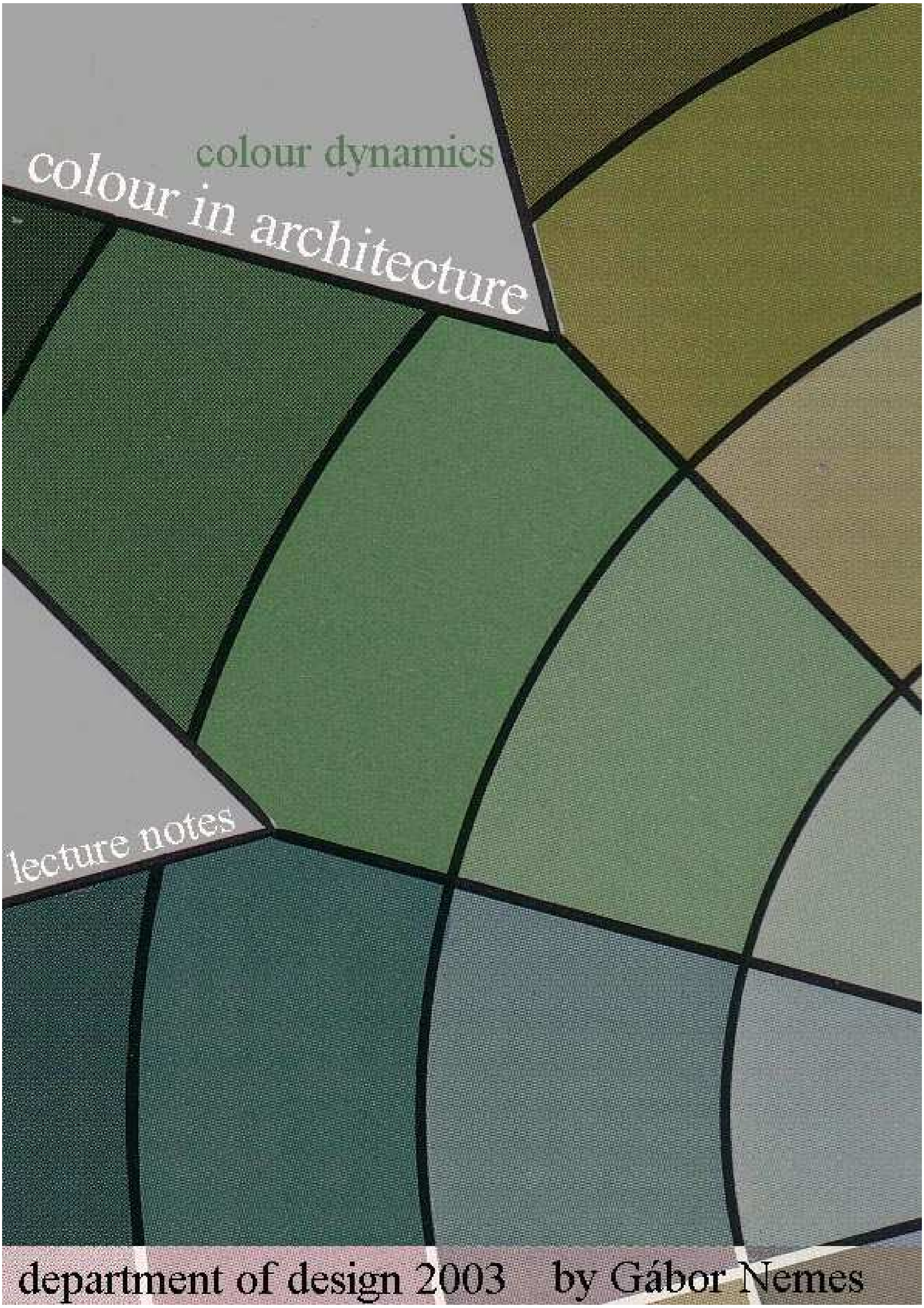

colour dynamics
colour in architecture
lecture notes
department of design 2003 by Gábor Nemes

Contents

Colours in architecture – colour dynamics

Introduction

Colours and architecture are inseparable in the same way as colours and shapes are conditional upon one another.
The frontal appearance of buildings and the functional arrangement of the internal spaces is impossible without choosing the right colours or group of colours. When we talk about colours we do not only mean painted surfaces or "coloured" architectural elements, but we should also take into consideration the colours of structural materials having their own natural appearance (such as bricks, stone, slate, different types of wood). Just think about light, yellowish maple-wood or reddish cherry-wood or brownish nut-wood… and we could continue giving a long list of the colours of natural types of wood, which can determine the colour appearance of buildings. Architects, if their aim is to create a harmonic and aesthetic looking building in every respect, must be aware of all the laws that help us find our way in the world of colours to be able to choose the most appropriate use of colours that suits their plan the most and is the most favourable both functionally and aesthetically.

I. Basic concepts in colour science

Before describing in detail the laws of the world of colours, it is important to become familiar with the different technical terms, basic concepts and the basic characteristics of colours.

Colour – colour stimulus – perceived colour
Colour is basically a physical notion, radiating energy.
On passing through a prism white light splits up into the following colours:

- ~ 390 - 450 nm wavelength: violet
- ~ 460 - 480 nm wavelength: blue
- ~ 490 - 530 nm wavelength: green
- ~ 540 - 580 nm wavelength: yellow
- ~ 590 - 640 nm wavelength: orange
- ~ 650 - 800 nm wavelength: red

The radiation entering the eyes is called **colour stimulus.**
The human brain transform colour stimulus into **perceived colour.**
In everyday life and in the course of learning the present subject first of all we deal with **perceived colour,** and we shall always mean this when using the simplified expression "colour".

Colour mixing
By mixing any two or more colours new colours can be made.

Colour mixing has two basic methods:

additive colour mixing
A method of mixing colours of light, in the course of which coloured light is added to coloured light and a brighter light is created, the coloured lights are blended.

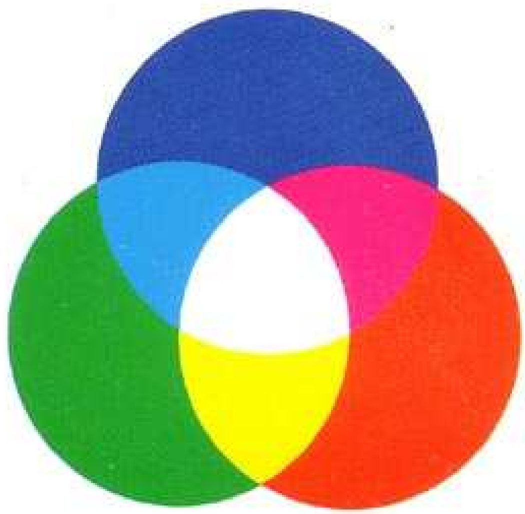
subtractive colour mixing
In the course of this method the colour mixed to another colour subtracts certain light from the colour it is added to.
In everyday life subtractive colour mixing is realised when paint pigments are mixed, so in the following first of all I shall mean subtractive colour mixing when I talk about colour mixing.

Determining colours
In order to determine any colour appearing in our environment we need three pieces of data, which are the three characteristics of the given colour:

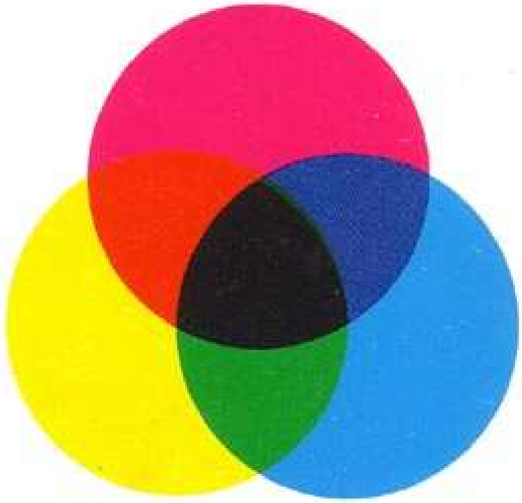
- hue
- brightness
- saturation

Hue
It can be said to be the most important, most decisive characteristic of colour, this is what is meant by "colour" in everyday language, so this is what determines whether a colour is yellow, blue, red, etc. A spectral colour is a colour induced by spectral colour stimulus.

Neutral colours are colours without hue, so they are white, black or grey.



Additive mixing of colours



Subtractive mixing of colours

And there are colours with hue.
On the basis of their hue colours can be grouped around **six basic colours**.
The six primary colours consist of **primary** and **secondary** colours.

