Forming Spaces with Colour and Light: Trends in Architectural Practice and Swedish Colour Research

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Architecture is space built for human life, and colour in architecture means colouring this space, or spaces. To choose colour for rooms within a building is profoundly different from two-dimensional artwork or colour design, as the spatial preconditions themselves interact with the chosen colours to form a three-dimensional totality. On the other hand, the experience of space is always present in our visual perceptions, even when we look at surfaces that physically have only two dimensions. Colour presupposes light, and the understanding of light and shadow is decisive for our spatial understanding. The purpose of this article is to discuss the issues of colour, light and space, mainly with reference to current Swedish research results and the experiences of practicing architects and interior designers.

Introduction

What is essential for a good use of colour in architecture? Many people would say that the choice of colour is merely a matter of taste, which means that everybody is equally qualified to express and practice their views on colour. Others press the need for artistic skill and claim that colour experience can only be expressed in a poetic manner. But colour in architecture has to meet many different demands, concerning human experience as well as economic and practical issues. To achieve this takes more than artistic sensibility. There is also a need for time-consuming work, commitment and, not least, knowledge. This knowledge is built up through research and in the practical work of architectural design, where a reflective attitude to our own and others' experiences is essential.

We live in light, which is an obvious precondition for seeing. But contrary to colour, light is seldom intellectually reflected upon, discussed or conceptualised. In building design, light is often reduced to a technical issue to be solved by others than the responsible architect. This is surprising, as light and colour are integrally related to each other. Both are aspects of the perhaps most important task of architecture: to form spaces for human life. This article discusses the issues of colour, light and space, mainly with reference to current Swedish research results and the experiences of practicing architects and interior designers, starting from an anthology published in Swedish in 2006 [1].

In a Surrounding World of Colour and Light

Why is there colour together with us humans in this world? This question, quoted from the Swedish physicist Pehr Sällström, could serve as a starting point for an exploration of the rich and challenging phenomenon of colour [2]. Colour understanding can be sought within many branches of science, but also amongst artists such as Paul Klee and Frida Kahlo and poets such

as Björner Torsson. But neither colour nor light can be fully described; however much we try there are always dimensions that reach beyond language and analysis. Colour and light are sensory qualities that have to be experienced [3].

Without the light from the sun there would be no life on earth. Without light no colours, and without colour contrasts no possibility of visual spatial comprehension. Colour, light and spatial experience are dependent upon each other, and all of them are absolutely fundamental for our existence as human beings. But what do we really mean by the concept of *light*? Physicists define light as electromagnetic radiation within a certain wavelength interval for which human vision has evolved a sensitivity and an ability to convert physical stimuli into sensual experience. The same definition is used in such science that investigates the importance of light for humans as biological beings, with the methods of environmental psychology [4,5].

But the concept of light can also be used in another way, to denote a visual phenomenon, that which we see as light. The interrelations between the physical and the visual aspects of light are complex, and to be able to sort them out we must have a clear terminology. Anders Liljefors suggests the two concepts of 'physical light' and 'visual light' to distinguish between the physically measurable radiation and the visual experience of light [6].

Also the concept of *colour* has several meanings. The psychologist J J Gibson has truly written that 'the meaning of the word *color* is one of the worst muddles in the history of science' [7]. I would add that this very muddle has resulted in a serious lack of understanding between different disciplines dealing with colour, and also to serious misunderstandings within each of these disciplines. We use the same word, colour, but we never know if we actually mean the same thing.

