

Colour and Light in Design - Levels of experiencing colour and light

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Abstract: *In our designed culture, every environment, object and picture is analyzed from the viewpoint of colour and light. Colour and light play an important role in social life and culture. This paper springs from an epistemological project about concept formation in the field of colour and light. Based on own observations and scientific and scholarly references it presents a graphic model describing possible constituent relations between colour and light experiences. Design is the art of using knowledge – implicit or explicit – about how humans perceive, experience, and relate to the world around. In design all senses are involved, but when dealing with colour and light we can confine ourselves to vision; designers must understand the conditions of visual perception. Human experience of colour and light has many sources; the given cultural context (conventional meanings of colour and light), the direct experience of the world around (colour and light expressions) and the basic perceptual functions (formal aspects of colour and light). There is need for distinct concepts and concise approaches to understand coherence of aesthetic and functional expressions. Design education calls for coherent and well defined structures that can be used to describe connections and distinctions between experiences of different kinds.*

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1. Background

The aesthetics of colour and light play an important role in the fields of art, design and communication. Colour and light in built spaces influence our experiences and feelings, our comfort and physiological well-being. Colour and light have great impact on health and can promote visual clarity, functionality, orientation and sense of security.

When designing, colouring and illuminating objects and environment (or ourselves) a general experience of a rich and complex world around is not enough. To a designer it is also necessary to have a sound knowledge of what constitutes *how* we experience the world – both for the creative process and a critical distance. It is one thing to experience or intuitively imagine the “tone” of an object or a “mood” of a space; another thing is to be able to consciously reflect on the sources of such experiences. Professionals in the field of design must in one way or another find distinct concepts and concise approaches in order to understand coherence and causes of aesthetic expression. Such concepts and approaches are not easily found. The essence of our experiences and emotions might even be beyond the limits of (verbal) language. But, as Ludwig Wittgenstein has pointed out, even if we cannot explain them verbally they manifest themselves to the senses. They can be demonstrated and their cognitive and perceptual basis can be described (Wittgenstein 1992 p 64, 122).

Creativity requires conceptual means to consider conditions and nature of intuitions and experiences. And this is not only important for designers, artists and researchers. It is also highly important to technicians and politicians – and, actually, to all of us. We are all responsible for how the world is designed. In design all the senses are involved, but when dealing with colour and light we can confine ourselves to vision; designers must understand the conditions of visual perception.

Colour and light are only seldom integrated from the beginning in the design process in education. Traditionally colour and light in design and design education have been looked upon as something that is discussed when the design is finished; designed objects or designed spaces are thought to be ‘coloured’ and ‘illuminated’ afterwards. This educational choice – or lack of choice – is done in spite of the fact that appearance is basic in spatial design, and that colour and light are absolute conditions of appearance. This way of looking at colour and light as being subordinated and of minor importance is based on an insufficient understanding of human visual perception and on basic conceptual confusions.

Academic research about colour and light is split between several disciplines. There is also technological research and development of light sources, light fittings, dyes, paints etc. carried out by industry. This division between different institutions and organisations has led to diverging research traditions and conceptual approaches.

Manufacturers and researchers often have difficulties understanding and forming opinions about each other’s methods and results, although they are working with similar questions. One important aspect of this is the absence of common and generally accepted concepts. The confusion about the concept of *colour* is discussed in Green-Armytage (2006). The need for specifications of the concept of *light* is discussed in Liljefors (2006). In design education this incoherence of the field has resulted in confusion of ideas about the nature of colour and light.

2. Colour, light and space

We live in a spatial and continuously changing world. Our cognitive and perceptual systems derive their distinctive characters from this fact. Even if our perceptions are subjective, our basic spatial experiences are natural perceptual facts and functionally universal. All senses add to the experience of a spatial and changing world around, but the principal *spatial* sense is sight. Vision provides a coherent and continuous understanding of space. We always experience the surrounding world as three-dimensional: visual patterns that *can* be understood as spatial are given naturally such an interpretation in perception (Gregory 1966, pp 147).

Traditionally, research about colour has most often neglected the need of knowledge about spatial visual perception, and although colour and light are mentally inseparable in our experience of the world around, the complicated relation between colour and light experiences has not been given attention. Colour phenomena have usually been presented two-dimensionally and without intention to be spatially experienced. If colour phenomena are abstracted from their natural and simultaneous connections to light, spatial order and cultural context, the causal relations behind them become inconceivable and mystified.