Primary colours:
- **yellow**
- **blue**
- **red**

Secondary colours:
- **green** created from the mixture of yellow and blue
- **violet** created from the mixture of blue and red
- **orange** created from the mixture of red and yellow

The changing of hue is a continuous curve starting over and over again, the so-called colour circle. The different colour systems (to be discussed later) created different colour circles, which, however, have the same basic characteristics. (E.g.: Goethe, Chevreul, Coloroid colour circles.)

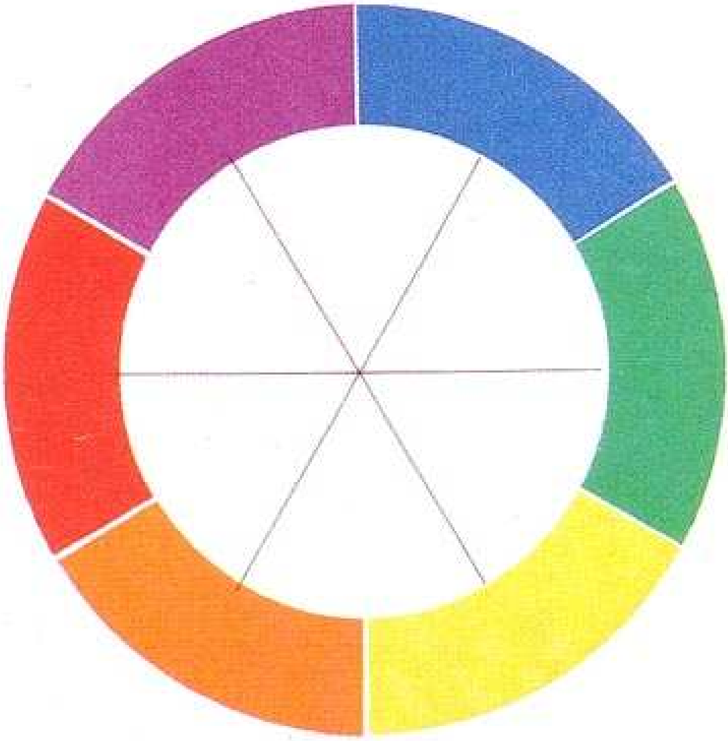
On the basis of their hue we can talk about warm and cold colours.
Warm colours are perceived colours in the long wavelengths of the spectre (first of all red and orange colours).
Cold colours are perceived colours in the short wavelengths of the spectre (first of all blue and greenish blue colours).

Brightness
A characteristic feature of colour, which shows the distance of the colour from the absolute white (in the case of certain colour system the distance from the absolute black).
In the case of subtractive colour mixing brightness can be increased first of all by mixing white to the given colour.
The brightness of a colour can also be interpreted so that every colour can be clearly allocated to the grey of the same brightness on the grey scale.

Saturation
It shows the position of a given colour between the spectral colour of the same hue and the grey of the same brightness as this spectral colour.
So the saturation of a colour can be changed, that is reduced, by mixing it with grey of the same brightness, as a saturated colour is a perceived colour in the case of which the colour content of the inducing light stimulus is high; unsaturated colours are also called **broken** colours.
(In architecture first of all broken-unsaturated colours play a significant role, as the use of saturated colours is rather restricted because of their vivid appearance.)

On the basis of the above any colour can be clearly determined on the basis of their three characteristics, and any desired shade can be achieved by changing the three characteristics.

Colour scales uniform according to perception, or aesthetically uniform colour scales



The six basic colours (Goethe,s colour circle)

Saturation scale

Brightness scale

In the case of colour scales or colour systems regular according to perception the aim of the creators was to have **regular** distances between the individual colour points and regular difference between the colours.
In the case of aesthetically regular colour scales there are the same differences between neighbouring colours not smaller than **harmony – colour difference**, where by harmony – colour difference we mean the smallest colour difference needed for using two colours in the same harmonic colour composition, in a way that they can be distinguished from each other and aesthetically interpreted.

When more than one colour is used, they become interrelated with each other, and a tension appears between them. **Colour contrasts** are the possible types of connections or interrelations between the colours**.**
When this difference reaches its maximum, it is the so-called **contradictory contrast**.

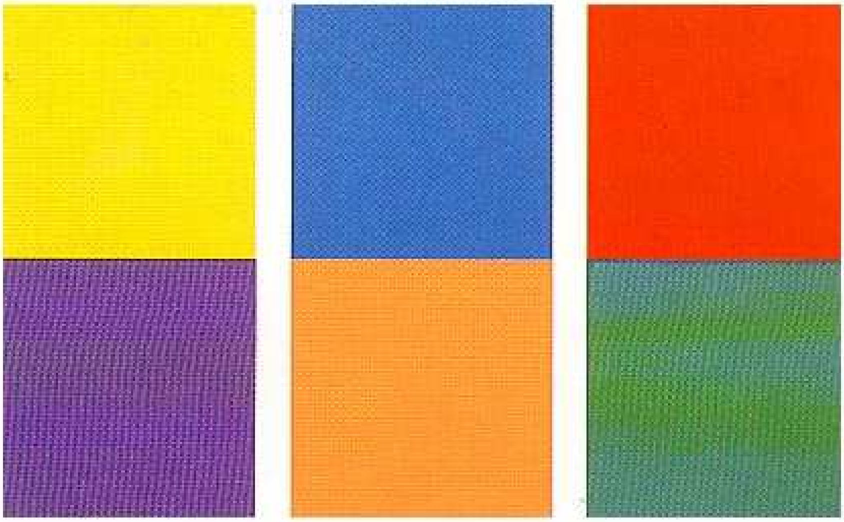
Generally there are the following colour contrasts:

Hue contrast
We talk about hue contrast when two (or more) colours have different hues. The most pronounced example is the **complementary contrast,** where the hues appearing in the contrast are each other's complementary colours, and they are facing each other at opposite points of the colour circle, so the hue difference between them is the maximum.
(When complementary colours are mixed with each other in the same proportion, on the basis of the rules of subtractive colour mixing they result in grey.)
Typical complementary pairs:
green – red, orange – blue, yellow – violet
The use of complementary pairs has been popular in fine arts for a long time, it results in a balanced picture surface, which radiates high tension at the same time. In the paintings shown as an example the decisive presence of complementary contrast can be seen very well. Especially Van Gogh and expressionism subsisting upon his art exploited the possibilities of expressing emotional tensions with the help of complementary contrast to the extremes. Complementarity can also be used well in architectural compositions, it is an elegant solution, obviously in the mellow world of broken colours.

Exclusively hue contrasts are rare in colour compositions, generally they determine the appearance of colour compositions together with other contrast effects.

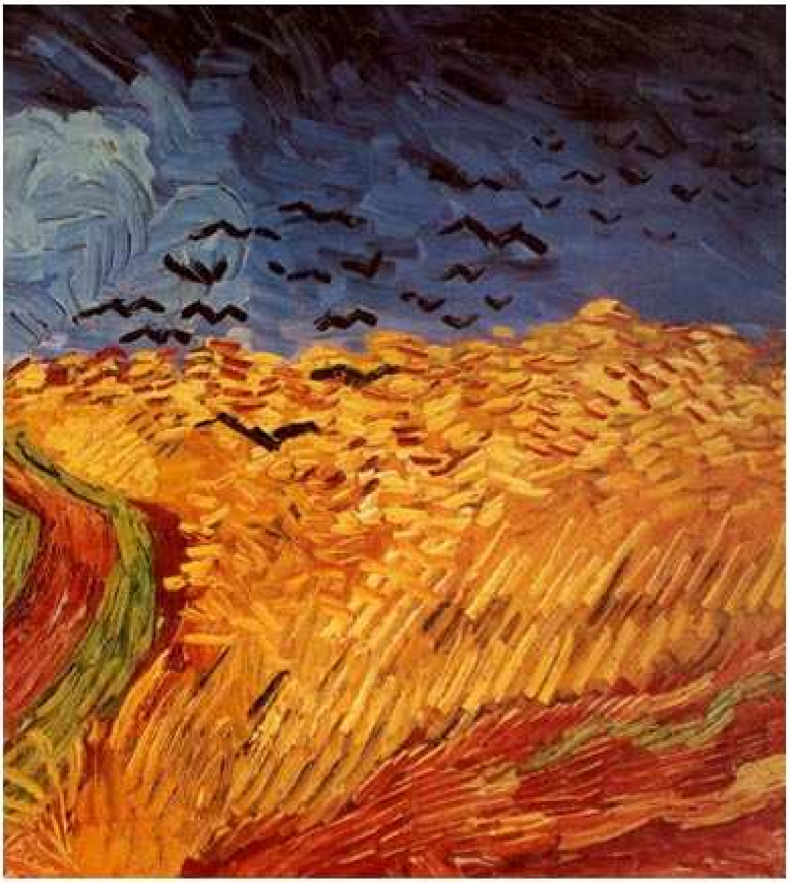
Cold-warm contrast
In fact it is a special type of hue contrast, but because of its basic emotional effects and its influence on the vegetative nervous system it is regarded as a separate contrast effect. In simple words it is a colour tension between cold and warm colours.
It has a strong associative effect, and the opposites in connection with it are:
far-close, light-heavy, wet-dry, etc.

