions, tastes, pleasant and unpleasant associations. "Once again Birren (1982) quotes Brown (unknown date), who basically says: "The skin sees in Technicolor. It is "... also a good detector and seems to reflect the direction in which the brain neurons process color information. The experiments demonstrating body reactions to color argue that colors lead to emotional states, which are specific to different shades. "

There are two phenomena that are fully recognized in the neurological world, which are "the constancy of Color" and "the observation of the negative." The constancy of color is the name given to the eye tendency in viewing objects with the same form under different light conditions. For example, a white sheet of paper appears white under a red light or a bright blue one (although different if viewed simultaneously under the two sources separately).

The observation of the negative is the name given to the eye's ability to, after a prolonged exposure to a specific hue, create an image of its complementary color (or opposite). For example, if the eye constantly observes a blue object, and suddenly the eye sees a white area, a Pink-orange version of the blue object on white surface will appear, for a
while. Some surgeons have used this principle to prevent this green observation purposes after lengthy operations involving the sight of blood (red). All operating theaters are now painted green. Experiments involving hypnotized subjects have confirmed the existence of this phenomenon of observation of the negative. Walls (1942) asked hypnotized subjects to focus on not existing colors: "The subjects observed complementary colors, although their retinas had not been stimulated" (Birren 1978). Surprisingly these were people who, in the state of waking, unaware the existence of negative observation of nowhere, but it should be expected the existence of complementarity to a particular stimulus "(Walls 1942).

COLOR PERCEPTION

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

Colors have their own characteristics, or attributes, which allow an objective description, and contribute to a good perception and identification. The color characteristics usually considered, are: hue, luminosity (value), and saturation (chroma). To these three fundamental attributes we may aid temperature. Hue is a universal variable present in all colors (Munsell 1976), and is defined by its wavelength that places it on the visible spectre. On common language, it is confused with the color’s 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 is the lightness graduation of a hue: is the distinction between any color 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.

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

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

Color temperature may be considered in comparison with other colors or by its effects. However, it can be also considered a color characteristic having a correspondence to its wavelength. Color 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 colors. The temperature decreasing scale of the principal colors are: red, orange, yellow, blue, cyan, magenta, and white. Dark colors 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 colors, and need more concentration to perceive cold colors. Pigment mixage implies mixing their temperatures. Also, the relative color temperature makes that a color may seem more or less warm in comparison with other colors.

It is common to represent color through a tri-dimensional form, known as “color 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 color 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 color 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:
Luminosity (or value)

Hue ______________________

Saturation (or chroma)

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 color/space, which forms a unity, and is represented by the following expression:

Being: h = hue; v = value; c = chroma; C = color; S = space

\[ C/S = (h \cdot v/c) / S \]

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

Newton established the concept of color complementarity, but it was Ewald Hering’s opponent color theory that related this concept with the vision mechanism.

The perception of a color 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 color. Therefore, the complementary color is the same as light rays absorbed, and the addition of the two colors rebuilds the white light. Complementarity to white is black, and primary colors are complementary to secondary colors. However, the totality of complementary colors is not limited to these colors and every color from the visible spectrum has its complementary color, its pair to the white color reconstruction.

After image is a complementarity relationship provoked by eye tiredness and by visual memory. This phenomenon consists in, after observing one color insistently, seeing the complementary color over a white background. This reaction is more immediate when the observed color has great intensity, and it happens because the cones sensitive to this color 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 color. Every hue forms 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 color, it can also be diminished or neutralized, applying a white or black contour. Successive contrast is the reaction to after image provoked by colors, observed one after the other. When the eye is moving rapidly over a colored surface, it observes the color in which it focus and also, the after image from the previously observed color. This phenomenon happens because the eye, trying to activate all the sensibilities, tints the adjacent colors with the observed complementary hue.

