

Colour Appearance in Different Compass Orientations

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Imagine that we are walking along a corridor, glancing into the rooms on each side. Instantly we can see that the colours of the walls are not the same, even though we assume that they were similarly painted. At first, we might think that this is a mistake, or even a failure. Again we assume that the architect intended the same hue and shade on both sides of the corridor. Or we might think that it is agreeable with a natural variation in colour, a variation that in fact tells us about time and compass orientation. Alternatively, we might suggest that the architect should avoid such colour design, by giving the rooms on each side of the corridor colours of different hues.

Colour appearance differs in rooms facing different compass orientations. Divergences in light and situation make a distinction between rooms facing north and rooms facing south depending on sunlight and diffuse daylight. This is a well-known phenomenon, causing problems in making colour design. The problem is that we lack the knowledge to predict how different compass orientations influence colour appearances in different rooms. It is a design problem that makes it difficult to achieve a planned result. The problem is to foresee how the colour of light can

affect colour appearance. How do we work with design in relation to rooms facing north or south? Is it possible to make a room with a “cool atmosphere” look warm and, vice versa: to make a warm, sunny room look cool?

Working as an architect, one still has to gain a knowledge of colour appearance by trial and error. Some intentions of colour design fail during the learning period, and result in disappointing and poor colour designs. To rectify failures in large building projects costs a lot of money, of course, and is seldom done. On account of this, I wanted to learn about colour appearance in daylight in general, and in north- and south- facing rooms in particular. The driving force was to carry out systematic studies in favour of design knowledge. I found that Billger had developed concepts and methods for colour research in enclosures.¹ She has broadened the field of colour research from colour samples into concerning colour appearance in rooms. Now it is obvious that this can result in knowledge otherwise not obtainable without the specific study of rooms. Billger made studies in artificial light and I made this investigation around daylight conditions. We have had a close collaboration and also used each other, and other colleagues, as observers. Beside

shifts in hue and nuance I wanted to discover how people responded to the colours involved and to the character of the room. As common strategies in colour design are either to enforce or counteract the light, the strategy is in itself interesting to evaluate as well.

In this article I first sketch out some divergences between north and south, warmth and coolness. Thereafter follows a presentation of my empirical research, briefly on methods used and finally some research conclusions.

An evaluation of north- and south- facing rooms

A room's compass orientation establishes conditions for experience. At first there is of course the matter of sunlight and diffuse daylight. In my research I use the word sky- light as a term for diffuse daylight. The motive is a need to separate between two kinds of daylight with differences in light distribution, light level, and spectral distribution. These contrasting conditions are differently processed, not proportionally, in the visual system.² The visual process affects contrasts as to either diminish or enhance them, like in assimilation and contrasting effects. The contrasting conditions also form impressions with other qualities, different experiences of room and colour.

Sky- light illuminates the north facing room together with reflections of both sunlight and sky- light. North-facing rooms have a relatively steady light level, with diffuse light and a good colour rendering. Therefore, sky- light is used as a standard model in specifications for artificial light. Rooms to the north are often thought of as being pleasant, with a greyish, dim light and a steady light level. However, while some people see sky- light as a neutral light, others see only cool light and a cool room character. Facing north, sunlight is seen mostly in the landscape outside, while the interiors rest in quiescent shade. Facing south, sunlight illuminates the whole interior and that result in a different expression. Sunlight, sky- light, and reflections from outside illuminate the south facing room. As clouds pass by, sunlight flickers and changes. It points out conditions of living life, such as time and weather. Clouds and atmospheric variations change, and this shows in colour appearance. In these rooms we can feel time fly, together with changes in mood. As if at random we are given sudden moments of joy, but possibly of long lasting monotony. Some of us experience discomfort in viewing conditions and burning heat in sunlit rooms,

some only comfort. Hue and nuance undergo changes. Without a knowledge about colour appearance in natural daylight we cannot control colour design. How do these differences affect colour appearance? (See figure 1, page 36.)

I have chosen to experiment with rooms facing north versus rooms facing south because they can be experienced as almost opposite to each other, both in how colours are perceived and how we experience the whole situation – the character of the room. This investigation is made in Stockholm, Sweden, and it concerns mainly observations on clear days, since fully overcast weather makes colours appear the same in all directions. Yet studies from all sorts of weather were made.