Saturation contrast
Colours in clear saturation contrast with each other only differ in their saturation (grey content) from each other.
It is a very elegant, subtle contrast effect, although it is rarely used on its own, but it is an essential element of fine, balanced compositions.
Generally the saturation contrast differences of warm colours can be perceived more intensively than in the case of cold colours.



Basic types of complementary colour contrast

Complementary contrast: violet-yellow (Van Gogh, seated woman)



Complementary contrast: blue-orange (Van Gogh, Summer storm)

Brightness contrast

It is a very characteristic, general contrast effect, where the brightness values of the contrasting colours are different. Human eyes can clearly perceive brightness contrast even in the case that there is a small difference. A dynamic, intensive contrast effect can be reached with it, which, in the case of sufficient difference, can also create tension similarly to complementary contrast. (It was a typical tool used in baroque painting.) As you will see later, brightness contrast plays a significant role in architecture both because of its three-dimensional and two-dimensional distinctive character.

Quantity contrast

Its main point is that different colours have different intensity, so the size and proportion of colour carrying surfaces is very significant, if the aim is to create a balanced, harmonic composition. The architectural significance of this type of contrast was first recognised and studied in detail in Bauhaus, as a primary aim of a planning architect is to achieve an equilibrium state, and it is important that the colour appearance does not make mass and space conditions worse, but corrects them, if necessary.

Equilibrium surface ratios in the case of complementary pairs

(according to J. Itten)	orange:	blue	= 1/3:2/3
	red:	green	= 1/2:1/2
	yellow:	violet	= 1/4:3/4

Quality contrast

It is a contrast effect, which important typically in architecture, and its main point is that the actual nature of the colour carrying surface – material surface, texture – can influence colour appearance. The same colour can have a different effect on materials of different quality: e.g.: metal, wood, glass, etc. It is essential to take it into consideration in architectural colour planning. It is not favourable when on a building (or in an internal space) the same colour appears on surfaces (textures) of different quality.

Simultaneous contrast

Its main point is that the colours appear simultaneously and together, and they have an effect on each other, influence each other.

“Colour values, when they are put next to each other, change their character. This is called simultaneous contrast.” Goethe (1790)

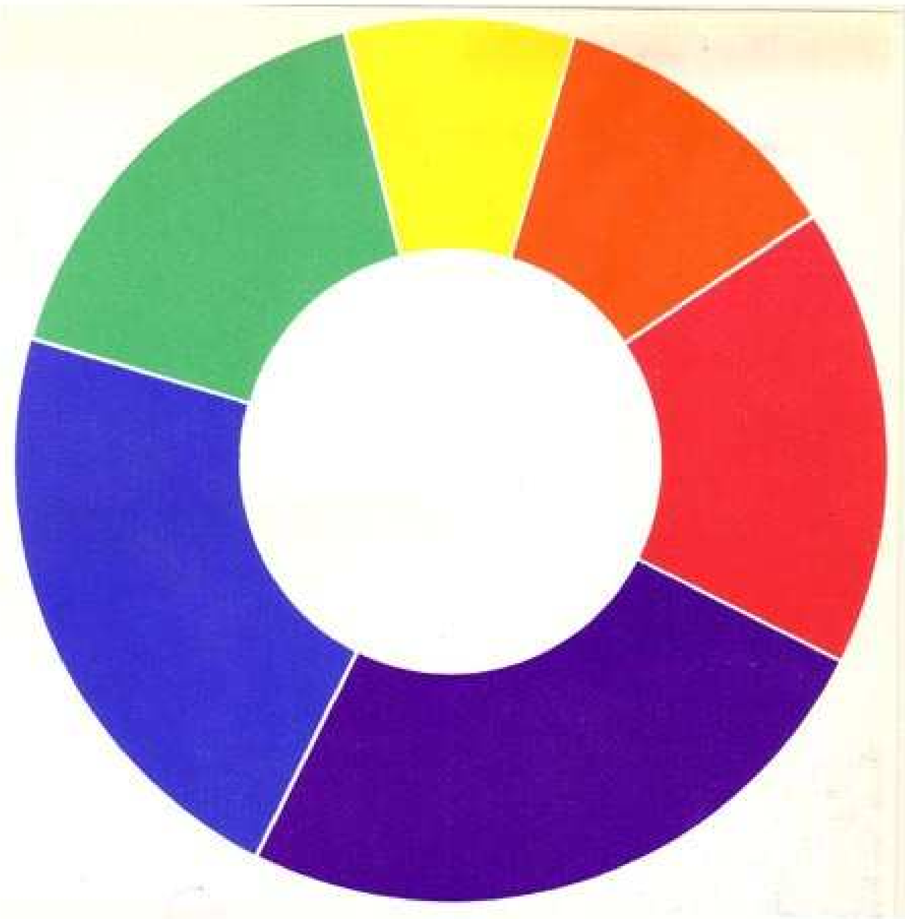
So it is important to examine the planned colours as they interact and then create the final composition.

Simultaneous contrast is demonstrated well by J. Albers, and it can be seen clearly that the same colour has a different effect when its colour environment is changed, and different colours can have a similar effect in the right colour environment.

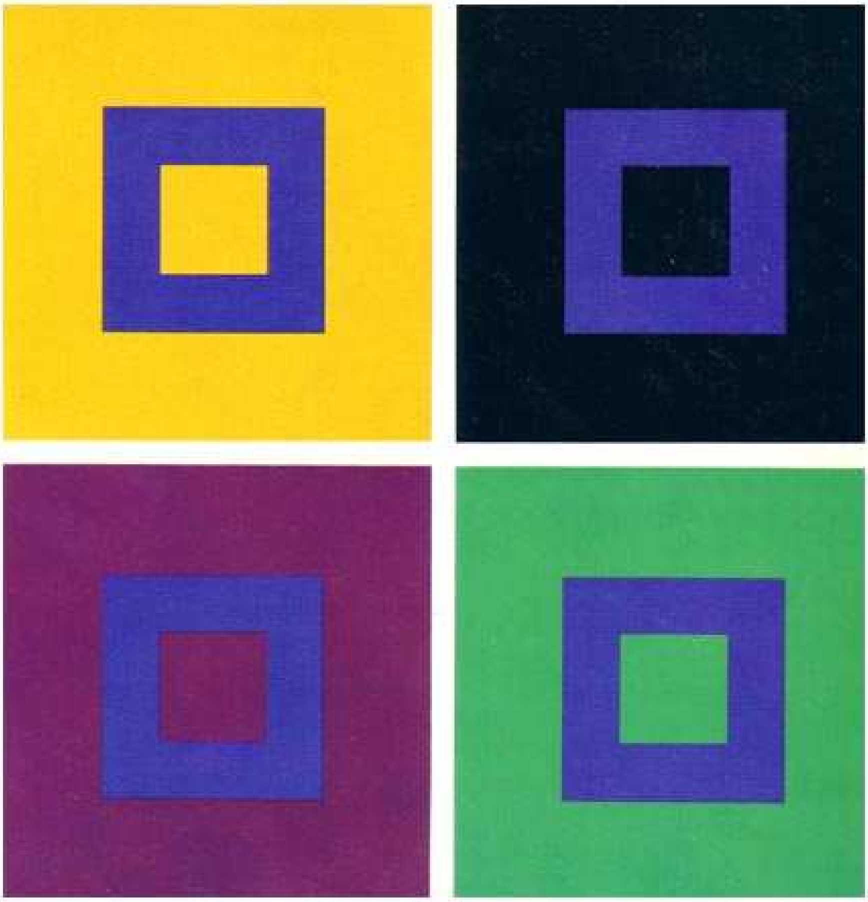
Successive contrast

Its main point is that colours influence each other’s appearance not only when they are viewed simultaneously, but this effect can also be observed when they are viewed successively, due to the so-called **colour memory** as a result of which the brain “remembers” an intensive colour seen before.