In Swedish the same word (*färg*) is used for experiences like red, blue or white and for what in English is called paint. Also, just like 'ligh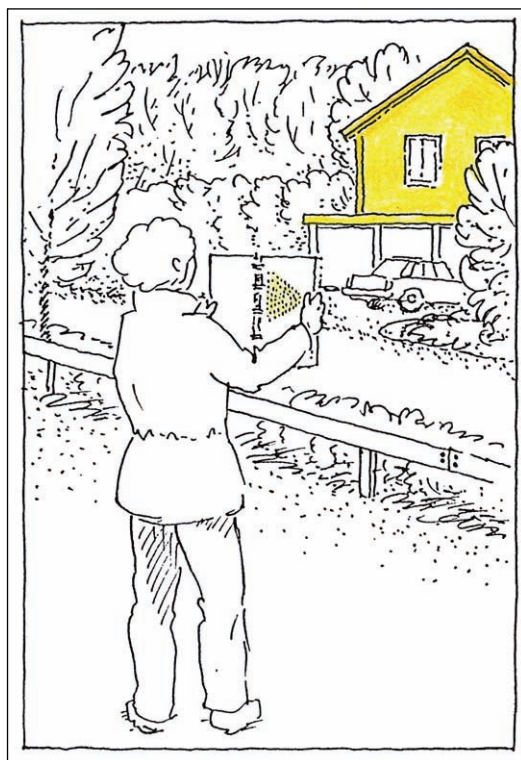t', 'colour' can be used in a physical meaning, denoting radiation of certain wavelengths. Paul Green-Armytage has identified seven different kinds of 'thing' that are named by colour names and defined each of them with reference to the means for identifying the colour [8]. In an architectural context the most important of these are *perceived colour* and *inherent colour*. The perceived colour is what we see in a specific viewing situation and is constantly varying with such as light, viewing distance and surrounding colours (Figure 1). The inherent colour can be defined as the perceived colour that the surface would have if viewed under standardised conditions, and it can be measured through visual comparison with standardised colour samples (Figure 2) [9]. The Natural Colour System (NCS) is a very appropriate tool for denoting both inherent and perceived colour and, not the least, for analysing the relationship between them under different viewing conditions. This will be shown later in this article.
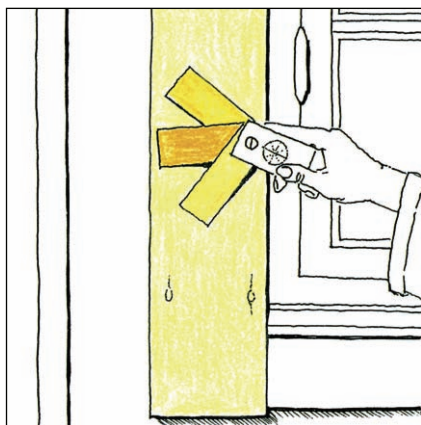

Figure 1 One way of determining the perceived colour of a facade is to compare it with the samples in the NCS atlas [9]

Figure 2 Inherent colour is measured by direct comparison with standardised colour samples [9]

Colour and Morality

Colour is, like few other architectural issues, loaded with moral and ideological connotations. To paint or not to paint, to restrict oneself to the colours of the building materials or to choose from a wider colour palette, is not only a question of what is considered beautiful or fit for the specific situation. In addition, each period in history has its norms for what is appropriate or not, and strikingly often the rationale has been based on value-loaded concepts like purity and authenticity.

Going one step further, we can see that even for painted surfaces there have been moral judgements, governing what colours should be used, how they should be combined and how colour should interact with architectural form. The most orthodox strategy has been to use only white and black, colours that could almost be seen as *not colour*, even if they were painted. There has also been the idea that the basic colours according to the principles of pigment mixture (yellow, red and blue) are more pure or authentic than other colours, as they are derived from the given preconditions of paint material. In addition to this, the use of specific colours has sometimes been given broader societal and ideological connotations, for example around 1920 when artists and architects wanted to use colour and light for the creation of a new world for a new time. Bauhaus and de Stijl are known representatives of this movement, whereas their equivalents in the young Soviet Union have long been kept outside our view (Figure 3) [10,11].

In older architecture it was very common to use the surfaces in rooms for painted pictures, but in some periods this has also been considered ugly or even immoral. We can be reminded of the pendulum swinging back and forth in these questions, when thinking of all the Swedish medieval churches whose pictorial wall paintings were lime washed in the 18th century and restored in the Gothic revival of the 19th

Figure 3 The Bauhaus school in Dessau (Gropius, 1925–26) is full of contrasts in colour, gloss and surface texture (ceiling in canteen building)

century. The same goes for such painting that imitates precious or prestigious materials. In the late 19th century techniques such as marbling and veining denoted high status, but during a great part of the 20th century they have been viewed with contempt as inauthentic 'cheating'. During the recent decades these techniques have, at least in Sweden, had a new period of high esteem and been used so much that the interest in them is once more declining [12,13].

The moral aspect of colour and material can be seen also on exteriors. Around 1950 Sweden was in the process of building of a welfare state, and suburban community centres were part of a new concept of city planning. In the Årsta community centre outside Stockholm, exterior murals created by the architects Erik and Tore Ahlsén provoked a debate, arousing great moral indignation over the alleged superficial venture of painting buildings in 'masquerade clothes' (Figure 4). One decade later a new type of architecture was created, using steel and glass, and this 'colourless' architecture gained positive judgements for its 'clarity', a quality that obviously was not seen as connected to a more uninhibited use of colour [14,15].

