Colour and light in space: Dynamic adaptation and spatial understanding

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Abstract

Based on our own observations and on scientific and scholarly references this paper discusses the appearance of colour constancy and the adaptation of colour and lightness in space. It presents part of an ongoing work, the aim of which is to formulate a spatially based colour knowledge.[1] Our scientific approach is holistic and mainly directed towards colour and light phenomena as such, not towards underlying physiological processes. Earlier research has discussed lightness perception in colours very near neutral grey, with so low chromaticness that you can ignore the hue. In our research we have found that surfaces with nominally chromatic colours under special circumstances can be perceived as white and thus serve as anchors for perception of other colours in the field of vision. We also discuss how distinctions are made between perceived colours caused by on the light colour and such caused by the surface qualities. What we call adaptation is not limited to basic perception. Experience of colour in space is both perceptive and cognitive, as part of interaction between the individual and the world on many levels.

1. Colour perception and physical measurement

In the field of colour and light, visual/perceptual phenomena are too are often described and analysed with the use of physically based concepts. This can give the false impression that physical measurements also measure what we see. The relationship between the physically measurable and our vision is, however, very complicated. Our vision is based on a continuous adaptation, which strives to keep the colours of the surrounding world such as we recognize them. But our adaptation not only depends on basic perceptual *reactions* but also on cognitively based *understanding* of the colour and light situation in the surrounding world. 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 paid attention to.

2. Anchoring of lightness perception

Our visual sense adapts to current light conditions: we perceive almost the same colour of an object independent of the light, on condition that the light source emits light with a full and continuous spectrum and that 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 professor Alan Gilchrist et.al (1999). They present a number of theories and discuss them in relation to many experiments carried out

1 Parts of the project *Den rymliga gråheten* (*The spacious greyness*), Konstfack 2008) have been presented with two papers at AIC in Sydney 2009 . The subsequent project *Så vitt vi vet* (*White - as you like it),* Konstfack 2009 is currently under publication in Swedish.

by researchers since the late 19th century. As pioneers they especially emphasize Katz (1935), who is characterised as a phenomenologist, and Koffka and other upholders of the Gestalt theory (Koffka 1935). As a result Gilchrist et al. present a new theory: *The anchoring theory of lightness perception.*

Gilchrist et al. state that it is not the luminance that decides 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.

3. Nominal chromatic colours as anchors for perception

Gilchrist et al. discuss how we perceive lightness in areas that are very near neutral grey, in other words colours with so low chromaticness that you can ignore the hue. In our research we have gone further and studied colours that have nominal hue and chromaticness. We have tried to find out if surfaces with nominally chromatic colours under special circumstances can be perceived as white and thus serve as anchors for perception of other colours in the field of vision. We also have tried to find out if this anchoring may affect also the perceived hue of other colours seen simultaneously.

We have with the help of observers tested how he nominal hues of light colours affect the perceived hues of darker colours in the field of vision. One of these observation series was carried out on a LCD Monitor, where 45 combinations of whitish but just slightly chromatic backgrounds and darker greyish samples were shown to 10 observers who were asked to assess the hue of the darker colour with reference to NCS elementaries. The answers of the observers gave a clear support to the hypothesis that the perceived colour of the sample shifts in the direction of the complementary colour of the nominal background colour. This could be interpreted as a classical simultaneous contrast.

Apart from the answers given, it is, however, interesting to discuss answers to the question never asked; the observers where not asked to describe the whitish background colour. Not a single observer commented on the colour of the background and no one gave any indication that there were any differences between the backgrounds. The French philosopher Maurice Merleau-Ponty discusses how we experience the surrounding world in different ways depending on situation. He makes a distinction between two modes of attention: *the reflective attitude* and *living perception* (Merleau-Ponty 1989). This distinction is significant to our perception of colours. Strictly speaking it is not possible to find out how we perceive colours in *living perception*, since every question that directs our attention towards a colour of necessity gives rise to a *reflective attitude*.

Our interpretation is that, in our test, the observers had a reflective attitude towards the darker greyish samples; these were the subjects of the conscious analyses of colour qualities. The whitish backgrounds were seen as simply ”backgrounds” with a spontaneous living perception. The perceptive shift of hue of the darker greyish samples on the whitish backgrounds could be interpreted as a result of adaptation to the surface that spontaneously was perceived as white. Gilchrist et al. have shown that what we perceive as white perceptive anchor and determines the lightness we perceive. Our studies indicate that the acts as a perceived white can be an anchor also for perception of hue. All colours have, at least, a slight chomaticness and a hue. We never experience absolutely neutral – achromatic – colours. 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 (Fridell Anter and Klarén 2009; Klarén and Fridell Anter 2009).

This may give a new interpretation of the *simultaneous contrast* phenomena (Gelb 1929). In our understanding *simultaneous contrasts* are no specific optical illusions. They can be regarded as isolated *examples* of the function of normal vision in *all* spatial situations. Continuously changing light conditions in the surrounding world are counter- balanced by perception and thereby a continuous and relatively constant experience of colour and light is maintained.

Demonstration of simultaneous contrast is an important – and conspicuous – element in almost all literature about colour theory. Is usually presented two-dimensionally and without intention to be spatially experienced. One important example is the work of Joseph Albers (1963). Thus traditional colour theory has not observed the fundamental connection between simultaneous colour contrast and colour and lightness adaptation.

4. Colour in a spatial whole

When perceiving colours our vision does not react to 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 light situations and under these circumstances we perceive colours as more or less constant. 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. For nominally white surfaces this effect is more obvious than for nominally chromatic surfaces. We experience that the surface is 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 neutral light surfaces (Billger 1999).

Dependent on *modes of attention* a nominally white wall lit by a “warm” sunshine can be seen as slightly yellowish (with a reflective attitude) or as pure white – as a lightness anchor – or as the imagined “real” colour of the wall experienced “beyond” the two perceived colours (with living perception). As a suggestion we call this imagined colour *constancy colour* (Figure 1). According to the American philosopher Alva Noë, different kinds of visual appearances can be experienced simultaneously. Noë gives an example from shape perception: When a circular plate is held up in an angle we are able to experience circularity in what we simultaneously perceive as an elliptical shape. In the same way, we can experience a white constancy colour in a surface that we simultaneously perceive as having a hue caused by light (Noë 2004).

All these colour and light interactions are what make us perceive space. Normally we have no difficulties to make distinctions between what is caused by the light and by the qualities of surfaces. Perhaps we do not attend or give interest to the accidental colour of direct light, of

Figure 1. View from a winter day in Norway: The nominally white snow can be seen as slightly bluish and yellowish as effects of sunlight and shading or as pure white as a lightness anchor. Beyond the perceived colours we experience the constancy colour, the imagined "real" colour of the snow. Photo: Ulf Klarén

reflected light or in shades. But intuitively the logically distributed colour variations caused by light and reflections are indispensable spatial qualities.

Experience of colour in space is both perceptive and cognitive. What we call adaptation is not limited to basic perception (Noë 2004); it is interplay between the individual and the world on many levels. These include the basic level of hereditary basic reactions, the level of perceptive skills based on direct experience of the world and the level of cultural context. To understand and to describe colour phenomena it is necessary to regard colour as an integrated part of the comprehensive and dynamic perceptive process of exploring the appearance of the world as a – spatial – whole.

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