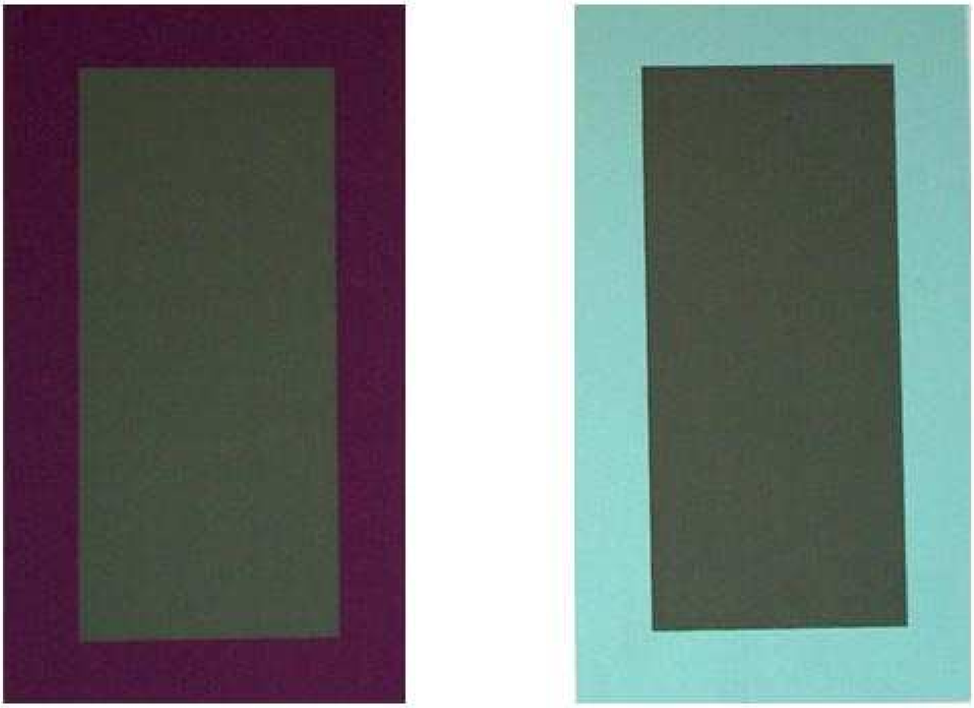
So first of all this contrast should be taken into consideration in the case of colouring successive spaces, especially if in the individual spaces the viewers get an intensive colour stimulus, and the effect of the contrast is even more pronounced.



Quantity balnce of the basic colours (after J. Itten)



Simultaneous contrast of colours (after J. Itten)



Simultanous contrast of colours (after J. Albers)

II. Interrelations between people and colours

When creating a colour composition it is important to know well and apply properly all the laws relating to interaction between colours and people. The effect colours have on people can be a direct biological effect or a factor influencing one's emotional state. In the interaction between colours and people the following important aspects need to be taken into consideration:

- colour preference

The expression means that certain colours are more popular than others, they have a nice effect.
The so-called **personal colour preference** is difficult to define but important, it is typical of a person, psychologically based and in the case of buildings planned for individual persons it is one of the most important aspects to be taken into consideration.
However, apart from personal colour preference mentioned above, which is difficult to define, we can also talk about colour preference, which can be more or less generalised and is characteristic of certain groups of people or historical periods.
Colour preference can be divided into the following classes:

- historical colour preference

In different periods of cultural history the preference of certain colours was different. It partly means the changing of hue preference: in the Middle Ages the Gothic style preferred cold colours, while in the architecture of new age history (Renaissance, classicism) first of all warm colours are dominant, and then in modern and mainly high-tech architecture cold colours are favoured again. The preference of saturation also changed during the history of architecture: while in the Gothic style saturated, intensive shades were more popular, in the period of classicism colours "faded", and first of all unsaturated colours came into the foreground. In respect of brightness, the third characteristic feature of colours, a clearly increasing trend can be observed: from the Gothic style until the modern ages there was a continuous brightening of colours, light shades became more popular. Obviously the colour preference of the individual historical ages was influenced by the nature of the colour pigments that could be produced, and for example this explains the fact that the use of warm earth colours was so dominant in the ancient times, as this pigment was available in the greatest quantity.
It is essential to know historical colour preference in the course of the restoration of a monument, creating an authentic atmosphere or making a townscape colour plan.

- colour preference according to age

People's colour preference changes in the different stages of their lives, so in the course of the colour planning of certain buildings (e.g.: nursery school, home for the elderly) it is important to take into consideration the relationship of the age group using the building to colours. It can be observed that while children are first of all attracted to saturated and warm colours, in adulthood broken and cold colours are preferred, and in old age unsaturated and dark colours come into the foreground.

- social/geographical colour preference

Certain societies, on the basis of strong geographical determination, prefer different colours or colour compositions. Let us just think about the intensive, saturated colour composition of African costumes, or the preference of warm earth colours in certain Mediterranean cultures. It is important for architects to know that if they are planning a building in a foreign country, not in the well-known colour preference conditions of their own society, they must study and take into consideration the colour preference of the locals in the course of colour planning.

Colour preference studies are also made in special social groups, such as criminals or mentally handicapped people, but describing the results of these studies is beyond the possibilities of this subject because of a lack of time, but in the case of planning certain concrete buildings these must also be taken into consideration.

In connection with colour perception two basic characteristics of the human eye (and brain) must be mentioned, namely **chromatic adaptation** and **colour constancy**.

chromatic adaptation:

The adaptability of the eyes to the environment lit by light sources of different brightness (luminance) and different colour.

colour constancy:

Colour constancy is a process in the course of which the changes of the stimuli affecting the eyes are still followed by the constancy of the colour experience. Memory (the remembered colour) and the so-called central correlation process created as a result of a higher nerve function play a significant role in the creation of colour constancy.

As a result of chromatic adaptation and colour constancy the changing of lighting does not necessarily result in the changing of the colour of an object in the mind, so within certain limits a given colour can also be evaluated independently from lighting.

The biological effect of colour

Colours have a direct effect on people's physiological parameters, and these effects must be taken into consideration in the course of planning the colours of an environment. Unfavourably chosen colouring may have a damaging effect on physiology, whereas appropriately planned colouring may even reduce environmental damage.

red has a stimulating effect on the nervous system, it increases blood pressure
orange has a favourable effect on the operation of the digestive system
yellow stimulates brain activity
green has a smoothing effect on the nervous system, it reduces blood pressure
blue has a temperature reducing effect, it relieves pain
violet has a favourable effect on the heart action, it stimulates the heart's operation

The emotional content of colours

Apart from human biology colours also affect the psyche.

According to Goethe: "Experience teaches us that the individual colours all radiate different moods...

The colours of the positive side are: yellow, reddish yellow (orange), yellowish red (red lead, cinnabar red). These colours put people in an active, lively, industrious mood.

The colours of the negative side are: blue, reddish blue and bluish red.

These colours put people in a restless, soft and yearning mood.

Green: the human eye finds real satisfaction in this colour."

I think there is nothing to add to the quotation above, the emotional content of colours was just as obviously perceivable and assessable two hundred years ago.

The so-called **colour association** is closely related to the phenomena described above, and it is one of the most important elements of the relationship between colours and people. Colour association can be realised at three content levels: it has a biological, aesthetic and symbolic basis.

The biological basis of colour association

Professor Antal Nemcsics, with his experiment carried out in the course of his research in colour dynamics, demonstrated that the association red-warm has a biological basis, as the subjects of the experiment found that in a room lit with red light a lower temperature was more comfortable than in the case of cold-blue lighting.

The biological content of colour association is closely related to the colour-physiological connections.

The aesthetic content of colour association

Colour associations are usually connected to sensations created through other sense organs, so for example colours may carry musical or poetical associations. The aesthetic content of colour association is based on the emotional effect of colours.

The symbolic content of colour association

Symbolic contents may have a religious, political, historical or status nature.