Figure 4 Wall paintings on cinema facade, Årsta Community Centre, Stockholm (1947–54) (Photo: L Lander)

So colour ideologies have come and gone: from the self-determining colours of materials in the 1960s, over the playful and colourful time around 1970 and onwards, towards an attitude where both the colours of materials and painted surfaces are seen as legitimate alternatives [16]. Today colour choice seems to be quite free, without pressing moral values about the superiority of one colour or another. Still it can be difficult to vindicate colour's importance for architectural totality. And still the question remains: why has colour, and no other aspects of architecture, been specifically loaded with all these moral judgements? It is never claimed that a period can be, or not be, *permitting* towards a material like stone or timber. In those cases 'authentic' and 'inauthentic' are not relevant categories. There seems to be something special about colour as phenomenon, as essence, that creates a wish to tame it. Might it be because colour, irrespective of our wishes, is uniquely important for human experiences and feelings, for better or worse?

The Architect's Work with Colour and Light

Colour and light seldom have any prominent place in architects' education, and the colours of architectural history are often forgotten or neglected (Figure 5). Thus the newly examined architect can often feel insecure if he or she abandons the stylised whiteness of the cardboard models. There are, however, also teachers of architecture who take extra efforts to introduce colour and light throughout all the educational process [17].

As education on these issues tends to be limited, the effects are readily apparent in the practices of professional building designers. Working as an architect seldom offers significant opportunities for developing a solid experience of the interaction of light and colour in the creation of space. Questions concerning colour and light are often seen as subordinate to *form*, *volume* and *function*, and therefore are introduced only at a late stage of the design process.

Figure 5 Le Corbusier, Housing estate, Berlin 1958; in spite of the intricate play with shadows and painted surfaces, colour is seldom even mentioned in presentations of this building

Thus the prophecy runs the risk of being self-fulfilling. If colour and light are not considered as central design factors, they cannot assume any great importance in the formation of spaces and space sequences. Colour becomes something cosmetic, a code system for finding the way or an attempt to cover up shortcomings in other aspects. Lighting runs the risk of being reduced to a pure technicality.

However, despite these shortcomings, there are many architects who see colour and light as important, maybe decisive, means for the forming of spaces (Figure 6). In their work, knowledge and understanding is built up through a careful recapturing of experiences from their own projects and through an interested consideration of others' work. In spite of the differences between projects and methods, the work of such architects seems to have an important common denominator: every project starts from a basic idea in which colour and light are important ingredients. The idea can be nourished from different perspectives:

Figure 6 Medieval exhibition in the Historical Museum, Stockholm, rearranged and repainted in 1996; (left) detail sketch by interior architect Gertrud Olsson, responsible for exhibition design and colouring, (right) one of the exhibition halls; in 1997 this project was given the best environmental colour design award by the Federation of Swedish painting contractors [21] (Photo: G Hildebrand)

surrounding nature, valuable components in already existing rooms and buildings, or the character of the intended function. The important thing about the idea is that it exists and offers a sounding board for all those small and big choices that constitute design work [18,19].

At the same time it is obvious that all aspects of both colour and paint are important. There are hue and materiality, gloss and texture. There are the diverse characters of stone and wood processed in different ways, and there is the difference between latex paint and linseed oil paint. And, not least important, there is the will and capability to make all the concrete decisions regarding colour, materials and processes and the persistence to follow them up throughout the building process [20].

Swedish Work on Colour, Light and Vision – Examples

For those who want to know more about the interaction of colour, light and space there is an endless number of questions but very few definite answers. Researchers working with these issues try to delimit a small part of the complex problem and explore it specifically, fully aware that they can never consider all aspects at the same time. So knowledge is built up, piece by piece, but with every new insight conquered there also arise new questions. Research can never give definite answers about the best ways to select colour and light, but it can gradually build a more solid platform to start from. Sweden has a long tradition of colour research, and this section presents some projects with direct impact on colour in architectural contexts.