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

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

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

The shadow color of the object depends on the incident light. Every colored light creates a shadow in its complementary color, which is not the effect of simultaneous contrast, but real color. White light, the day light, activates every eye sensibilities and its shadow is black. However, the colors of the shadows provoked by various colored lights correspond to additive color mixtures. On the other hand, on day light absence, the colored light resultant shadows are different. One colored light have a black shadow, because it is the absence of light. When the object is illuminated by two complementary colors, each color provokes a complementary shadow and where the shadows overlap the black color is seen, while the mixed light is the result of the two colors additive synthesis. With analogue lights, each light projects a shadow in the other incident color, the overlapped shadow still will be black,
and the mixed light will be the two color additive synthesis. The results of the three primary colors projection are three primary colors shadows, one overlapped black shadow, and a white light mixture, because the additive synthesis of the three light beams reconstitutes the sun light.

COMMUNICATIONAL STRUCTURAL RELATIONSHIPS WITH COLOR

From the world of perception one goes to the world of communication. In order to accomplish an informative act it is not enough to be in touch with the surrounding environment through sensorial reactions. At that point perception becomes the channel through which the signals are transmitted and transformed into signs which are more than simple responses to physical stimuli; they are the basis of meaning, having in one unit the signals' physical support and the references to the objects and images which are connected to them.

"Signal is the physical concreteness of a message" (Cherry 1957).

The significative contents result from an action between: a physical support, or information support; an idea or thought indicating a meaning and giving sense to something physical; and a behaviour between thought and physical support, creating a significative reality.

Summarising, this triad of communicative elements define what in science of communication is called a sign (Cherry 1957; Pignatari 1976). “A sign is a stimulus - i.e. a sensitive substance - whose mental image is, in our mind, associated to another stimulus, bringing the other about for a communication to take place.” (Giraud 1973).

Significant + Signification = Sign

Sign, is, therefore, comprised by a significant and by a meaning. The plan of significations constitutes the plan of expression, and the plan of meanings constitutes the one of content. The signification can be conceived as a process, as an act which joins together the significant and signification, the result of the act is, consequently, the sign.

This way, the signification is not a “thing”, but the psychic representation of the “thing” (Afonso 1983). Sign is used to transmit information, to tell someone something that another one knows and what one wants the others to know, too. It comprises the following communicational process: origin - sender - channel - message - receiver (Eco 1973).

Sign, is a result between a significant, a physical instrument which carries a meaning, and the meaning itself which gives it a communicative sense.

In color / space language, the physical structure composed by chromatic signals supports a significative charge in accordance to the color itself. The sign language derives from the relationship between structure and meaning (Pignatari 1976). Being a sign a basic element of the significant organisation, its interpretation is based in the unity definition, i.e., the sign is the unity of signification. The group of signs articulated among themselves creates the language, a sign means that the message be invoked.

According to Rudolf Arnheim (1971), things and events wouldn't be worth anything if there was no information: events simply can't occupy the mind only as sensorial reflexes "without the information of what is happening in space and time, the brain cannot act", they are the natural relationships between perception and thought.

One talks about information in a general sense. However, in a strict sense, according to the science of communication, "information theory represents a method of computing the units, the transmissible and transmitted signals", not interfering in the field of significance: "it doesn't represent a method of computing the significants units, semiotics being the study of meanings" (Eco 1967).

“That color can play an enhancing role in the communication of visual messages is readily apparent. It can serve to attract attention, as to increase the readership of an object” (Tannenbaum 1966).

As this study, in the search for equilibrium between the sensible knowledge and the scientific knowledge, the message structural level doesn't restrict itself to definitions of physical computations of the color / space unity, in order to have a perceptive psycho-physiological relationship. It is essential to establish a link between this level and the other one, in which the computation of unities is of a subjective nature; the judgement of expression and contents
goes beyond the simple quantification of information, which only has a meaning after a semantic-aesthetic qualification. Therefore, there must exist an equilibrium between the information transmitted by a group of computable signals and the meaning given by judgement of sensible values, so that the language of color / space unity can effectively constitute a communicative basis for the transmitter / receiver relationship.

