Colour Science as one of the designer’s tools

T Vargot
Design and Visual Arts Department, South Ural State University, 76, Lenin prospekt, Chelyabinsk 454080, Russia
E-mail: vargotta@susu.ru

Abstract. In the modern age of globalization and high-tech, when information can be obtained in unlimited quantities, there is an acute problem of selecting really important aspects of harmony. In Russian design, unfortunately, little attention is paid to the consideration of things as an image, its functions and attitudes towards culture. It is obvious that harmonious colour perception is developed in the process of studying the colour science, its bases and laws such as the laws of subjective color perception, optical mixing, mutual influence of colors and types of contracts, as well as the ability to assess the size and consistency of the object’s color relations, the integrity of perception, the vividness and expressiveness of colour, which from the internal basis of the visual image.

1. Introduction
In order to understand how colour works, we need to understand the physics of its origin. Colour is the phenomenon of light, caused by the ability of our eyes to determine the different amounts of reflected and projected light. Being an optical device, the eye, is a sense organ, designed to perceive and transmit light signals. Colour perception takes place on the visual part of the eye retina, it converts light quanta into nerve impulses. There are two types of receptors in the human eye: rods and cones. The rods react to shades of gray, and with the help of cones the brain is able to perceive a spectrum of colours. There are three types of cones: the first type reacts to the red-orange colour, the second - to the green, and the third - to the blue and purple. When one kind of cone is stimulated, the brain sees one corresponding colour [1,2,3].

2. Methods creating a colour image
The material for creating a colour image is contained in the light information. According to modern views, any perceived colour is a product of the brain. Visual perception is a complex phenomenon. It includes such processes as the selection of a figure, the estimation of size, brightness, distance of a perceived object, emphasizing of details, etc. These perceptual mechanisms must be taken into account when creating any design product and making it colourful. As a function of consciousness, perception is expressed through the sense organs acting according to objective laws. Therefore, the criteria for its evaluation are based on parameters characterizing the two sides of this process: the objective characteristics of perception and subjective aspects associated with the level of development of the individual, his personal perception, emotions, feelings, knowledge, life, culture and upbringing. [4,5].

1. Objective criteria for perception include the formation of colour and the structure of the human eye. The person from the physical point of view and from the point of view of the formation of colour, line, shape and their inherent characteristics perceives colours, forms, lines in exactly the same way. Subjective criteria follow different laws [6-8].
2. They can not influence the objective, natural person's ability to distinguish and perceive colours, volumes, lines. An important step to the formation of the ability of harmonious colour perception is to master the knowledge of colour harmony, to systemize colour sets, to be able competently mix, compile and combine colours and their shades, according to the given objectives.

3. Therefore, to develop the ability of harmonious perception, one must master the knowledge of colour harmony. This knowledge is well described in the theoretical studies and practical materials (exercises) of I. Itten. The basis of it is a twelve-colour wheel. Then there is the coloristic formula, which is built on simple geometric forms (triangle, square) by rotating the vertices inside the circle, which gives a harmonious consonance (Figure 1).

![12-colour spectrum](image)

Figure 1. 12-colour spectrum.

The definition of harmony lays the foundation for a harmonious color composition. For the latter, the quantitative ratio of colors is very important. Based on the brightness of the primary colors, Goethe derived the following formula for their quantitative ratio: yellow: red: blue = 3:6:8. We can make a general conclusion that all pairs of complementary colors, all combinations of three colors in a twelve-part color wheel, which are connected to each other through equilateral or isosceles triangles, squares and rectangles, are harmonious. Color combinations can be extremely minimal and consist of two or three colors: light blue, medium gray, white and black, or dark brown, light brown, red and black, or yellow green, yellow and black and brown. They could also have a very extensive color gamut, including yellow, red, blue in their various variations and degree of saturation, or two or more pure colors in their various tonal manifestations.

