COLOUR AND LIGHT: CONCEPTS AND CONFUSIONS

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ABSTRACT

Colour and light are things that all seeing persons have often reason to refer to, comment and discuss. Such discussions often end up in misunderstandings due to the fact that both *light* and *colour* have several – and often conflicting – meanings. This causes problems for professionals in either colour or light or both, for example when quantifying light, discussing light qualities or specifying an exact colour and its characteristics. This paper summarises a project that aimed at sorting out the confusions and at contributing to a better understanding across different disciplines and professions dealing with colour and light. The project identified numerous conflicting usages and potential causes of misunderstanding in the colour and light terminology. A careful analysis of the most important concepts and their usages was carried out. Three main causes for potential misunderstandings of colour and light terminology were found: 1) confusing the different ways of understanding colour and light through physics, human perception or attempts to combine the two. 2) the confusions caused by different modes of appearance of colour and light and 3) the confusions arising from different of modes of perception.

1. INTRODUCTION

The study was carried out in English, with some references to Swedish and Finnish languages. Despite dealing with terminology, it was not a linguistic project; the focus was on concepts and their use, rather than linguistic differences. We therefore believe that the findings of this study can be readily used and tested in various language environments.

There are two basic approaches to formulating terms that define colour and light. The first is based on our visual experience of the world. This experience spans – as biologically inherited and culturally accumulated knowledge – the whole length of human evolution. The second is based on physics as a scientific way to explore and understand nature. This approach is only a few centuries old and is permeated by a tradition of exact quantification. Psychophysics is a branch of science that aims to bridge the worlds of experience and physics by formulating quantifiable relationships between the two. *Photometry* and *colorimetry* are examples of such endeavours.

Confusions usually arise from words or sentences being understood in diverging ways. One type of confusion arises from mixing concepts belonging to different academic or professional traditions, as in the photometrically defined measure *luminance* and the perceptually defined attribute *brightness*. Another type of confusion is exemplified by *lightness* and *brightness*. Both terms have specific definitions in perceptual science, but at the same time they have their different usages in everyday language.

A third type arises when general experiences or categories have to be further defined for scientific or technological purposes. These can be similar, but not exactly the same, in

different conceptual systems. For example, in everyday language we can talk about *vividness* of a colour and be reasonably confident of being understood; but there are many terms in scientific and technical usage, such as *chroma*, *chromaticity* and *chromaticness*, that have similar or slightly different meanings that can still differ from the everyday concept of vividness. Especially problematic are words that are given alternative conceptual definitions in science, while having a more or less stable and established meaning in everyday usage. Take for example *saturation*: even if each of the scientific and technical definitions is clear, it is very confusing that one term can have so many different definitions.

There are also generic words and terms that have very specific meanings within a given scientific discourse, such as the concepts *inherent colour* and *identity colour*. The words *inherent* and *identity* have meanings that can lead to misinterpretations by those not familiar with the scientific discourse.

2. SOME CONCEPTS AND HOW THEY ARE CONFUSED

2.1 Lightness and brightness

The words *lightness* and *brightness* have both wide generic use and specified scientific applications. In everyday usage 'light' and 'bright' are sometimes used synonymously. For instance a room can be described as either "light" or "bright" with reference to either its surface colours or its illumination or both. Modern perceptual science has reserved separate and distinct meanings for these two words: "Lightness is the perceived reflectance of a surface – – Brightness is sometimes defined as *perceived luminance*." (Adelson 2000).

Neither lightness nor brightness can be physically or psychophysically measured. Photometric units and measuring tools are based on methods of measuring electromagnetic radiation as weighed against a theoretical model of the light-sensitivity of the visual system. This gives information about such as the *reflectance* of a surface and the *illuminance* (lux) reaching the surface. The *luminance* referred to by Adelson is measured in candela/square metre and *can* be measured. Luminance has an indirect relationship with reflectance and illuminance, but none of these is the same thing as the experience of *brightness*.

2.2 Inherent, identity and nominal colour

The very word colour is used in a number of conflicting meanings, a matter that has been previously discussed by Paul Green-Armytage (2006). We have identified the following usages of the word: The perceptual aspect of colour includes conventional colour names and terms referring to artistic work, but also perceptually defined terms for scientific use, such as the NCS colour properties. The physical aspect of colour is defined by spectral power distribution. Technological colour concepts are defined from the way colour is produced in a specific process, such as RGB or CMYK, and are not applicable in other contexts. The aim of the psychophysical approach is to describe perceived qualities through the use of physically measurable quantities, such as the units of CIELAB or different colour appearance models. (Fridell Anter 2012).