As previously mentioned, in terms of color/space there is a visual communication because it relates to specific perceptive channels for the chromatic sensations of sight.

Conjugated with space, color, even if physically present in all kinds of perception inherent to the sensation of space, participates in them only in the theoretical sense of the meaning, because it isn’t susceptible to information content through other sensorial channels. Consequently, space, characteristically defined by color, belongs to the visual communicative structure. Therefore, all characteristics which are peculiar to it in the structural formation, have correspondence in the visual meaningful formation.

According to the analysis of Abraham Moles (1971) in his studies about art and computer, "a piece correspond to a great number of communication systems, which in principle can be separated objectively by an observer, and even subjectively by the receiver if he is paying attention". He quotes as an example: "In a real message between human beings, the receiver and the sender distinguish spontaneously a hierarchy of levels correspondent to repertoires of different signs. Therefore: spots of light, alphabet letters, words, expressions, constitute syntactical elements which correspond in the written language to overlaid levels. The signs of a certain level join themselves in a stereotyped way to become the supersigns, for example, the words which are elementary signs in a following superior level".

But in visual communicative reality we never see the form separated from the color nor the color separated from the form. Only in special conditions could one visualise a mental image (and not the real one), with both languages separated (Moles 1971).

However, in its concept there exists the distinction, and in practical terms one talks about form, triangular, square, circular, spherical, cubic form, etc., and one talks in color, blue, red, brown, grey, etc., a sign association happens naturally. The form has stronger links with reasoning, the reason to relate configured structures: there is a mental construction in geometrical language. Color has stronger links with emotion, the feeling to relate lights and shades: there is a mental harmony in chromatic language. Both of them complement each other by reason and emotion, because one constructs the other, one brings the other into harmony, in a sensible whole which can be translated as a unified language of form and color, thereby, a group of unities: color / space - signs.

Kandinsky (1926) gives each form a specific color, which would permit an interpretation of superposition of sign repertoires, like Abraham Moles (1971) proposes. One can find the following relations of form and color given by Wassily Kandinsky (1926): "Correlations Line - Plan - Color".

acute angle-------------triangle-------------yellow

right angle-------------square-------------red

obtuse angle-------------circle-------------blue

After analysing the correlations given by Kandinsky, Faber Birren (1961b) explains: "Red suggests a cubic form, because it is hot, dry and opaque, qualitatively. It is heavy, solid and substantial and offers a strong visual attraction. Because it is very well focused by the eye it suits structured plans and rigid angles. Yellow, implies a triangle form or a pyramid form with its vertices turned to the bottom. It is the color of bigger visibility in the spectre and, qualitatively, it is acute, angular and crisp. It is lighter than substance because it doesn't have much weight; it is more space than volume. Blue implies a form of a circle or of a sphere. It is cold, wet, transparent, atmospherical. It is the one with less focus in the sight and, normally, it produces a smudged image, particularly distant. Because it is extense it doesn't give harsh details". The same author illustrates the correlations with secondary colors, the ones obtained by the mixture of two primary colors (in filters and pigments); sequentially it sets up the correlations according to the same scheme of primary colors and with the following interpretation:

right angle-------------rectangle-------------orange

acute angle-------------hexagonal-------------green

obtuse angle-------------ellipse-------------violet and purple
For these correlations, Faber Birren (1969), makes intermediary interpretations, in accordance with component colors, i.e. between red and yellow for orange, between blue and yellow for green, and between blue and red for purple.

In conclusion, transcribing words from Goethe (1989), "since color occupies a very important place in the series of elementary phenomena designated to it in a more complete variety, filling in like the limited circle does, we shouldn't be surprised to verify that its effects are always determined and significative, and are promptly associated to the mind's emotions. We shouldn't be surprised in observing that when presented by itself, acting on the mind, the combinations which creates harmonies and disharmonies, impresses us even in its more elementary characters, without a relation with nature, form or the object whose appearance is deposited on its surfaces”.