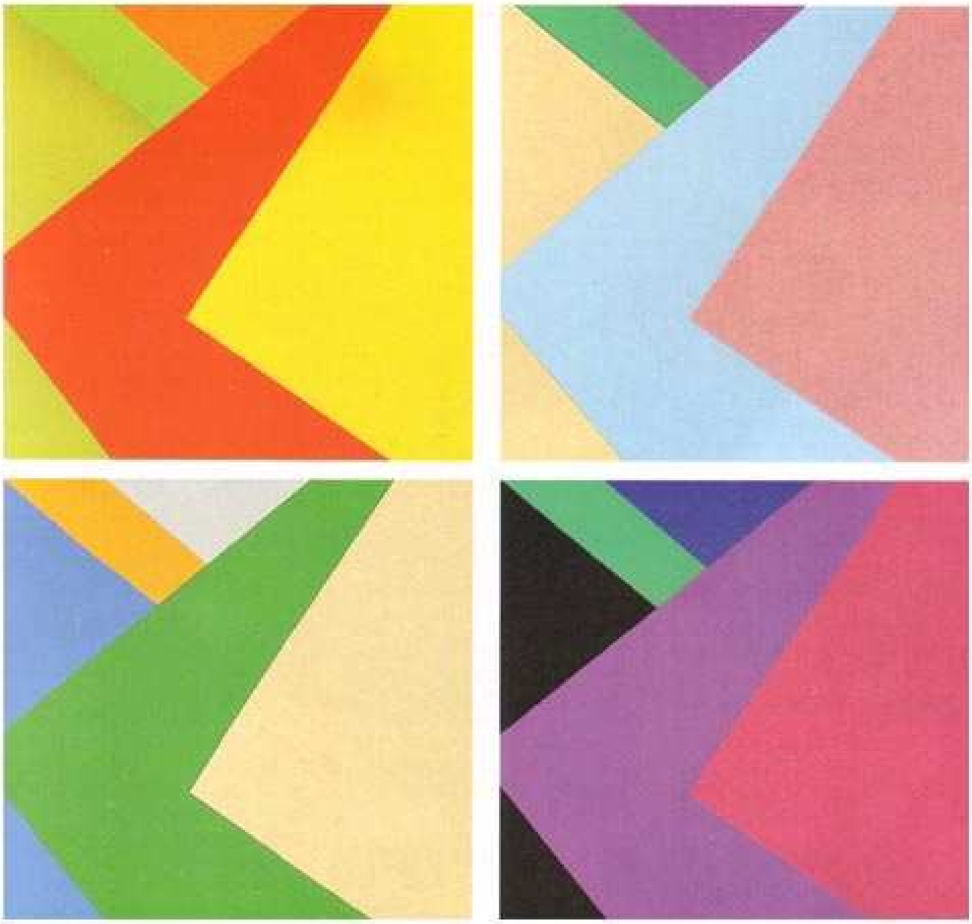
The most basic symbolic associations obviously occur in meanings, which evidently follow from the nature of the given colours. E.g.: red-blood, life; yellow-light, etc.

The origin of the symbolic content of colours reaches back to the prehistory of human kind (e.g.: the dark blue of the sky = tranquillity, passivity), and it was continuously expanded by the religions and cultures created during history.

Naturally symbolic contents are not permanent, they depend on historical and cultural circumstances. Here are a few examples of symbolic contents created in different eras of cultural history:

- in ancient Egypt blue and green were regarded as spiritual colours (as symbols of Amon Osiris)
- in the liturgical and heraldic colour symbolism of the Middle Ages green represented hope, while red was the symbol or courage.

It is important for the architect to be aware of the system of colour symbols of a given society, culture or religious group to avoid creating a completely different effect than intended because of not knowing the symbols.



Emotional content of colour compositions: dynamic, rational, harmonic, melancholic

III. Colour – space – architecture

After discussing the basic characteristics of colours and the significant laws of interaction between people and colours, it is time to talk about the connection between colour-space-architecture, that is the basic principle determining the possibilities of using colours in architecture.

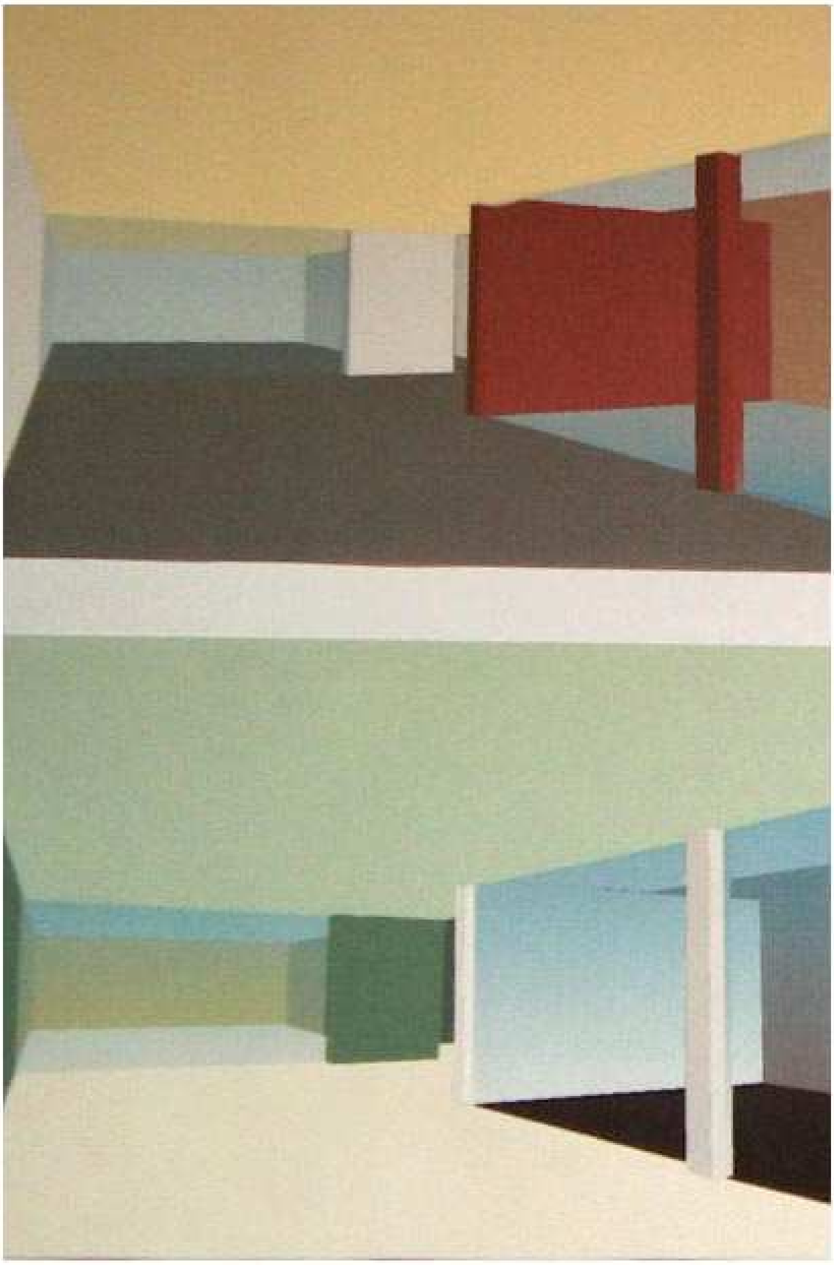
Colour and space
First of all we must talk about the space expressing abilities of colours and their appropriate use in interior spaces.
The space sensation modifying role of colours and its laws can be described as follows:

The space sensation modifying role of hues:
It is a basic principle that warm colours bring things closer, while cold colours make things more distant. J. Itten, on the basis of his experiments, came to the conclusion that "the graduation of the space defining depth effect of the six primary colours conforms with extreme and mean ratios", and "from cold and warm colours of the same brightness warm colours press forward, while cold colours press downwards."
Using this law and colouring appropriately the individual limiting walls of the space, an optically different effect can be reached than the real dimensions of the space.

The space sensation modifying role of saturation and brightness differences
It is a general rule that saturated and bright colours seem to be closer than unsaturated, dark colours. In the case of saturated and extremely saturated colours small modifications in saturation result in hardly any change in the sensation of distance. At the same time the smallest modification in the saturation of average saturated colours has a strong effect on the sensation of distance.
So on the basis of the laws described above the ceiling of an interior space should be given a cold, unsaturated colour to make the space look higher, at the same time a warm, saturated floor colour makes the floor look more concrete and close, which has a good effect on our feeling of security.
It is a general rule that in the case of interior spaces from the aspect of brightness it is best to determine the floor – wall – ceiling brightness scale in a way that the floor is given the darkest colour and the ceiling is given the brightest colour.
A dark ceiling may make the space look depressed, while a too bright floor may make it insecure.

Building mass, façade appearance
Colours can also influence the sensation of mass: saturated colours make objects look bigger, while unsaturated colours make them look smaller. The same stands for light colours: the brighter the object, the bigger it looks.
Consequently colours also have a mass sensation modifying effect, which can be exploited in architecture. Building parts of a smaller mass, which are important at the same time and must be made more pronounced, should be given a more saturated, bright colour to emphasise their significance, and vice versa: the optical size of a disproportionately big building mass can be reduced with a darker, unsaturated colour.
The structure of a building can also be emphasised with colours. Not too saturated tones are suitable for pronouncing levels and floors. Emphasising functional structures with the use of colours helps to make the visual appearance of a building radiate a feeling of stability.

Monochrome composition expressing volume and space



Interiors in warm and cold colour harmonies

Favourably the hue, saturation and brightness of the colour of doors and windows (or other important architectonic elements) should be distinctively different from that of the walls.
At the same time it is important to take into consideration the geographical position and orientation of a building when choosing the right colours. For example the Mediterranean sunshine invigorates white and light tones. On the façades of areas with less sunshine extremely saturated, contrasting colours are the most suitable. Red and yellow comes to life in sunshine, while blue and green are more effective first of all in shade.
Obviously in the course of colouring a building the so-called **colour tradition** of the given region or architectural style or function should always be taken into consideration. And naturally the building material presented in its natural colour, whether it is concrete, wood, stone, metal, etc., is a decisive element of the colour composition of a building. When colouring individual surfaces the planned colour should be in harmony with the nature of the carrying surface, because this is the only way to ensure the elegant appearance of the quality contrast described above.