A study on colour appearance: aims in the investigation

The aim was to investigate how colour appearance differs between north- and south facing rooms. The investigation had three aims:

- The first aim was to describe shifts in hue and nuance with regard to the compass orientation of interiors. By this it would be easier to accomplish a desired colour design in a planned room. Facts and figures of predicted shifts in hue and nuance could help in colour design in general.
- The second aim was to examine and discuss different ways to work with colour design in various lighting conditions. Architects and designers often use two contradictory methods, either to counteract or to strengthen the light situation. Because of this it is essential to know if it is possible to counteract the colour of light. Is it possible to make a room with a “cool light character” to be experienced as “warm”, and vice versa? In order to evaluate this matter, it is important not only to ask, “what colour is it?” but also “what does it look like”? Answering the first question one might say “blue”, and the second “cool”, “vibrant” or “receding.” More knowledge in valuations like these can help to bridge the gap between a planned design and the result. From the view of an architect and designer, it is no use studying a colour without connection to a thing and/or a situation. This brings us to the third aim of this study.
- The third aim was to describe the room and its character in terms of colour and light. In a room, colour has a close

relationship to its location. Therefore it is important to look at the situation as a whole, including both colours and room. This third aim was less studied than the other two, but still deserves to be mentioned. In this article, room character is defined as the subject's experience of the appearance of room, colour, and light in combination. Beyond an experimental situation, colour instead is merely a background in the room as a whole. A room consists of both physical elements, light and colours, by which it gains its character. As humans we react to the situation as a whole and relate colour, climate, light, and appearance to an experience of reciprocal actions. Here questions of a total appearance belong. Again, it is important to treat the question of what the colour looks like, apart from hue and nuance: the experience of a character as an added consideration.

Terminology

- *Colour variations*: are defined as the local colour appearances of the identity colour. These differences might depend on light distribution, reflections from other surfaces and contrast effects.³
- *Identity colour*: is defined as the main colour impression of surfaces or parts of the room that are perceived to be uniformly coloured.⁴
- *Inherent colour*: the colour that the colour object would have, if it was observed under the standardised viewing conditions that are a prerequisite for the NCS colour samples to coincide with their specifications.⁵ I quote Fridell Anter: This means that the inherent colour is a constant quality of the object and does not depend on external conditions (apart from bleaching, pollution, and other physical changes of the object itself).
- *Visual Evaluation*: is a method for visual evaluation of light and room to specify both physical and visual aspects of the light situation. The method is designed to establish and evaluate those connections.⁶

Methods in the empirical research

My research is based on an empirical investigation of experimental character made with comparative methods in north- and south facing rooms. The overall research objective is to describe what happens with colours in various lights, not really why it happens. Observations are made using *room*

models and *full-scale interiors*. The investigation is qualitative, with a perspective based on perception and phenomenology. The designer's perspective is taken as a starting point. Shifts in hue and nuance differing from the *inherent colours* are in focus, together with the colour gestalt and room character. The questions involved have two perspectives; what does the colour look like in the room and what does the room look like in the colour? A total of 126 studies were made; 43 studies of room models and 83 full-scale studies. Six methods for assessment and description have been used. In the investigation we have been working with two perspectives of attention, *the colour perspective* and *the room perspective*. The colour perspective aimed at describing, in our own words, the experience of a colour in the specific room situation. This perspective demands a certain amount of time, as in experiencing a work of art. Through the colour perspective the colours were looked upon as a colour gestalt. In addition to this, the observers used a verbal description, exemplified with expressions as brilliant, dull, beautiful, glaring, full or pushy. The room perspective belongs to the total experience of room, colour, and light. In this lies the difference between a colour sample and the same inherent colour in a room where enclosure, shadows, distances, light and different light reflections together form a compound experience.

In the introductory room studies of model rooms, I used 3 yellowish and 3 bluish colours in two nuances of chromaticness; one was a pale nuance, the other was and a more chromatic one. These studies were fruitful and I decided to go on with the same inherent colours in the full-scale studies. (See figure 2 page 36.)

The observers made several observations each, out of 12 inherent colours. Room models were used mainly to test concepts and methods. The room model was made of white cardboard with a "window" facing north respectively south, with a carefully arranged window at the side for observations. All four walls were painted in the same inherent colours, one at the time. The model had a grey painted floor in NCS 3000-N and white cardboard ceiling. It was made in a scale of 1:5, measuring 700 x 980 x 480 mm, the window for observations measuring 23 x 28 mm. For full-scale studies a building site shed, with one window in each short side, facing north and south was used. The shed measured 8, 40 x 2,90 meters. The floor covering had a beige plastic surface and the ceiling was painted white. The walls had a

coating in glass fibre textile and a latex paint, glare 7, was applied with a roller. Inside the shed, all four walls were painted in the same inherent colour. In experiments, one side was shut so that there was either sunlight or sky-light, alternatively.