In the 1960s and 1970s Anders Hård, Lars Sivik and Gunnar Tonnquist carried out their pioneering research, starting from the notion that *colour is what we see as colour*. Their research resulted in the Natural Colour System, NCS. Today NCS is an international colour language used by researchers and practitioners throughout the world [22]. During recent decades the research focus has proceeded from the study of the intrinsic nature of colour to surveys on colour perception and colour experiences in spatial contexts. How is the colour experience altered when the room is lit in a different way? How does colour influence the experience of spatiality? And how are we humans and our activities affected by the colours of our rooms?

The phenomenon of *simultaneous contrast*, also called contrast enhancement or induction, has been known for a long time and has been extensively explored by artists [23,24]. But how does simultaneous contrast work in a room, where colour is surrounding us instead of being seen on a defined flat surface? Monica Billger's experiments with simultaneous contrast and other colour effects in the three-dimensional reality have shown that colours in an enclosed space affect each other through inter-reflection much more than through simultaneous contrast (Figure 7). She uses the concept *colour elasticity*

Figure 7 The two blue walls meeting at the corner pillar have the same inherent colour but very different perceived colours due to reflections from opposite walls (watercolour from one of Monica Billger's courses for architecture students at Chalmers University of Technology) [26]

to describe how much the perceived colour of a specific material can vary within a range of given conditions (Figure 8) [25].

Also Maud Hårleman has explored colour in rooms, but her focus has been on the role of light. How is the experience of colour and space affected when the room gets its daylight from different compass directions? (Figure 9) [27]. Both Billger and Hårleman have found the same tendency for rooms where all four walls have the same colour: the colour of the room is always perceived to be darker and more chromatic than a small sample of the same inherent colour. For example, a paint that appears pale green when presented as a small colour sample gives a room that is much more clearly perceived as green.
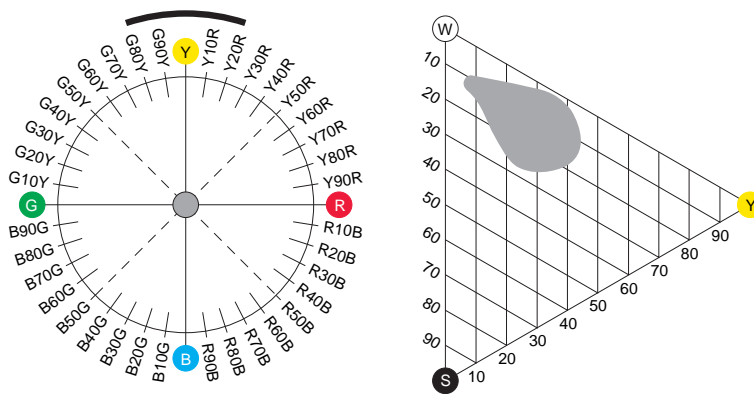

Figure 8 Colour elasticity for a specific yellow inherent colour when seen in a room with different lighting, shown in NCS circle and triangle, based on the work of Billger [25]
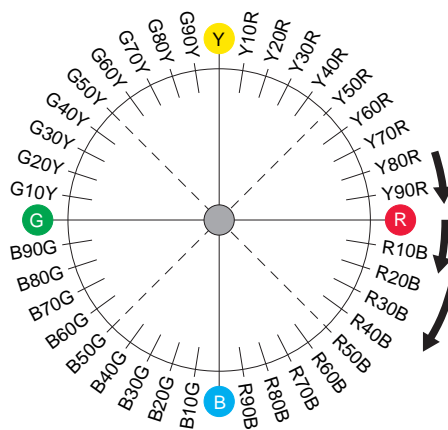

Figure 9 Tendency for hue shift of pink colours in rooms with only skylight, shown in NCS colour circle, based on the work of Hårleman [26]