Concepts describing colour and light as integrated in a spatial whole have to be based on coherent spatial experiences. Spatial perception demands spatial relations and directions, size gradients, enclosure, etc. David Prall (1936, p 39) says:

You cannot make a spatial whole except with elements the very nature and being of which is spatial extension – The elements must lie in an order native to their being, an order grasped by us as constituted by relation. We call structures intelligible (–) so far we find them capable of analysis into such elements so related.

Colours as such have no spatial extension. They have no formal structure except colour qualities related to other colour qualities, i.e. contrasts in lightness, whiteness, blackness, hue or chromaticness (this colour terminology refers to The Natural Colour System, NCS – The Swedish standard for colour notation). If focusing on colour in spatial context, colour and light theory is given theoretical connection to our intuitive understanding of the world around and can be part of a wider field of aesthetic research and education.

3. Colour, light and physics

In the field of colour and light, visual/perceptual phenomena too often are described and analysed with the use of physically based concepts. This can give the impression that physical measurements also measure what we see. But this impression is false and it is not only a question of simplification. Using physically based concepts to describe perception of colour and light may be both misleading and incorrect. This does not, however, mean that concepts referring to abstract but measurable structures of the physical world are not useful. But they are useful only as long as they are used to describe the material world. It is, for example, necessary for paint industries and light source industries to have instruments to control and maintain physical standards of their products.

We experience colours intuitively as properties belonging to the outer world. In the physical world – beyond the reach of the senses – the existence of colour and light can

only be demonstrated indirectly by measuring spectral electromagnetic radiation with wavelengths between approximately 380 nm and 760 nm. The human eye responds to this radiation, but the rays themselves are not visible. Isaac Newton remarks that “the rays, to speak properly, are not coloured. In them there is nothing else than a certain power and disposition to stir up a sensation of this or that colour” (Newton 1704).

It is true that experience of colour and light is dependent on electromagnetic radiation but the colour of an object are only to a certain degree dependent on spectral distribution of the radiation that it reflects. The Norwegian neurophysiologist Arne Valberg states: “The reflection properties of surfaces relative to their surround are more important for colour vision than the actual spectral distribution reaching the eyes.” (Valberg 2005, p 266). The American philosopher C.L. Hardin concludes that there is no “reason to think that there is a set of external physical properties that is the analogue of the (colours) that we experience” (Hardin 1993, p xii).

4. Colour, light and adaptation

The relationship between the physically measurable and vision is complicated. Our perceptual systems counterbalance physical changes in the world around. Our vision is based on a continuous adaptation, which strives to keep the colours of the surrounding world.

When perceiving colours, our vision does not register the absolute intensity or the absolute spectral distribution of radiation that reaches our retina. Instead *distinctions* and *relations* are registered. Hence our visual system is developed for a continuous spectrum of light and gradual changes between different illuminations. Under these circumstances we perceive colours as more or less constant if our visual system has had time to adapt to the specific light situation.

The mechanisms that make us perceive and determine the lightness of surfaces observed in different situations have been thoroughly considered by Alan Gilchrist et al (1999). Gilchrist et al. state that it is not the luminance that determines the perceived lightness of a surface. Any luminance level can be perceived light or dark depending on context, and the surface that we perceive as white functions as an “anchor” for perceived lightness of all other surfaces seen simultaneously.

Most often our anchor for “white” is defined as the surface that has the highest luminance in the visual field – *Highest Luminance Rule*. This is, however, not true in all situations, since we also have a tendency to perceive the largest area in the field of vision as anchor for “white” – *Area rule*. As long as the lightest area also is the largest, the two rules coincide, but they come into conflict if the darker one also is the largest. Then we tend to perceive the largest area as white at the same time as the smaller and lighter area also is perceived as white - a paradox that is solved by perceiving the smaller area as luminous.

But even if we experience that an object has the same colour in different light we can at the same time perceive a slight tone of colour that reveals the character of *light*. All colours have at least a slight chromaticness and a hue. We never experience absolutely neutral – achromatic – colours (Fridell Anter and Klarén 2009). For nominally white surfaces this effect is more obvious than for nominally chromatic surfaces. We experience the surface as white but we understand at the same time that it is illuminated with a light of a special quality and intensity. This involves not only light coming directly from the light source, but also reflected light from surrounding surfaces. Reflection from chromatic surfaces in a room can give a hue to a nominally

neutral or slightly chromatic surface, which is especially evident in nominally neutral light surfaces (Billger 1999).