For careful and conscious evaluation of colour and room, competent observers were used. All six observers were architects and four of them were colour researchers, used to assessing colour appearance, room evaluations and the NCS colour system. Observations were based mainly on two of those as permanent observers and for comparison, the other four observers were used on certain occasional studies. Notations were made on a form; descriptions in verbal while colour variations were marked on a sketch with an NCS colour notation. In an hour-long session of visual assessments, the observers commented on various aspects of the colour appearances, including impressions of change caused by atmospheric conditions. Six methods of observation were used. The observers evaluated the light situation by means of the *Method of Visual Evaluation*. A *Colour Reference Box Method* was used to gather data with a *Colour Reference Box*. *Psychometric scales* were used to describe the room character. An *Associative, reflective method* was used to describe colour response with verbal descriptions in the observer's own words. Between each change of inherent colour, a *watercolour painting* was made of both the north- and south facing room. In some cases, data from the studies seemed contradictory. To make an analyse, *memory colour* and a *colour scheme* were used together with these water- colour paintings. Put together, the colour scheme provided the missing link. In most cases this link proved that there where different sizes in area of distribution between some of the colour variations.

In assessing the light and colours in the room, the observers were guided by the questions in the form. They started with a holistic view of the situation as a whole, then shifted focus between colour variations, identity colour and room character. It was not required to use the different methods in a strict order, but I considered it of importance to commute between approaches to keep the vision vital. Secondly, they should evaluate the light situation with the *Method of Visual Evaluation* by Liljefors and Ejhed. This is made according to seven factors: lightness level, light distribution, shadows, glare, reflexes, colour of light, and colour appearance. The method in observing how room, colour and light interacted

was essential. As this method revine a certain amount of time, it slowed down the overall pace and thus made it possible for careful observations.

In assessing colour appearance the Colour Reference Box Method by Billger was used. This method consists of a colour matching method using a Colour Reference Box.⁷ The Colour Reference Box was set up with a standard source of illumination to provide a reference situation, were NCS colour samples were illuminated and compared to certain areas on the walls. In these experiments a daylight lamp, D55, was used. The box is made so that the light did not leak out and affect the room situation. The observers placed colour samples in the box to be visually matched with identity colour and colour variations on the walls. They were instructed to choose the sample, or an interpolation between several samples, which they found to be the best match. Their data were noted and arranged in tables for analysis. Comparisons were made between the same *inherent colour* under likely comparable conditions in north- and south orientations. (See figure 3, page 36.)

For evaluation of the experience of colour and room, some method was required. Such a method for description was developed and is called the *Associative, Reflective* method. This method originated in the will to use the means of a designer, and since the aim was to increase design knowledge it seemed useful to work with a designer's special work procedure. A designer must be attentive to appearances, enjoy to focus and test different impacts, and be able to express these as images or characters. Theoretically, the associative, reflective method is influenced and inspired by phenomenological theory, in approaching colours as phenomena. Colours become a phenomenon together with room and light. Through an intentional concern in experiencing phenomena in themselves, one can sense colours and the whole situation as a work of art. In describing experiences the observers wrote descriptions in their own words. In the form for notations, various aspects of colour appearance found a mean for description, including impressions of changes over time. The colour character could be described as filled, brilliant, greyish, beautiful, gloomy, glaring, dull, or hard to define. In describing the room character a semantic scale in three steps was used. Impressions of emotional tone (light-heavy), dynamism (advancing-receding), spatial quality (closed or open, distinct or diffused) and character (warm-cool) were noted.

Research observations

1. *Shifts in hue and nuance*

The investigation showed distinct and settled shifts in hue and nuance between the rooms depending on their compass orientation. In sunlight all colours changed to be more chromatic, warmer and more yellowish. Greenish blue and blue colours shifted towards green. In sky-light, the inherent pale yellow colour in most cases appeared as less yellow, with either more blackness or whiteness. The blue and greenish-blue colours changed towards elementary blue, both in hue and chromaticness. Also small shifts in hue, even as small as 5–10 steps in the NCS scale, were noticed as distinctly different hues in the room. (See figure 4, page 37.)

Reddish-blue colours could vary, as by chance, both in sunlight and sky-light. Often the inherent colour appeared as more reddish in sunlight, although in all cases the same hue was found in sky-light. It was experienced as a distinct hue shift, although we still found the colour sample among the samples picked out for the north facing room. This sort of result might have depended on a methodological problem with the colour reference box; and it is therefore my intention to make further studies on this.