**COLOR AND ERGONOMICS**

Color has always been a concern of every civilization, from the more remote and primitive till the more developed and actual ones. Therefore, the comprehension of the color phenomena has been a research objective for philosophers, theorists, artists and scientists.

Color can greatly influence your ergonomics and your fashion design project when it is applied appropriately. However, it can really mess things up when it is not used in support of our cultural and psychological understanding of color. But when you get it right it can be a game changer.

Michel Pastoureau (1997) defends that nowadays colors can only be understood when related with the colors from the past, with which they are in continuity or rupture. Far more than the color use, humans have tried to control and explain the color phenomenon, ever since prehistoric times.

“Although the idea of “color” may seem a simple concept, it conjures up very different ideas for each of us. To the physicist, color is determined by the wavelength of light. To the physiologist and psychologist, our perception of color involves neural responses in the eye and the brain, and is subject to the limitations of our nervous system.” (Lamb & Bourriau 1999:1)

“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 1996:3)

Frieling points out the major responses to light of a certain color: red color is devastating; blood pressure is inconsistent, there is a higher heartbeat, induces dryness in the throat and headaches. The subjects have a tendency to move away from the source. Yellow light leads the subject to the tendency to move away from the source, and a subjective sensation in hands. "Yellow causes tension at the same time releases and activates the motor activity". The violet-blue (and blue) light "... leads to calmness and to the ability to concentrate". The green light "... has a similar effect to the stimulus of the light scale heterogeneous tendencies." (Frieling, 1990)

Cheskin (1947), from the Color Research Institute of America, when conducted tests involving four different interior spaces, each of which of a single color (red, yellow, blue and green), including table chair and typing machine equally colorful, for subjects using the machine. The results were as follows:

- **Red Room**: increased blood pressure and pulse, overstimulation, difficulty of working.
- **Blue Room**: blood pressure and pulse rate decreased, the activity decreased.
- **Yellow room**: without any effect on blood pressure or pulse rate.
- **Green Room**: was produced monotony. No other effect registered.

Other research carried out by Mahnke (1996) concludes that the ultraviolet light may have a wide range of physiological effects such as “a decrease in pulse rate, a dropped in blood pressure, skin temperature changes in metabolism and a reduction in reaction time, an improvement in health and resistance to certain types of infections.”

The principles of physiology and psychology are fully interconnected. Both are controlled by neurological
processes, although the exact nature of the process that controls the psychological reaction is effectively unknown. Graham (1997) presented a thread that outlines the path between a biological cell and psychology, in order to overcome the existing hole in medical theory.

COLOR PSYCHOLOGICAL ASSOCIATIONS

“Research on the psychological aspects of color is difficult for the mere reason that human emotions are none too stable and the psychic make up of human beings varies from person to person.” (Wright 1998:28)

Even without detailed knowledge about the psychological effects of color, it is well known that it can affect our moods, our disposition. There are some colors that are exciting and inspiring, just as there are others that are depressed. How often we use expressions like "I feel blue", "green with envy", "red with anger", without thinking about the meaning that lies behind each of these words. Our feelings and emotions are directly affected by the hormonal balance or imbalance in our body. Once this is affected by the colors, they have, of course, an indelible influence in our feelings and dispositions.

The psychological effects of color have been extensively investigated through the use of colorful cards, instead of using painted compartments. As Sivik (1997) concluded, "... there is considerable disparity between the conclusions drawn by cards or buildings”. Hesselgren (1987) states: "Most of the tests on the preference of colors now indicate the effect of the color contrast between color under investigation and its background (usually white)."