Klarén and Fridell Anter (2011) have shown that the “lightness anchor” also functions as a perceptual anchor for experience of hue. With an analogy from music theory white anchoring could be regarded as a “transposition” where the surface that is perceived as white is the “keynote” – or “keycolour” – for perception of both lightness and hue in a given light situation; the “keycolour” decides all relations between the colours in the field of vision.

The French philosopher Merleau-Ponty (2002, p 355) discusses how we experience the surrounding world in different ways depending on situation. He makes a distinction between two modes of attention: he talks about *the reflective attitude* and *living perception*. We use the reflected attitude when we attend to and consciously compare one colour to another. In living perception colours are manifested to us in the totality of spatial relations; it is the everyday way of attending to colours. Depending on modes of attention, a nominally white surface lit by ‘warm’ sunlight can be seen, with a reflective attitude, as slightly yellowish. With living perception, however, we may feel that *the same* surface is white; we experience intuitively that it also has – independent of the accidental yellowish light – a constant colour experienced beyond the perceived colour. One could call this colour *constancy colour* (Klarén 2012, p 24). Constancy colour refers to a natural perceptual ‘skill’; we intuitively summarize the totality of perceived visual information in a given context.

We have a tendency to regard the constancy colour as the “proper” or “real” colour of the wall. Ewald Hering’s concept *memory colour* (Gedächtnisfarbe) touches on this phenomenon, but confines it to expected colours in objects: “What the layman calls the real colour of an object is a colour of the object that has become fixed, as it were, in his memory; I should like to call it the memory colour of the object” (Hering 1920). Merleau-Ponty says that the “real” colour persists “not as a seen or thought-of quality, but through a non-sensory presence.” (Merleau-Ponty 2002, p 356).

All these colour and light interactions are what makes us perceive space visually. Normally we have no difficulty in making distinctions between what is caused by the light and what by the qualities of surfaces. The logically distributed colour variations caused by light, reflections and shadings are to our intuition natural and indispensable spatial qualities.

There is a tight perceptual attunement between us and the world around. The experienced world is in ecological balance with the human environment, and the perceptual relation between the outer world and the human inner world is without hindrance.

In addition to the basic perceptual processes and the direct spatial understanding of the world around, human comprehensive experience of colour and light is also related to culture. Imaginations, conceptions and ideas *about* the world provide a context to our sensory experiences. The American philosopher Alva Noë (2004, p 1–3) remarks that adaptation is not limited to basic physiological reactions. It is both perceptual and cognitive and derives its origin from multiple sources, external as well as internal. Human experience of colour and light in the world around is related to the context as a *whole*. It is made up from interplay of the individual and the world on many levels. In this sense colour and light are *natural* but *non-physical*.