Colour and function

When planning the colours of a building the function of the planned building must be taken into consideration. Completely different colours are suitable in the case of a hospital, residential house, school or place of entertainment.
Instead of just talking in general let me put down an instruction here that the colour science-based analysis of successful buildings of the right function must always precede making the colour plan of the buildings. At the same time it is a generally accepted rule that in the case of buildings of a complex function colouring should possibly help people to find their way inside the building.
In the case of spaces planned for permanent occupation the use of strong, saturated colours or such contrasts on large surfaces should be avoided.

IV. Harmony of colours

After discussing the basic laws of the relationship between colour-people-architecture, we have come to the most essential point: how to create harmonic, balanced colour compositions, what types do they have, and what criteria should be fulfilled to create them?

Harmonic colour compositions can be grouped on the basis of the hue parameters of their colours. On the **number** of hues appearing in the composition there are monochromatic, dichromatic, trichromatic and tetrachromatic harmonies, which contain colours belonging to one, two, three or four different hues. There are also so-called polychromatic harmonies, which contain more than four hues, but from the aspect of architectural use they are too “colourful”, and they are not used in planned architectural colour compositions.

Monochromatic harmonies
It is the simplest version of colour harmony compositions. The colours used in the composition belong to the same hue.
Three different types of harmony can be created:

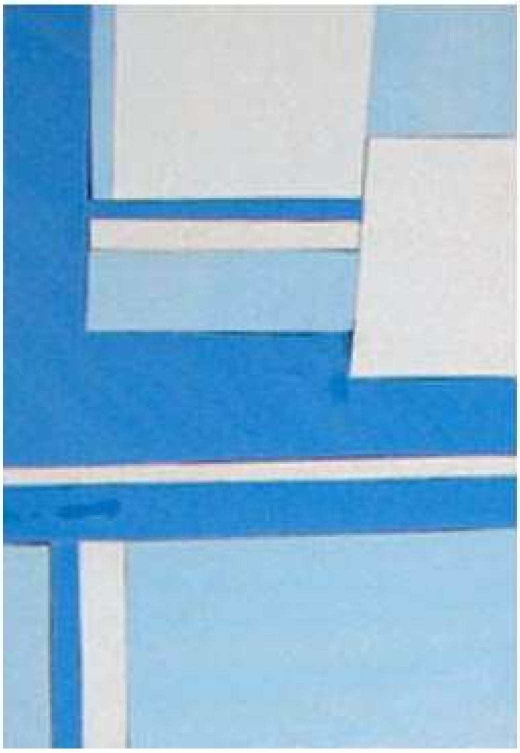
a.) **only the brightness** value of the colours used in the composition is different.
b.) **only the saturation** value of the colours used in the composition is different.
c.) both the brightness and saturation values of the colours used in the composition are different.

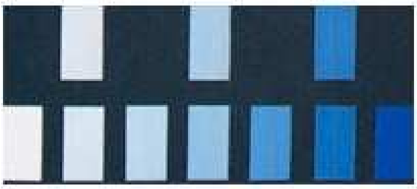
If

a.) only the brightness of the colours used in the composition is different, we get a very simple composition, which is suitable for creating dynamic harmony. It is a popular colour composition in modern architecture.
b.) only the saturation of the colours used in the composition is different, we get a very fine, decadent colour harmony. This type of harmony is rarely used on its own, it has insignificant dynamics, but at the same time it has a serious aesthetic content.
c.) both the brightness and saturation values of the colours used in the composition are different, we get a complex, rich colour composition, where the dynamics of the brightness contrast and the fine aesthetics of the saturation contrast are asserted at the same time.

It is true in the case of each type of monochromatic harmony (and obviously in the case of the multicoloured compositions discussed later) that the colour composition has a **harmonic** effect, if the brightness and saturation conditions of the colours are **on a scale**, that is there is the same distance between the brightness and saturation values of the individual elements. This makes the harmony more balanced.

Dichromatic harmonies
These are harmony compositions the colours of which belong to two different hues.
In this case too the brightness and saturation values must be on a scale.
So-called complementary harmonies are of outstanding significance, in this case the two hues are in complementary contrast with each other.
Compositions where the hues are at a 130^{o} angle with each other in the colour circle (e.g.: blue and red) have a similarly important aesthetic content. Generally these compositions also include a cold-warm contrast.
If we consider all the possible different brightness and saturation values, we shall see that dichromatic compositions offer the possibility of a really great diversity of colour.

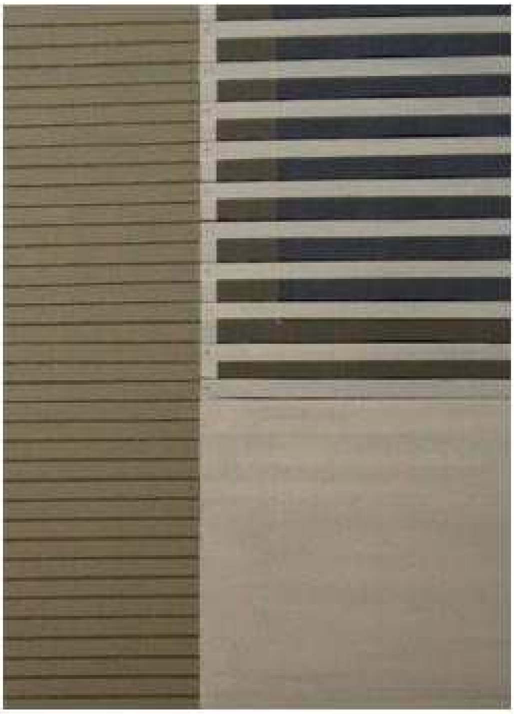




Monochrome composition with brightness contrast

Monochrome composition with saturation contrast

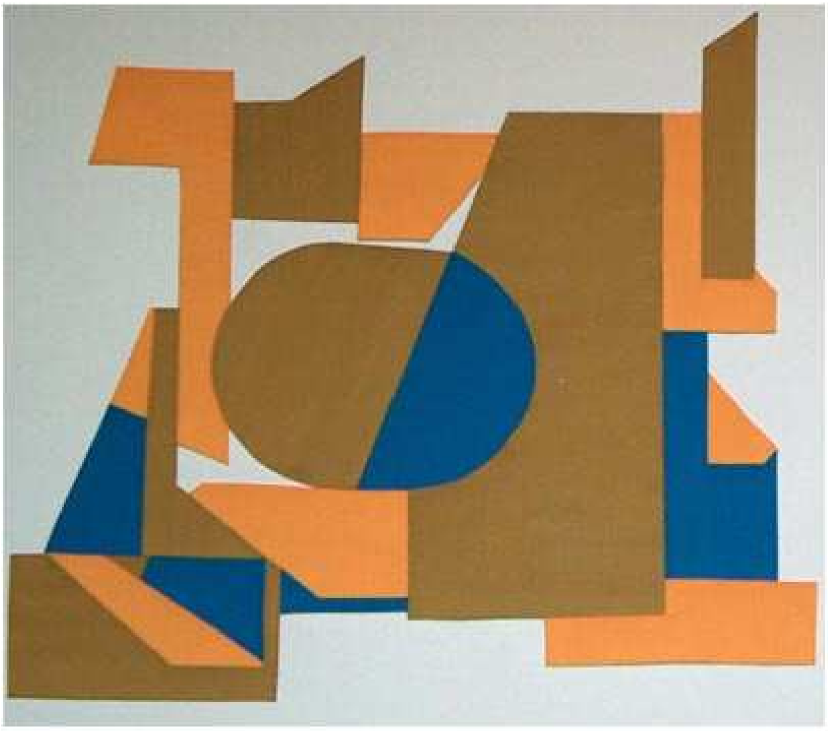
Monochrome composition with saturation and brightness contrast