It is believed that most of color effect is based on associations of education from childhood, such as the sky and sea are blue, the grass is green, etc. The principles are applied in architecture due to taste associations, which can be translated into benefits to the overall effect of the building. The second way of experiment involves the projection of light of a particular color directly onto the retina of a subject so as to compare the physiological reactions. (Ellinger, 1941 and 1957)

Some colors can calm us, while others can stimulate our mental activity. Through the process of restoring balance of Color energy directed to the pituitary, it is possible to restore the metabolic and emotional balance. This can relieve stress, tension, anxiety or depression. Certain colors can help us to deal with our feelings of loneliness, frustration or pain. The use of color to modify the emotional energy also results in the change of perception of the world and our way of living. Once color is directly linked to the subconscious, we can use it to diagnose and treat a problem at a deep level.

So far we have developed some studies based on relevant literature data and experiments with users, crossed with scientific research conducted in several countries, which have already conducted to some psychological associations to some of the most used colors.

We also added a survey by inquiry, questionnaire based, and involving 623 people from Portugal and UK, both gender, with ages between 23 and 72. Here we present some of the results, as example:

RED – vital, powerful, ambitious, hot, intimate, sensual, determined, friendly, brave, antidepressant, furious, impatient, angry;

ORANGE – hot, insurance, creative, stimulant, entertaining, cheerful, with humor, independent, antidepressant;

YELLOW – cheerful, light, bright, mentally stimulating, logical, smart, orderly, optimistic, clear thinking, fearless;

GREEN - harmonious, mental and physical relaxing, peaceful, natural, refreshing, calm, sincere, insurance, free, generous, restrained, personal domain;

TURQUOISE - refreshing, cool, calm mentally, youth, power concentration, control, communication power, confidence;

BLUE – cold, clear, relaxing, mentally calm, brings peace, tranquility, wisdom, spacious like the sea or the sky, sensitive, hopeful, faithful, believer, flexible, quiet;
INDIGO / VIOLET / PURPLE - dramatic, spiritual, creative, intuitive, media, mystical, inspiring beauty and art, protective, clean;

MAGENTA - support, natural, kind, considerate, condescending, compassionate;

WHITE – peaceful, cathartic, cold, isolated;

BLACK – comforting, mysterious, female, protective, restrictive;

GREY - independent, secure, tab, lonely, self-critical;

SILVER - changeable, harmonious, feminine, sensitive;

GOLD - desire, understandable, powerful, high ideals, abundance;

BROWN - support, mentally mean, land, seclusion.

OUR PERSONAL COLORS

A group of scientists from USA have recently discovered that there is a connection between children’s color of the eyes and their personalities: children with dark eyes are more gregarious and extroverted than the clear-eyed.

We all tend to have one or several colors that best express the kind of our personality and make us feel comfortable and give extra vitality and inspiration. A person’s color is the one that captures the essence of that person entire personality. It will not necessarily give her any extra energy but, if the person is already feeling good, it will create the maximum impact, projecting the full force of her personality (Wright, 1998).

Many people are led to change their own colors for hair coloring or the use of colored lenses. They are subconsciously driven to the personality usually associated with certain colors, they think they are missing. Looking at the colors that people use most often, we get to know a bit more about them. There are several types of psychological tests that lead to a higher analytical knowledge of our personal colors. One of the most widely known and applied is Max Luscher Color Test which was developed in order to be used by psychiatrists, psychologists and physicians in order to provide them with relevant information about a particular person by knowing his or her colors choice.

The Luscher Color Test was devised by psychologist Max Luscher in 1969. Its effectiveness has been known in advertising and industry (automotive and fashion) for years. It’s uncanny what this test can reveal consistently. What’s far more revealing is our unique living relationship with color, which is revealed over time and in a variety of contexts under many influences. http://www.johnpaulcaponigro.com/blog/136/the-luscher-color-test-online/, accessed in 12.10.2012

This personal knowledge about colors meaning and what they reveal about our personality, can lead to a better use of Color in Fashion. (Rossignol, 2001)

We can synthesize the essential data collected and interpreted, by stating that if we prefer to wear red, we are impulsive, excitable and energetic; there is a demonstration of ambition and a taste for seeing things happen quickly; we like to be the best in everything we do; we can be a little insensitive to others’ feelings, since we like to be the center of attention; red means vital force, with our nervous activity pushing us to achieve results and succeed; the habit of wearing red may indicate that we attach great importance to sexual desire and eroticism - this energy may be best used in the form of creative force, leadership, as well as development and expansion; or that we are bold and outgoing, but we tend to get angry and bad-tempered if we cannot make our way.