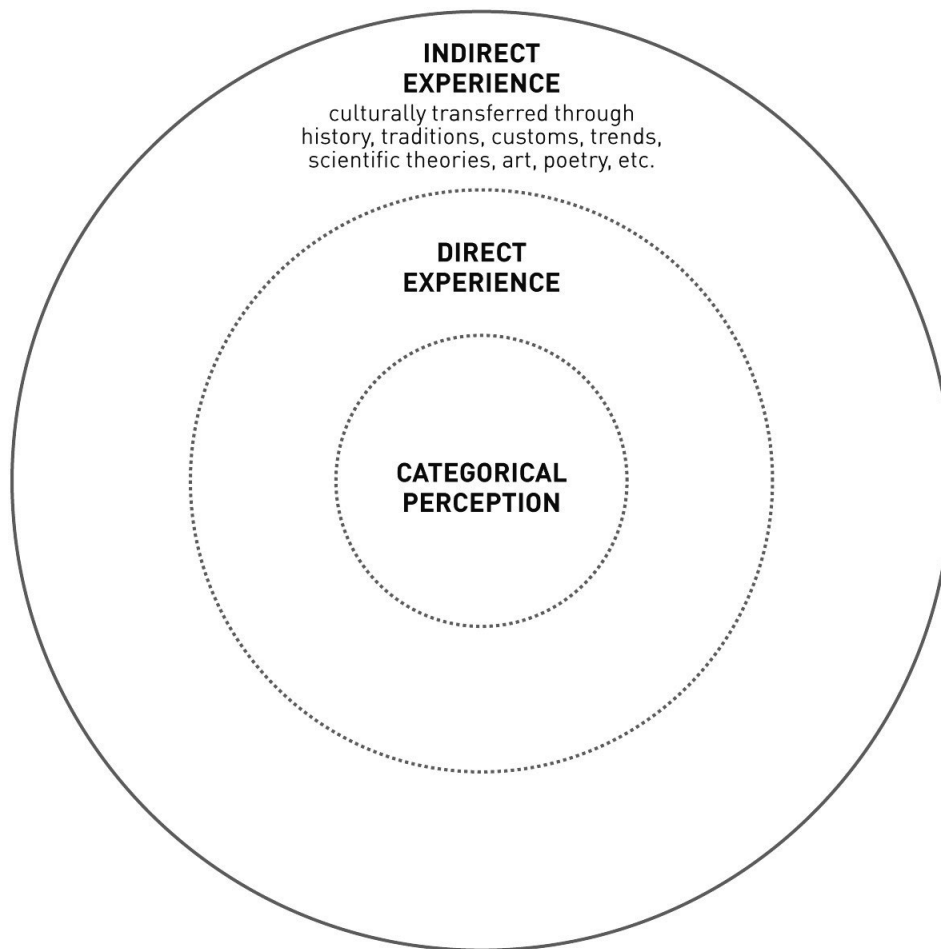


Figure 1. Experience levels (Model by Ulf Klarén)

5. Levels of experience

It is true that we *see* colour and light, but what we so vividly *experience* is a *coherent* world full of life and meanings. The human experience is multidimensional and dynamic. Its totality cannot be described easily. Just like all sensory experiences, colour and light are perceived and understood on different levels: from the basic that are common to all humans to the most rapidly changing cultural trends.

Figure 1 shows levels of experience - from experiences based on *categorical* – basic – *perception* (formal aspects of colour and light) through *direct experience* of the world around (colour and light expressions) to the *indirect experience* (conventional meanings of colour and light), imbedded in cultural expressions; history, traditions, customs, trends, scientific theories, art, poetry, etc.

5.1 Categorical perception

Categorical perception gives basic spatial and temporal structure to experience of the surrounding reality. It comprises the basic perception of colour, light and space, balance, verticality and horizontality, movement, etc.

We perceive the surrounding world (and ourselves) in time and space, as were it, without hindrance. The world appears as an *aesthetic surface* (Prall 1936). We perceive patterns of colours, shapes, sounds, scents, tastes and textures as part of a spatial context. The ultimate purpose of categorical perception is to build a comprehensive mental image of the human world: "A reality without well-defined borders is divided up into distinct units by our perceptual mechanism" (Gärdenfors 2000, p 20. Our transl.) . By natural selection man has been endowed with certain perceptual and cognitive tools for survival that are basically common to us all. Categorical perception is in some respects determined genetically, but for the most part acquired in early life.

Perceiving colour distinctions and colour similarities are basic to colour perception. If, for example, in a colour combination, the colours have the same whiteness, blackness, chromaticness, hue or lightness, we can sense that these colours have something in common. We are use to saying that colours in such colour combinations *fit together* or *harmonize* or that the colours of a painting or a room *hold together*. This experienced unity of colours, however, has nothing to do with preferences. It follows from the visual system itself: the ability to recognize colour distinctions and colour similarities is part of the categorical perception and is therefore predetermined. It is natural in the same sense as recognition of characteristic colour scales in perceptive colour systems.

5.2 Direct experience

By *direct experience* we gradually learn through living to understand the relations of colour and light to the world around. The direct experience is dynamic and simultaneous; perceptions, feelings and emotions form a coherent whole. Making use of natural perceptual abilities (the categorical perception) and interplaying with the physical world we develop perceptual "skills"; we acquire abilities to catch the spatial significance of colour and light in space. We also learn to recognize the perceptual qualities of materials, how they feel and how colour and light relate to them, etc. Patterns of sense-qualities always belong to functional situations in life, each one having a characteristic perceptual and emotional content; the light always illuminates *something*, it is always *something* that has a colour, and a spatial situation always has a special atmosphere. Direct experience provides spatial understanding, meanings, and emotional content to the physical world around.

The German philosopher Gottlieb Baumgarten, originator of Aesthetics as a specific academic discipline, describes knowledge that implies a coherent intuitive understanding and is given to us directly by sense experiences. Baumgarten claims that aesthetic knowledge *constitutes* logically based knowledge, "that sensible cognition is the ground of distinct cognition; if the whole understanding is to be improved, aesthetics must come to the aid of logic" (Baumgarten 1983, p 80). The tacit meaning of the direct visual experience of colour and light, materials, textures and objects is an aspect of our aesthetic approach to the world.