Maybe this is due to the inter-reflection effects shown by Billger. Four green walls would reflect light radiation between themselves which would make all of them look even greener. It is interesting to compare this result with Karin Fridell Anter's conclusions about facade colours (Figure 10) [9]. On a facade, like just inside a room, the perceived colour becomes more chromatic than the colour sample, but whereas the room becomes darker than the sample, the facade colour is perceived lighter than that of the sample. This may be because there are no inter-reflections, or because outdoor light is much stronger than interior illumination? An
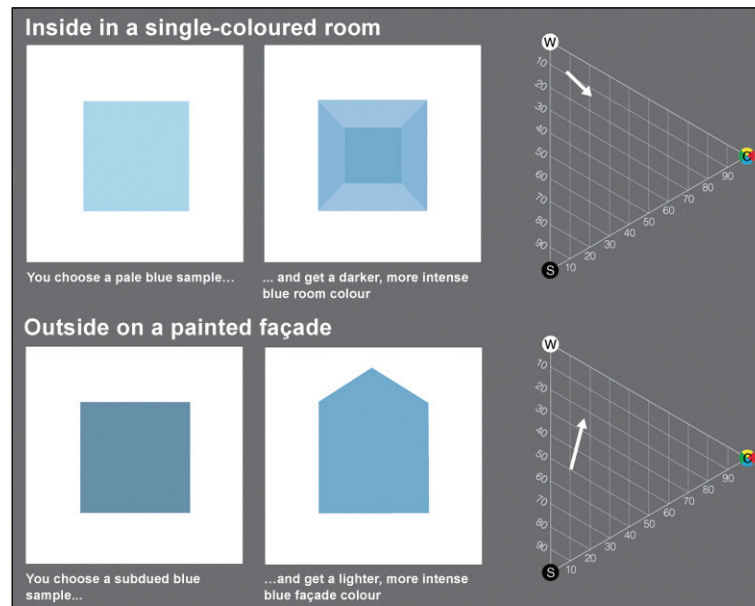
Figure 10 Colour samples and reality [1]

appreciation of the results of different researchers can create a deepened understanding in the mind of the viewer, at the same time as prompting new questions.

For several decades, Lund University in southern Sweden has been the centre of research within the field of environmental psychology. Researchers have undertaken controlled experiments on human biological and psychological reactions in different colour and light environments, and they have also asked themselves more specific questions concerning the role of colour and light in different localities. This has led to an increased awareness of the importance of colour and light. It has not, however, yielded any universal rules for good interior illumination and colour design, and given the complexity of the issue, such rules might be neither possible nor desirable [28–30].

Instead recommendations for interior illumination and colour design must start from an understanding of the specific situation. For example, Helle Wijk, a nurse, has based her research on colour issues from her own experience of the needs of elderly patients. She starts from an ambition to provide patients in stressful situations with a safe and easily understood hospital interior, and her results and their applications can be of general use for the planning of hospital wards [31,32].

Spatial Awareness and Aesthetic Attention

As has been discussed already, light and colour are essential for forming architectural space. Throughout history there have, however, been various notions on the connotations and evaluations of architecture's spatial qualities. Those intellectual premises that are jointly called *architectural theory* often take their starting points in other fields of thought than architecture itself. Religious notions of seeing God as a universally present light was echoed in Gothic cathedrals and churches with seemingly endlessly high vaults flooded with coloured light. In the early 20th century, the drive for social and technical progress gave rise to architectural

ideals expressing dynamics and movement, and with Einstein's theory of relativity, space itself seemed to be vanishing [33,34].

Still, of course, whatever architectural ideals are to be expressed, the world we live in is three-dimensional and in that sense *spatial*. Our visual sense is developed for understanding the spatial context that surrounds us, thereby providing the preconditions necessary for us to recognise, understand and evaluate what we see. Even on physically flat surfaces our visual sense strives to create an impression of space, a fact that gives rise to what is often called visual illusions. Artists over the ages have attempted to use certain codes in their flat depictions of a three-dimensional world including colour and light. One such code is the classical *chiaroscuro*, another one relies on chromatic shadows, for example used by Michelangelo in the Sistine chapel. All such codes start from an attentive viewing of colour and light in the real world. Our intuitive experience of the world around us creates mental patterns closely tied to our emotions. Thus the understanding of logically expressive symbols such as those of light and shadow are not culturally determined but created by sensual experiences common to all mankind [35,36].

Classical books on colour discuss colour harmonies, colour connotations and contrast phenomena, most often with the help of two-dimensional examples. These examples are open to new interpretations if they are taken as special cases or as representations of spatial experiences. A particular colour combination can be experienced as beautiful on a surface and ugly in a room, or vice versa. Contrast phenomena that are obvious on a surface can disappear in a three-dimensional space, where other less well understood effects can assume a greater importance. The colour and light of an enclosed space can be reproduced on a flat surface, and when we see a flat surface we unconsciously interpret it spatially. Colour, light and space are so intimately related to each other, and work together, that we can only with difficulty distinguish them as separate experiential qualities. Thus a route for new research is indicated: the joint study of colour, light and space can lead to a new and deepened understanding of our sensory experience of the world.

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