The preference to use orange means that we are competent, action-oriented, impatient. We are also independent, organized and self-motivated. Orange is the color of creativity and be practical. Means that our energy levels are high and are sometimes restless; we have a strong will, and we tend to be active and competitive. We are also excitable and can seek to dominate others. The bright orange and burnt orange can make us feel frustrated or blocked. We should try to use the orange peach directing our energy to others in a careful manner.
If our preference is yellow, we have an interesting and stimulating personality; we like to be active and involved in what is happening - alive and vital, can cope well with life's challenges; it represents spontaneity and communication; we are active, ambitious, willing and researchers; there is a desire and hope of greater happiness, which implies a conflict in which it is necessary to free ourselves; it pushes us in search of the new, the modern, the development and the informal.

The use of green is an indicator that we are cautious people and we are led to not easily trust others, in addition to being observers of life, but do not want to involve ourselves more than necessary. It gets us quite a calm life. We are benevolent, humanistic and self-oriented. If we use the blue-green is because we need a peaceful environment, wishing to free ourselves from stress, and move away from the conflicts and disagreements. We have difficulty controlling the situation and the problems resulting therefrom, proceeding cautiously. We have feeling of speed and keen eye for detail. We use pale yellow with green, in order to help us to share them and to develop an optimistic attitude.

The use of light blue indicates that we are creative, perceptive and sensitive, we have a good imagination and a practical way of approaching life. Our approach can be analytical and are advised to use our knowledge to solve problems. We like to do things at our own pace and not be rushed. It is a sign that we need a safe and peaceful environment.

We can also apply this to other color as dark blue: we are intelligent, self-confident and have a great feeling depth; we feel a responsibility for others and like to make decisions; we need tranquility around us and we must be surrounded by attention, tenderness, affection and love; the noisy people disturb us; we may suffer from mental stress, leading us to the lack of action and relaxation.

The violet means that we have a sensitive, compassionate and can easily impose on us. We must have attention with regard to choice of friends as sensitive as us. To be happy, we must work where we are needed. We should try to use purple or magenta, which is a color with more red. This leads to increase our self-confidence and leads to the development of our vulnerability protection.

If our preference is the color purple, this is an indicator that we are very intuitive and we have deep feelings and great aspirations. We are always interested in the best, including friends. Less people do not enter our schemes, except only when they are needed. We should try not to be arrogant, giving more time and attention to listen to others. The purple can make us feel tax systems, rules and regulations accredited by others. We have to be sensitive to our own bodily and spiritual needs.

The use of gray indicates that we are very individualistic. Many people may get the impression that we are self-sufficient, since present a great self-control and prefer to remain without getting involved. We tend to isolate ourselves, which can lead to loneliness. We can be passive when we feel stressed and overwhelmed. We need rest, relaxation and freedom from everyday stress. Perhaps we need a break by introducing the ocean blue or green country. People who use the gray are usually those who think and can be good critics. Those who lack judgment and struggle to form opinions should use gray.

The brown clothes suggest that we are honest people, grounded, like that of a structured and sustainable lifestyle. We are lovers of the best things life can offer, lovers of good food, drink and company, and sexy. Do not forget that brown is the color of Mother Earth. This is a protective color; can accumulate emotion or a secret that leads us to put ourselves in our "shell" and be afraid of the outside world, although we feel protected by the use of brown or brownish colors. There is a desire to be emotionally safe and accepted by the outside world. We need to understand our own value and to leave out the "smallness" of mind.