5.3 Indirect experience

In the *outer* circle we find *indirect experience* - principles, concepts or models that help to understand or give perspective to experienced phenomena in the two inner circles. Being embedded in cultural expressions (history, traditions, customs, trends, scientific theories, art, poetry, etc.), indirect experience forms a cultural context to which all experiences of necessity are related. History, scientific theories and theoretical models provide a basis of explanation and analyses. Traditions and customs serve as guiding rules. Art and design, literature and poetry summarize common experiences: art and design with expressive or significant form, literature and poetry with verbal language. Thus indirect experience can convey meanings and feelings to phenomena based on direct experiences and categorical perception.

The indirect experiences can change and be reinterpreted, but can never totally be taken in or controlled by the individual. Indirect experiences are implicitly present in all perceptions. Abstract figures or words can be associated with symbolic meanings and scientific theories may refer to perceptual appearances. A colour combination, a specific light situation, a designed object or a spatial design may – as content of an associative symbol – be connected with special concepts or feelings. Associative symbols are basically social/cultural understandings. They are arbitrary and can be changed or replaced. The associative symbols may not be mistaken for the emotional content that has its origin in direct experience and the individual's perceptual interaction and interplay with the world around.

Being dependent on their origin the principles, models or concepts of the outer circle have indirect or direct relations to phenomena in the two inner circles: visual symbols and concepts used in perceptual colour or light theory refer *directly* to phenomena in the two inner circles, whereas concepts and symbols describing the outer world in abstract terms have *indirect* relations to them; thus words, figures and concepts based on physical analyses with quantitative measurements and instrumental methods have an indirect relation to perceptual phenomena.

The three experience levels are interdependent and implicitly present in all perceptions. A perceived distinction between a red colour and other colours is a basic – categorical – perception. The experience of the colour of a wall – whether in light or shadow – is a direct experience of the world around. The knowledge that red has a special position in a colour system, or that red surfaces absorb electromagnetic radiation in a special way, or that red houses may be of high social importance, is based on indirect experience.

Art and design have a special and complex relation to direct and indirect experience. On the one hand artistic works can serve as "models" or "examples" for how we may attend to light and colour in our direct approach to the world. On the other hand they are also, as appearances, direct experiences.

Experiencing colour and light in a living context always includes emotional and intuitive understanding; we experience spontaneously spatial relations and moods in a cultural context. This is how our overall perception normally works. In adopting an aesthetic attitude we consciously attend to this spontaneous process of understanding; perceiving aesthetic qualities in art and design – or in the world around – means that we open up for reflection on experiences us such.

The American philosopher Susanne Langer's aesthetic philosophy is a part of the epistemological tradition from Baumgarten. Connecting to Wittgenstein she asks, *how*

do we give symbolic form to the tacit dimension of our direct experience? She claims that the emotional content we can experience in a piece of art or a designed object is symbolic in a special way (Langer 1957, p 60); perceptual patterns of colour, light and form, abstracted from their normal context in life, can be used as symbols for *felt life* in pieces of art and in designed objects. Susanne Langer calls them *logical expressive – or articulated – symbols* (Langer 1953, p 31)

Wittgenstein (1993, p 19) says that feelings follow experience of a piece of music, just as they follow courses in life; a piece of music consists of a sequence of tones. It has a structural resemblance to courses in life – a rhythm, pauses and breaks, pitches, etc. – and thus they can be used as examples. The auditory structure in music is not a course of life, but felt life abstracted in a logical expressive symbol. The same is true for all sensory experiences.

The expressive symbols are what we may call the artistic or aesthetic dimension in pictures, in utility goods, in architecture; they can make us feel something *in* something or see something *as* something. Susanne Langer (1957, p 73) describes them as *objectification of feelings*. As logical expressive symbols, colour and light expressions in art and design can serve as *examples* of direct experiences that may promote new perceptual approaches the world.

The logical expressive symbols occur in the borderland between direct and indirect experience. What we are used to calling “expression” in an articulated object or space is perceived as a direct experience, but without being separated from its symbol. Encountering articulated patterns in a piece of art or a designed product we experience recognition. Susanne Langer says that “in one way, all good art is abstract, and in another way it is concrete” (Langer 1957, p 69). The aesthetic dimensions in art and design are, depending on aspect, both direct and indirect experiences.

6. Conclusion

In a sense colour and light are “always something else”. They have many aspects and their relations to different levels of experience must always be considered. Our visual experience is not without structure or laws and there are certainly many concepts describing it. One could even say that there are too many – and disparate – concepts to be useful in communication. What is emphasized here, however, is the need for a coherent and well defined overall structure of content. Without a comprehensive structure of content it is not possible to see how different kinds of colour and light experiences – and colour and light concepts – are related to each other, or in what respect they refer to different aspects of reality.

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