2. *Occasional colour variations*

Occasional colour variations were often decisive for colour appearance. During the investigation it was noticed that a hue shift in the identity colour could be accounted for by different factors. Either it was an overall hue shift in colour appearance or, a hue shift could arise as a general impression from occasional colour variations. This can be related to the phenomena of assimilation, concerning how colours are affected by other colours in patterns etc. In assimilation, colours seem to blend, as opposed to contrast effects. Colour variations were often decisive for colour appearance, even when they did not show in the identity colour evaluation. For additional reasons, shadows in particular, were an issue of great importance for colour appearance. Most important, it seemed that their hue often differed from nearby areas. That implied a more complex *total appearance*.⁸ In experiencing the room together with colours and light, these variations were included in a general impression. On top of this, shadow and shade contained layers of deep symbolic nature. This was significant in evaluating what the colour looked like. (See figure 5, page 37.)

3. *Elasticity*

Hue shifts depending on changes in light conditions inside each room over periods of time were also observed.⁹ When the sky in the north-facing room eventually became fully overcast the elementary yellow colour (S1030-Y) turned to looking more like wet hay (greyish-brownish). As this investigation was based purely on colour appearance and therefore lacked the apparatus for measuring light levels, we did not know what exactly caused the hue shifts. Regardless of one reason or another, distinct hue shifts were observed not only between rooms but also, during the day, inside each room. As these hue shifts constantly returned, it seemed important to take them into account. In evaluating colour appearance in rooms, one single colour cannot be chosen as representative for various lighting situations in one room. Therefore, the term elasticity is defined as “the range of different colour appearances of an inherent colour inside the room.”¹⁰ From mutual experience in research, Billger and myself started to define elasticity from different lighting situations. Billger describes the term as: “the way a specific coloured material can vary in appearance under different specified conditions in a room.”¹¹ From my viewpoint I define it as “the way a specific coloured material can vary in appearance under different periodical variations due to daylight conditions in a room”. The elasticity concept can be helpful in establishing what a chosen colour might look like in a planned room. A range of colour notations likely to be seen under normal weather conditions in a room, instead of a single colour seen only occasional, would be useful in design work.

4. *The concept of warm and cool colours*

The concept of warm and cool colour appearance is more complex than was expected. It was concluded that they consisted of different aspects beside hue. The first aspect was the association with warm as opposed to cool phenomena, as fire and ice. In this respect blue was always cool and red was always warm. The second aspect was the relation between other colours in comparison; because of this we could speak of “warm blue” and “cool blue”. The third aspect was blackness and chromaticness in combination. In the investigation I found a connection between “warm” and whiteness as opposed to “cool” and blackness. Though, in some cases there was a weak connection between warm and blackness

as well. A fourth aspect seemed to be “colourfulness” as opposed to “less colourful”.

5. Advancing and receding colours

Some colours were advancing while others were receding. In spite of basic knowledge about the capacity of colours to advance or recede, this was a stunning experience. In sunlight most colours were advancing. However, yellow and reddish-yellow colours were most strongly advancing and seemed to fill the whole room. On those occasions, the chromaticness was highly increased and the hue shift was 5–10 steps toward red. The increased chromaticness, together with the hue shift, seemed to cause this effect, as it was not as legible for pale colours. In sky- light, yellow colours were often dull, having less chromaticness and more whiteness or blackness, except for those moments when they occasionally shone up due to changes in the atmospheric conditions. They were neither advancing, nor receding. On the other hand, it was found that the reddish- blue colours were strongly receding in sky- light. Elementary blue and greenish- blue appeared as vaguely receding.

6. The room character

Colours with high chromaticness made the room secluded and introvert. Light was seen in the landscape outside and it only shone in as a small, lustrous patch on the wall, but still did not seem to affect the room or the colours in the room. On these occasions the wall colour seemed to hold both the room and the observer as hostage; inside and not really able to take part in what was going on outside. Yellow and especially the greenish- yellow colours, were the opposite, as light made them luminous.

The south- and north- facing rooms could be characterised as having either a warm or cool character. This room character probably arose in the interaction between physical temperature, the colour of light, emotions, and memories of the whole situation. The question of warm and cool seems to depend merely upon a mental state – and affects us differently as individuals.

Methodological discussion

The Colour Reference Box is a helpful aid in colour matching. The method is still under development by Billger who has described some adaptation effects between artificial day-

light and incandescent light. In a few extreme situations, the observers in my investigation experienced the different light situation between the room and the Colour Reference Box as a possible problem in colour matching. One situation was when the south- facing room was painted in yellow colours and the light in the Colour Reference Box looked bluish. The other was in the north- facing room with bluish colours where the light in the box looked yellowish. A preliminary test was carried out to see if we could map out the adaptation effect between the northern and southern light situation. However, we could not detect any clear tendencies for the adaptation effect in the daylight studies.¹² Figures from this investigation are not changed on account of several factors; they correspond well with verbal descriptions, memory colours and the painted pictures used in the investigation. We have to carry out more studies of this effect concerning rooms in daylight, to be ensured of this. Still, I used the method and found it reliable in my studies.