Between people with limited or, conversely, with the greatest possibilities of color perception, all intermediate color gradations that you can imagine are enclosed. There are subjective combinations in which one color - red, yellow, blue or purple - dominates quantitatively, as a result why we are tempted to say that this or that artist sees the world in red, yellow or blue. In this case, it seems that this or that artist sees everything through colored glasses, and it is very possible that his thoughts and feelings are also colored accordingly. An extremely important foundation for any aesthetic color theory is the color wheel, as it provides a color arrangement system. Since the colorist artist works with color pigments, the color order of the circle must be built according to the laws of pigment color mixtures. So, in my color wheel, blue is against orange, and a mixture of these colors gives us a gray color [9-11].

The starting point of the theory of color impressions is the study of color manifestations in nature. This means that we should study the impressions that colored objects make on our eyesight.
3. Undamentals of theory and practice.
If we choose three colors from a twelve-part circle, the arrangement of which relative to each other forms an equilateral triangle, then these colors create a harmonious triad. Yellow, red and blue are the most definite and strongest harmonious harmony that can be considered the main one. The complementary colors of this trinity - violet, green and orange also have a harmonious triad[12-20].

This system is universal and convenient in those cases when there is a doubt in the choice of colour. For example: in a twelve-colour wheel, two diametrically opposite colours are additional and form a harmonious combination. If you select three colours from a twelve-colour circle, the arrangement of which forms an equilateral triangle relative to each other, then these colours create a harmonious triad (Figure 2).

4. Relevance
This way with the help of educational tasks, we gain the goals of teaching the coloristics theoretical and practical basics to future designers. It is also important to know the laws of subjective colour perception, optical mixing, mutual influence of colours and types of contrasts. Another important thing is the ability to assess the size and consistency of the object's colour relations, the integrity of perception, the vividness and expressiveness of colour, which form the internal basis of the visual image.

It is necessary to understand that the notion of harmonious perception is connected with real pictorial practice. Through painting, the student understands a multi-stage process, including the
artistic vision, the interaction of colours, the display of colour and tonal relations, which forms the
construction of colour and form. In order to understand the mechanisms of harmonious perception it is
important to understand the "colour setting", which is defined as a system of expectations, formed in
advance of the perception of aesthetic reality. The setting is made by the emotional qualities of the
individual, by their temperament. Harmonious perception should not be seen as a means of solving a
problem, but as a value on its own. For example, in the perception of any work of art a lot of subtle
factors are involved, such as upbringing, literacy in art, mood, etc. This way every opinion about
colour harmony is partially subjective. Therefore, subjective criteria behave according to other laws.

5. Universal color system

They can not influence the objective laws that have emerged as a result of centuries of research and
experimentation. That is why it is important to rely on the scientific facts of harmonization in colour
science when solving such tasks. The perception of colour value lies deep in the subconscious. There
is no tangible object from the physical point of view, which is called “colour”; there are waves of
different lengths. The human eye perceives this difference of lengths and makes a world of colour.
However, each person feels colour, they have biological, psychological, social, and cultural
dimensions, which all together convey meaning and determine the perception of information.
Undoubtedly, everyone has their own concept of colour harmony, but a professional must rely on the
basic compositional principles when working in the field of design, such as:

- proportions
- harmony
- rhythm

Following the above-mentioned laws when creating any work of art, be it design or painting, will
help during the working process and its implementation[1].

The clearer the meaning becomes, the more feelings become aggravated, and artistic perception
gets used to the logical analysis of observations. Students must wage a "struggle" with nature, for its
possibilities of exposure are different and exceed the visual means that we have in art. Cezanne
worked with great interest on the motives of nature. Van Gogh was destroyed by this struggle, trying
in tireless work to convey his impressions of nature, transforming them into his own system of color
and formal pictorially.

To arrange in color means to place two or more colors side by side in such a way that their
combination is extremely expressive. For the general solution of the color composition, the choice of
colors, their relation to each other, their place and direction within the given composition,
configuration of forms, simultaneous connections, sizes of color areas and contrast ratios as a whole
are important. The theme of color composition is so diverse that it is possible to reflect only some of
its main provisions.

The section on color harmonies has already talked about the possibilities of creating a harmonious
composition. When considering the expressive properties of color, we established the necessary
specific conditions and relationships that could reveal the expressiveness characteristic of each color.
The nature and effect of color is determined by its location in relation to its accompanying colors.
Color is never alone, it is always perceived surrounded by other colors.