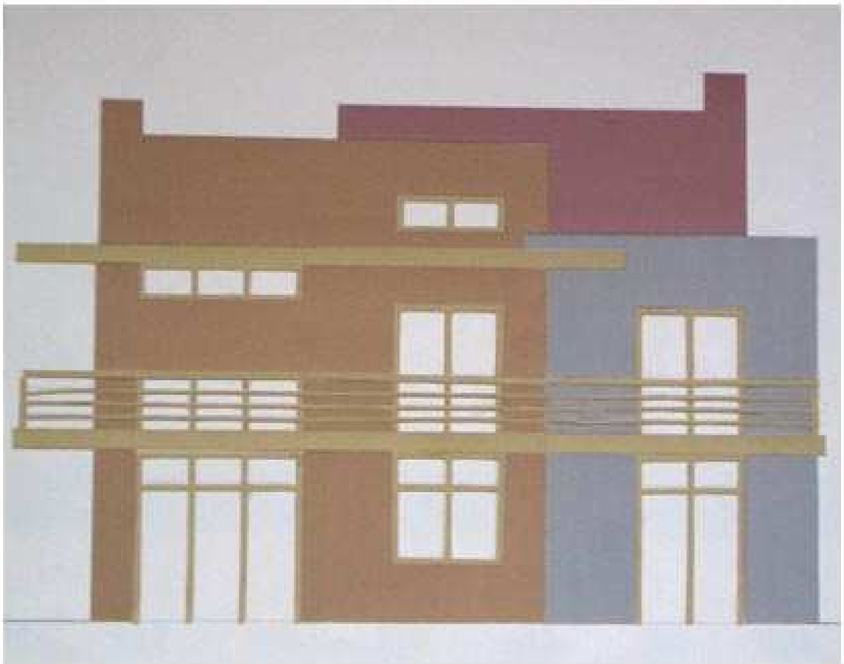
Monochrome composition with saturation and brightness contrast

Monochrome composition with saturation and brightness contrast

Monochrome colour harmony on the facade



Bichrome composition with complementary contrast



Trichrome harmony on the facade

Trichromatic harmonies

In this case the colours of the harmonies belong to three hues. These are very rich harmonies, but their emotional content is less as evident as compared to dichromatic harmonies.

So-called **triad** harmonies are of outstanding significance, where the hues are situated on the colour circle more or less symmetrically (that is approximately at 120° from each other) creating a fairly complete colour composition.

So-called **group** harmonies are also very important, they consist of two hues, which are close to each other and a hue at 34° from them. They are harmonies with a clear emotional content, as a given hue is dominant in them, which is finely modulated by the other hues.

Tetrachromatic harmonies

In this case the colours of the harmonies belong to four hues, literally they can include the complete colour circle, consequently they are very varied.

So-called tetrad harmonies bear special significance and they are often used. In this case the hues are situated at 34° 130° 230°, or 130° 230° 326° from each other, so they are regularly positioned on the colour circle.

Tetrachromatic harmonies created from double complementary pairs must also be mentioned, but in their case it is difficult to avoid an unbalanced, variegated visual effect.

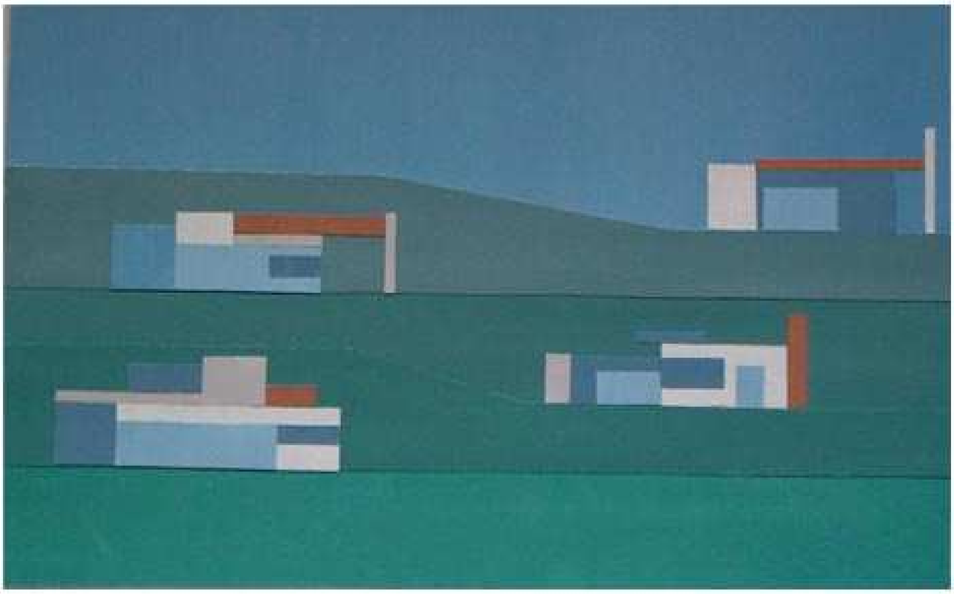
The compositions described above can only achieve a real colour harmony on architectural compositions, if apart from complying with the above criteria the laws discussed in the previous chapters are also observed: colour preference, colour association, the architectural appearance and function of colours express the architectural intention together, in a uniform way, on the basis of the architect's plan.

We must not forget about the conditions of lighting either, as it is a basic condition of colours. Obviously the direction, intensity and temperature (cold or warm lights) of the lighting may have a basic influence on the final appearance of colour compositions and on creating the intended harmony.

It is easy to understand that architectural colour harmony is a complex unit, and architects must be aware of all its elements and laws to create a "nice" building, which complies with the aesthetic aims.

The study of colour dynamics and colour science can help them to reach this aim.

Historic street coloured with harmonic colour compositions



Possible colour variation of residential park

IV. A short history of colour science
Modern colour systems

A short history of colour science

Ever since the European renaissance artists and scientists have been concerned about defining and explaining colours, their laws and systematisation. Leonardo and Newton were also deeply involved with the science of colours is, but the first basic work in colour science, which is regarded as "modern" and certain elements of which still have their effects today, was "Colour Science" (Zur Farbenlehre) by J.W. Goethe, at the very beginning of the 19th century. He named the six spectral colours, and he assumed that colours were created from a mixture of light and darkness: that is when white is gradually darkened, yellow appears first, and when black is gradually lightened, blue appears first. This assumption is regarded as the first formulation for arranging the primary colours in order of brightness. Goethe's colour theory describes the emotional content of colours, and the principle of complementarity also appears first in his work, and becomes generally accepted later on during the 19th century. In connection with Goethe's colour theory we must mention the name of a German painter, Philipp Otto Runge, who shared Goethe's views on colour theory, and created his colour system according to them, the so-called "colour sphere", which classes colours both on a brightness scale and on a grey scale.

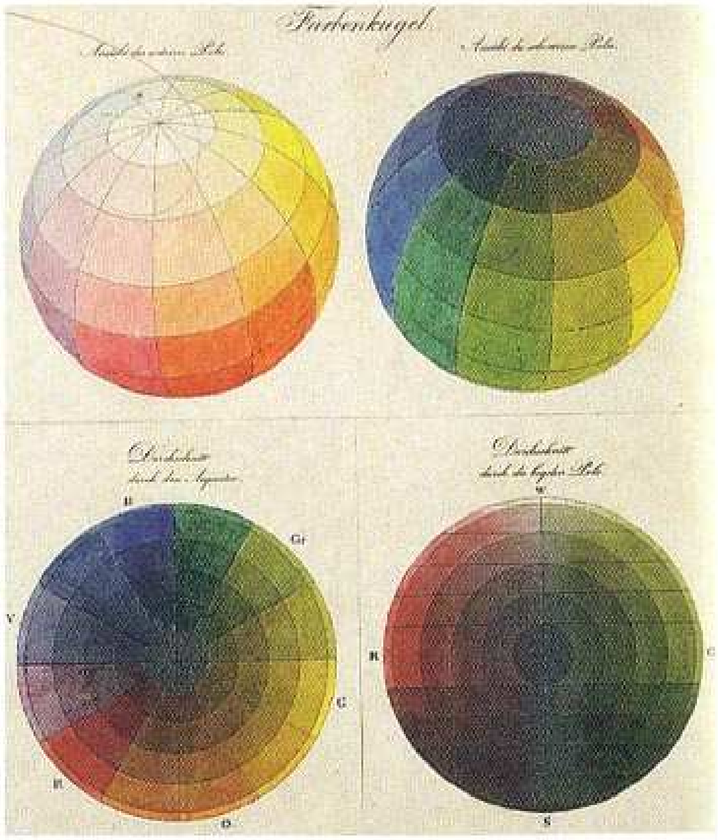
The next important stage in the history of colour science was the colour sphere created by a French chemist, Chevreul in the middle of the 19th century, and his book "On the laws of the assortment of coloured objects and the simultaneous contrasts of colours", in which he deals with contrast phenomena, first of all complementary contrasts.

Chevreul's colour theory had a great effect on French painting, and so it indirectly became a basically decisive factor in modern painting.