It is apparent that full-scale studies in colour research are of importance for colour research and for interior architecture. I also found it most useful with a reflective attention in describing colours and rooms, to grasp the phenomena involved. The method gave possibilities to express even unexpected experiences of colour and room character. The identity colour it did not work out properly now seen indispensable for colour research in interiors. In some cases though, probably because it does not cover the range of colour variations that are significant for interiors in natural daylight. It might be useful to work out a way to catch a wider range of colour variations in the identity colour as opposed to only one notation.

Closing thoughts

The contrasting conditions of north- and south facing rooms cause shifts in hue and nuance, but also impressions with other qualities, such as colour quality, colourfulness, room character and experienced temperature in colour. The task is to form a clear relationship between architecture, colour design and the compass orientation of interiors. Colour design would improve knowledge in making better use of colours, as well as light and shadow. Given a greater importance, colours would contribute to an extended meaning in architecture, instead of being interchangeable. It is exciting to imagine colour designs made to emphasise different locations in compass orientation. Colours that are chosen

to fit the colour of light would enrich the built environment. They would clarify shades and shadows and take north- and south facing rooms into account as a rhythm in built areas.

In my investigation it became clear how colour appearance functions on several levels. For myself, as an architect and designer, the most important level is a total colour appearance. Colours are, as a part of the built environment, only momentary objects in focus. Mostly they form a background for activities in life. As an example, yellow-painted walls in a north facing room, could on a cloudy day literally be described as follows:

Like a paper in the fireplace,
quickly crumbling dark,
while burning to ashes.

It now remains to deepen the questions at issue. As presented in this article, a hue shift in general has been shown concerning some yellowish and bluish colours. Green and red colours remain to be studied. For further investigations the room perspective remains to be focused upon, – that is, the character of the room painted in a specific colour. In connection with this it is important to investigate further the concept of warm and cool character. It seems to be essential to use concepts like these to grasp the experience of colour.



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Notes

1. Billger, M.: 1999. Amongst her methods and concepts I have adopted the Colour Matching Method with the Colour Reference Box as well as the Identity Colour.
2. Liljefors, p. 151. 99.
3. Billger, 1999, p. 11.
4. Ibid. In some cases, the concept of identity colour did not work out properly in this study, probably because the identity colour does not cover the range of colour variations that are significant for interiors in daylight.
5. Fridell Anter, 2000, p. 24. The standardised viewing conditions are defined as: • light booth with simulated daylight, 6x20 watt Luma Colorette fluorescent tubes, colour temperature approximately 5400K, diffused through a opaline plastic sheet which gives approximately 1000 lux. • measurements of the light booth specified, its walls light grey with specified luminous reflectance. • the colour sample to be observed measures 6x9 cm and is placed on a white panel with specified luminous reflectance, tilted about 45°. • the sample is viewed at approximately 90°, from a distance of about 40 cm.
6. The method is developed by Liljefors, A. and Ejhed, J, 1990. Liljefors 1996.
7. Billger and Håggström developed the colour reference box at Chalmers University of Technology. For detailed description and discussion about adaptation effects, see Billger, 1999, paper 4. For further clarification "Assessing Colour Appearance in a Real Room Using Magnitude Estimation and Colour Matching Techniques" Billger in MPL Proceedings, London April 2000. Hårleman 2000, p. 29 and p. 87.
8. Hutchings has introduced the concept of total appearance. It involves series of images including colour. There are two classes of appearance image, the impact, or gestalt image, and the sensory, emotional and intellectual image. The total appearance treats the background to consider how people respond to images and behave. Those images are founded on both biological ground and social training and include several aspects such as security, climate, landscape, memory needs, and definitions of the object or scene.
9. By atmospheric conditions there are constant changes in light level and spectral composition.
10. Hårleman, 2000. page 41.
11. Billger 1999. page 12. "For instance, a specific yellow paint which is used in a room might possess an elasticity to appear greenish- yellow in a fluorescent illumination, to appear yellow but with a low degree of chromaticness in daylight, and to look strong and slightly reddish yellow in incandescent light."
12. By collaboration, adaptation effects in some situations with artificial light were mapped out; hence they can be compensated for and controlled. A preliminary curve has been worked out describing tendencies for different inherent hues in situations with artificial lighting. This way it can be made possible to foresee not only hue changes but also the approximate size of these changes.

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