If our preference is white, as this color contains all other colors on the spectrum, it shows that we have a positive, well balanced and optimistic personality; we possess high values and we must be open-minded and communicative. On the contrary, if we prefer to use black, it shows that we have a strong will power, we are disciplined and always opinionated; it also demonstrates that we have an organized and independent character, being sometimes too stubborn and independent; we have a lack of confidence in ourselves and have an innate ability to lead life with efficiency; this color represents renunciation and those who choose to wear it constantly want to renounce everything as a stubborn protest; however, the black used on occasions demonstrates that we have control on ourselves in order to communicate an authoritarian image. (Chiazzari, 1998)
FASHION AND DRESSING FOR HEALTH

The colors we use can provide protection against many physical ailments as well as can give us emotional inspiration. Obviously the clothes also protect us from the elements and is a form of personal expression, protects us from the world around us and affects the way we feel and think. The tissues act as color filters, enabling certain chromatic waves to pass through our skin. This means, for example, in the case of a green tissue, the natural light which passes through the fabric absorbs green vibration and green passes into our system.

White clothes allow all wavelengths of light to pass and thereby to "feed" us with equal amounts of different colored energies. On the contrary, black color away all the light from us and this is the reason why black clothes often form a layer of protection around us. The use of black often draws energy and can have a negative effect on our health detriment, since the body needs light energy in order to function normally as a living organism.

For many reasons there is a strong relationship between our clothes colors and the effect that their energies have on us. The colors we use can give us protection against many physical problems and also provide emotional support and inspiration.

We must choose colors depending on the harmonization with our Color-Season type and related with

- our energy levels of the moment
- our physical health status
- our state of mind

The State of the Art correlating color and clothes, or fashion, is still not very significant. So, several studies using quasi-experiment methodology were implemented. We worked with 12 different sample groups, each of them composed by 10 women with ages between 21 and 58. During 2 and half years we developed experiments in UK and Portugal, which results crossed with the literature evidences led us to important conclusions, but still not totally conclusive.

These are the achieved main results:

RED

TO WEAR: When we need to raise the morale, or we feel tired and lethargic or we need to encourage physical exercise and a competitive spirit. Red helps positive progress and success, and to put our plans into action. We use red when we want to feel sexy and alive.

TO AVOID: When we get tired easily, or when we suffer from constipation, myalgia, mononucleoses, or chronic fatigue syndrome. Do not use it if we have a colored physique, high blood pressure, or if the anger easily. Also avoid if we are nervous or tense.

PINK

TO WEAR: If we are a caring person, lovers and we need to be compassionate and friendly. Rose encourages the self-esteem. Some shades of pink to help loving exchanges. Salmon and deep pink surround us with love. The shocking pink stimulates our most sensual pleasures.

TO AVOID: If we are emotionally immature, if we need the figure of a father or a mother, or if we are too dependent on others. We may feel that we are too sensitive to external dependencies.

ORANGE

TO WEAR: If we are to suffer from depression, or we need to bring joy and light to our lives. The orange relieves the serious air of thought and promotes smile. Encourages independence of mind and self-motivation as well as helps to release creativity and negative emotions related to a poor self-image. Orange is good for increasing adrenaline, and pains suffer, especially in the neck, arms and links.
TO AVOID: If we feel confused, frustrated or claustrophobic. Orange is not advisable if we feel sick or nauseous, it will make us feel worse.

YELLOW

TO WEAR: When we want to be alone, so that we become detached or impartial. Yellow promotes rational thinking and reasoning, and can improve memory. It aids communication, sharing and self-expression. Yellow is a good color for accessories. The golden yellow promotes shine and vitality, as well as the ability to meet new challenges. Yellow is adding value and confidence builder.

TO AVOID: If we are predisposed to criticism and suffer a loss of anchorage and stability. Yellow can encourage selfishness and is not advised if we give too much importance to material wealth. Yellow can cause irritability and a feeling of nausea. In this case we introduce the gold instead of yellow, which will encourage us to find our inner desires.