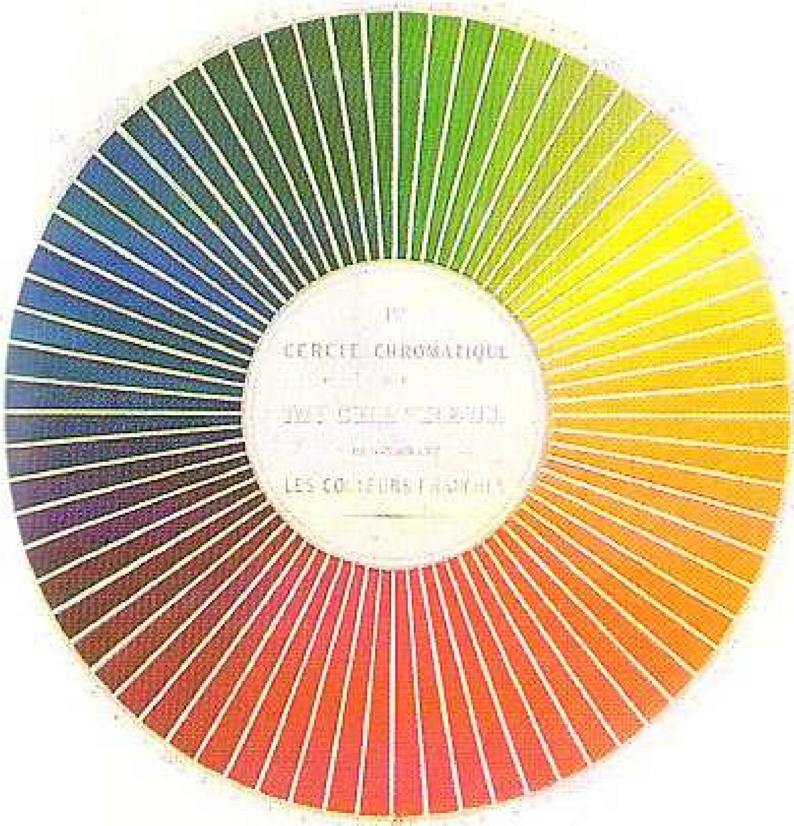
In 1850 James Clerk Maxwell, a Scottish physicist, carried out an experiment to demonstrate that colours can mix even in the eyes, and not only on the palette or on the canvas, and in 1879 an American scientist, Ogden Rood supplemented this discovery by saying that "if different colours are juxtaposed in the form of lines and dots, when they are viewed from the right distance, their mixing is mostly performed by they eyes." The trend of pointillism in painting subsisted on this recognition, and the appearance of colour printing procedures based on raster points was also based on this.

The creation of modern colour theory, which still has its effects today, is related to the German Bauhaus school and its two leading teachers, Johannes Itten and Josef Albers.

Itten described his views on colours and their interactions in his book "The Art of Colour", and Albers in his book "Interaction of Colour"; their theories became starting points of modern colour systems, and the present subject is also based on them.



Ph.O. Runge: colour spheres



Colour circle of Chevreul

Modern colour systems

People are able to distinguish several millions of surface colours, so there has always been a demand for the systematisation of colours. Basically in modern colour systems the colours are positioned in a three-dimensional space. Colours are identified on the basis of catalogues containing so-called **colour patterns**, and generally a three-component code belongs to the colours patterns showing hue, brightness and saturation values (in certain systems the code numbers show the colour mixing components of the colours).
Modern colour systems are classed in the following categories:

- colour systems based on additive colour mixing
- colour systems based on subtractive colour mixing
- colour systems based on equally spaced hues according to perception

colour systems based on additive colour mixing
These systems regard colours as individual colours of the colour circle, and the additive mixture of white and black.
The most significant system based on additive colour mixing is the
Ostwald system
The basic system was created in 1915.
The possible hues are groups according to the following:

- primary colours
- bright colours (primary colour + white)
- dark colours (primary colour + black)
- dull colours (primary colour + white and black/grey)

The practical realisation of this colour system was a collection of colour patterns published in the USA with the title: “Color Harmony Manual”. The fault of this colour system is the lack of equally spaced hues according to perception.

colour systems based on subtractive colour mixing
These systems describe colours as a mixture of colour pigments.
A typical example is the “Coloriser” colour system created in the USA in 1947.
The colour collection contains 1322 colour patterns. The colour space is not continuous and not equally spaced.

colour systems based on equally spaced hues according to perception
In the model of these systems there are equal spaces between the colour points. These are the most widely used colour systems, and the first one was the
Munsell colour system (in 1915)

The colours are described with the following three data: hue (H)
chroma (C)
value (V)

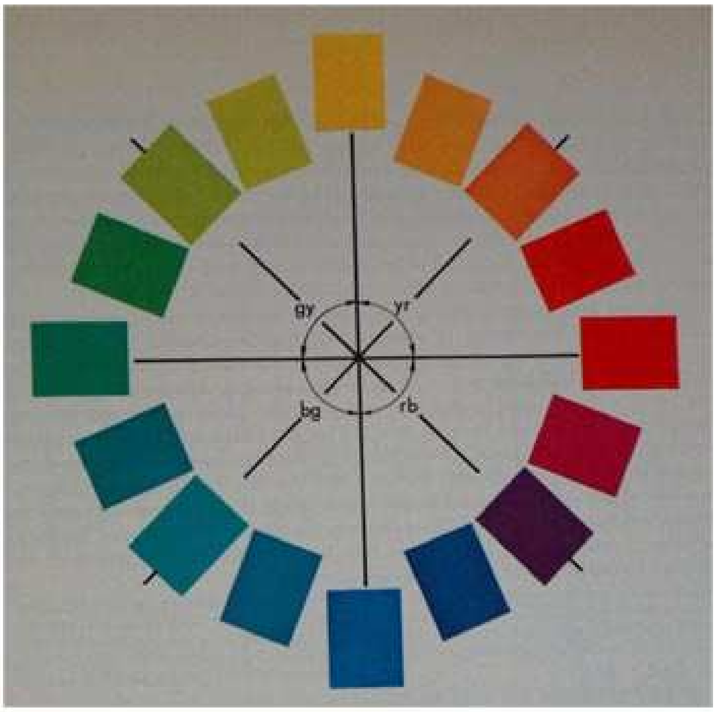
The colour circle, the hue scale is divided into 100 equal parts according 10 hues of the 5 primary colours and 5 mixed colours each:
R-red, YR-yellow-red, Y-yellow, GY-green-yellow, G-green, BG-blue-green, B-blue, PB-purple-blue, P-purple, RP-red-purple.
The latest colour collection is “Chroma Cosmos 5000”, which was published in Japan in 1978 and contains 5000 colour patterns.

DIN colour system
It is a standard German colour system since 1953. The system divides the colour circle into approximately equal parts according to 24 perceptions:
The saturation value of the colours is marked with the letter “S”, the saturation value of the achromatic point is S=0.
The brightness value of the colours is marked with the letter “D”.
The latest colour pattern collection is “DIN 6164 Glänzende Farbmuster” published in 1983, and it contains 571 colour patterns.

NCS (National Colour System) (1972)
The system is based on that there are six primary colour perceptions:
white (W), black (B), yellow (Y), red (R), blue (B), green (G), and all the other colour perceptions are more or less related to these. The NCS describes each colour with their extent of similarity to the six selected colours.
Its colour pattern collection is “Color Atlas SS 019102” published in 1979, and it contains 1412 patterns.

The Coloroid colour system (1979)
The novelty of this colour system is that colours are systematised based on **aesthetically** equal spacing:
On the basis of hue (A), saturation (T) and brightness (V).
Its creator is professor Antal Nemcsics, who worked out this colour system at the Department of Design of the Budapest Technical University.
The numbers of the system allocated to brightness and saturation values are extremely suitable for creating a scale, which is a basic condition of colour harmonies, so the colour system is very suitable for the purposes of practising and teaching colour planning.
The Coloroid system operates with 48 primary colours (hues), which are marked with a two-figure number:
10-16 yellows
20-26 oranges
30-35 reds
40-46 magentas and violets
50-56 blues
60-66 cold greens
70-76 warm greens

Saturation is the second characteristic or co-ordinate of the colour. The saturation of Coloroid clear colours (boundary colours) is 100, and the saturation of achromatic grey is 0.
Coloroid brightness is the third characteristic or co-ordinate of the colour.
The brightness of the Coloroid absolute black is 0, and the brightness of the absolute white is 100.
Coloroid brightness shows the distance of the colour from the absolute black on a scale the division of which is aesthetically even.
As the Coloroid colour circle does not consist of colours of equal absolute brightness, it is obvious that in a three-dimensional colour space the colour circle is a spatial curve returning into itself, and the volume bordered by this curve and the absolute black and absolute white is the so-called Coloroid colour solid.
Colour dynamics studies at the Department of Design are taught on the basis of the Coloroid colour system.



NCS colour circle

The system's colour collection is the Coloroid Colour Atlas published in 1988, and it contains 1617 colour patterns.

Literature:

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