In The Swedish Institute of Standards edition SIS 1993, 2.6 the terms *inherent colour*, *body colour* and *local colour* have been offered as translations of the Swedish word and concept "egenfärg", which translates more literally into English as (an object's) "own colour". This was based on the work of Anders Hård, whose definition of *inherent colour* was as follows: "… the colour that one imagines as belonging to a surface or a material, irrespective of the prevailing light and viewing conditions". (Hård & Svedmyr 1995, p 215; our translation). Hård´s definition includes a method for operationally determining the inherent colour, which obscures the notion of an imagined 'real' colour: "... it can be operationally determined e.g. through comparison with a standardised colour sample." (Ibid.) Here Hård in

effect refers to the standardised viewing conditions under which the NCS samples are perceived to correspond with their codes. Hård implies that the colour perceived under these conditions is equal to the 'real' colour.

Karin Fridell Anter has used *inherent colour* in a meaning different to the above, as a reference point or 'helper concept', to which perceived colour changes of surfaces are compared. Unlike Hård, Fridell Anter makes no claims about the inherent colour representing any 'real' colour. (Fridell Anter 2000, pp 59–64). We suggest, therefore, that to avoid confusion, the term *nominal colour* be used as a more fitting description of the concept behind *inherent colour*.

Monica Billger has introduced in her thesis *Colour in Enclosed Space*, the concept of *identity colour*: "*Identity colour* is defined as the main colour impression of surfaces or parts of a room that are perceived as uniformly coloured." (Billger 1999, p 11). Billger remarks: "The perceived colour is analysed on two levels of reflective attention, one that can be called holistic and one that is more detailed" (Ibid.) By changing our mode of attention we are able to separate the various layers or spatial attributes of perception.[1] This shifting of attention between local and global or between object, light and shadow, is a part of the normal working methods of any visual artist. The difference between the reflective attentions of an artist or visual researcher and those of the 'man in the street' is one of level of consciousness. Neither *nominal colour* nor *identity colour* claims to represent 'the real colour of the object'. The important difference between the two concepts is that *nominal colour* can be measured by comparison to a colour sample, whereas *identity colour* cannot be measured or operationally determined in any way, only perceived through holistic reflective attention.

2.3 Saturation, purity, chroma, and chromaticness

The chromatic strength or vividness of a colour can be judged with perceptual, physical or psychometric criteria. If perceptual criteria are used, they usually apply to 'related' colours; if physical or psychometric criteria are used, they can refer also to 'non-related' colours. A colour's mode of appearance depends largely on its degree of relatedness. In related colours (surfaces, colour chips etc. viewed naturally) the scale of vividness is: neutral white, grey or black – fully vivid colour. In the Munsell colour system, vividness is called *Chroma* and is judged in proportion to a neutral grey of the same value (lightness). In the NCS vividness is called *Chromaticness* and is judged in proportion to the sum of the colour's blackness and whiteness. The NCS includes a concept of *saturation* that is unique and different from all other meanings of the word: colours that lie on a straight line connecting NCS black and any other colour of the same hue display a constant relationship of whiteness and blackness and thus, according to this NCS definition, possess equal saturation. (Arnkil 2012).

In non-related colours (a light source surrounded by darkness, a surface colour viewed through an aperture), the scale can be: darkness (no light or colour) – maximally bright chromatic light (devoid of blackness or whiteness). This is called *Chromaticness* in CIE terms. Alternatively the scale is from neutral achromatic (white) light to fully chromatic light of the same luminance. This is called *Saturation* in the CIE system. (Billmayer & Saltzman 1981).

There are two further terms related to the concept of vividness in the CIE system. *Excitation purity* is a term related to the CIE 1931 xy chromaticity diagram. It relates directly to the psychometric concept of tristimulus values of spectral sensitivity in the human visual system. (Optical Society of America 1973). *Chromaticity* is defined as the hue and saturation of a colour without regard to its luminance. In the CIE chromaticity model a very dark green and a very bright green could have the same chromaticity. The difference between colours of

[1] See for example: Merleau-Ponty, M. (2002). *The Phenomenology of Perception*. London and New York: Routledge.

equal chromaticity and equal saturation, then, is that colours of equal saturation may vary in hue whereas those of equal chromaticity may not. (Arnkil 2012)

To add to the confusion, the various three-part formulations of colour of computer programmes, such as HSV, HSL and HSB (based on the concepts of hue, saturation and brightness or lightness), all tend to treat the S-variable of saturation differently. It is judged in relation to either blackness (0 output in all RGB channels) or whiteness (maximum output in all RGB channels), but along different paths, depending on the shape of the HSV/L/B space in question.

3. CONCLUSION

The above are just a few of the examples of how misunderstandings can arise when talking about 'light' or 'colour' across disciplines. One of the greatest stumbling blocks is using the terms without reference to their context. Different applications and different modes of appearance of colour and light may require different terms and different definitions. The key to communication and understanding is in identifying the differences in conceptual approach. Only this way the wealth of knowledge about colour and light residing in the traditions of physics, psychophysics, perceptual experience and the various technologies will become fully available to research across disciplines. When speaking about human needs and endeavours in colour and light, the common denominator and final reference point for all the approaches is the human experience of 'colour' and 'light'.

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