GREEN

TO WEAR: If we are hyperactive but we have difficulty making decisions or have a clear judgment. Apple Green promotes health, happiness and innovation. The green grass produces in us the effect to understand and help others, as well as encourage the abundance in our lives. The blue-green promotes optimism and faith in ourselves and in others.

TO AVOID: If we need action, since although green to equilibrium, also for the movement. Green gives space and time when we do not make decisions, but can promote the hassle, repression and inactivity.

BLUE

TO WEAR: If we need peace and relaxation, and if we want to have an empty mind, when we suffer from mental fatigue. The blue helps to restore self-confidence, independence and responsibility for others. Blue brings insight and wisdom, encourages decision making, and helps us to connect to our intuitive sense. Also aids communication and strengthens our powers of speech.

TO AVOID: If we feel depressed, since the blue can make us feel worse. If we need to recharge, power or if we are nervous, since the blue does not give us this help. If we are totally relying in our mental faculties to achieve solutions, perhaps we need to stay more in touch with our emotions. In this case we must introduce some oranges in our wardrobe.

PURPLE/VIOLET

TO WEAR: If we want peace and love without anxiety, and authority without requirement. Violet fabrics make peace and calm necessary to meditation and prayer, making us aware of our sensibilities. The use of purple helps us to open the mind to higher forces, by building a channel for creative energy.

TO AVOID: If we do not like silence or possess feelings of invasion of our own privacy. We should not use it if we are to feel us oversensitive and we need to be socially acceptable, or if we feel taxes above the rules and regulations. We should try to use magenta, since the red rays help build our self-esteem and promote action.

LILAC / MAUVE / LAVENDER

TO WEAR: If we want to promote sensitivity, a more peaceful nature and sweet. Mauve induces a feeling reserve, although it is good for others. It promotes the listening of our more intuitive side, so that we can use these insights to help others. We must use the mauve whenever we need time for relaxation and meditation.

TO AVOID: If we suffer from a lack of freedom, or are surrounded by people who are not sensitive to our feelings. If we need sensitive support of others, we must use the pink more.

WHITE

TO WEAR: If we need a greater inner knowledge. The use of white makes us more open mind, clear and receptive
to new ideas and plans without action. White gives us time to stop and think, to reflect without having to make a decision.

TO AVOID: If we're feeling lonely, isolated, or if we need to participate, act or make decisions. When we are ready, we can use the yellow to promote communication and division. Pink can bring sensitivity to our lives. Blue can bring understanding and orange can promote action.

BLACK

TO WEAR: If we are self-sufficient in authority and control, and we are in a position to protect. If we need to seek the advice or ideas of others, black protects us. We have to be in total control of ourselves, so that we can communicate an image of authority. We should always use the black with touches of another color strong, in order to counterbalance any negative effects.

TO AVOID: If we are depressed or desperate due to lack of self-recognition, self-denial. Black rejects the help of others and promotes isolation.

CONCLUSIONS

ColorErg has already achieved important results, which go far from the literature review on the research subject because of the project’s empirical phase. We are implementing a mixed research methodology based on user-centered design and participatory design, using survey methods, as well as direct observation, active research, supported by mechanical means, and quasi-experiments with sample groups of women.

Through recent researches, we know which areas of the brain are activated, as well as we can measure the behavior of humans in what concerns color issues. So, an experiment with users is under development in order to check brain reactions to the different color dimensions, comparing the results with those obtained by the other previously used methods.

The main objectives focus on the acquisition of scientific knowledge in the area that can serve as a projective tool for fashion designers, as well as to contribute, through the dissemination of its results, as a reference to the use of color to users in general.

As expected results, we intend to achieve:

- Systematization of scientific knowledge reusable by all within the interaction Color / User, through clothing;
- Guidelines for the use and application of color in clothing design projects, in Fashion Design.

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