The farther along the color wheel one color is removed from another, the stronger they contrast
with each other. However, the value and significance of each color in a picture is determined not only
by the colors surrounding it. The quality and size of the color planes are also extremely important for
the impression produced by a particular color [12,13].

However, when implementing a plan, the flow of intuitive sensations should not be constrained by
strict rules, since the plans are always not so unambiguous.

The spatial effect of color may depend on various components. In the color itself there are forces
capable of revealing depth. This is due to the contrast of light and dark, as well as the ability to change
the color saturation and its distribution[14,15].
6. Conclusion
The strength of the contrast depends on the distance between the reacting and inducing fields. The contrast weakens as the contrasting fields move away from each other. In addition, if we perceive two spots located nearby, not related to each other as a certain figure and background, then the contrast that they cause is formed on the principle of equal interaction. The contrast effect is affected by the magnitude of the induction field; the contrast depends not only on the size, but also on the shape of the reacting field. [16,17]. The phenomenon of warmth is a region of contrasts in visual perception. The property of our perception lies in the fact that upon seeing a warm color, the eye searches nearby for a cold, i.e. equilibrium. Having not found balance, a person feels disharmony in a coloristic system. This is the law of physics[18-21]. When a warm color is perceived next to it, an impression of a cold appears on the retina of the eye, although this is not in nature. The relativity of the contrast of warmth is confirmed by a number of factors. Thus, warm colors enhance the perception of cold and vice versa. Coldness is an integral part of harmony.

References
[1] Itten J 2007 The Art of Color (Moscow: D. Aronov) p 23
[2] Omeliyanenko E V 2017 Science of colour and coloristics (Moscow) p 57
[3] Ormiston R 2007 Color. Big book. Technical characteristics of 92 colors (Moscow: Art-Rodnik) p 269
[4] Lluch J 2019 Color for Architects (New York: Princeton Architectural Press) pp 116–126
[5] Finlay V 2003 Color: A Natural History of the Palette (New York: Random House Inc.) pp 245–236
[6] Finlay V 2004 The Brilliant History of Color in Art (New York: Random House Inc.) pp 50–51
[7] St. Clair K 2017 The Secret Lives of Colour (London: Coronet) pp 78–90
[8] Adams S 2017 The Designer's Dictionary of Color (New York: Harry N Abrams Inc) pp 100–114
[9] Eiseman L 2011 Pantone: The 20th Century in Color (San Francisco: Chronicle Books Llc) pp 74–80
[10] Albers J 2013 Interaction of Color: 50th Anniversary Edition (London: Yale University Press) pp 14–21
[11] Hornung D 2012 Color, 2nd edition: A workshop for artists and designers (London: Laurence King Publishing) pp 97–103
[12] Quiller S 2002 Color Choices: Making Color Sense Out of Color Theory (New York: Watson-Guptill) pp 36–39
[13] Eckstut J and Eckstut A 2013 Secret Language of Color: Science, Nature, History, Culture, Beauty of Red, Orange, Yellow, Green, Blue, & Violet (New York: Black Dog & Leventhal) pp 78–81
[14] Edwards B 2004 Color by Betty Edwards: A Course in Mastering the Art of Mixing Colors (New York: TarcherPerigee) pp 179–183
[15] Kastan D and Farthing S 2018 On Color (London: Yale University Press) pp 149–155
[16] Eiseman L 2017 The Complete Color Harmony, Pantone Edition: Expert Color Information for Professional Results (London: Rockport Publishers) pp 80–83
[17] Feisner E 2013 Color Studies (New York: Fairchild Books) pp 136–142
[18] Sherin A 2012 Design Elements, Color Fundamentals: A Graphic Style Manual for Understanding How Color Affects Design (Beverly, MA: Rockport Publishers) pp 46–48
[19] Kuno N 2018 Practical Color Combinations: A Resource Book with Over 2500 Sample Color Schemes (Tokyo: Nippan IPS) pp 163–168
[20] Malloy V 2015 Intersecting Colors: Josef Albers and His Contemporaries (Amherst: Amherst College Press) p 43
[21] Dobie J 2011 Making Color Sing, 25th Anniversary Edition: Practical Lessons in Color and Design (New York: Watson-Guptill) pp 77–79