Colour and Light:
Concepts and Confusions

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SYN-TES
HUMAN COLOUR AND LIGHT SYNTHESIS
towards a coherent field of knowledge

INTRODUCTION

Confusions and misunderstandings arise, because both light and colour have several – and often conflicting – meanings. This causes problems for professionals when quantifying light, discussing light qualities or specifying an exact colour and its characteristics. The project identified numerous conflicting usages and potential causes of misunderstanding in the colour and light terminology.

Three main causes of confusion

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.

3) The confusions arising from different of modes of perception.

Further potential causes of confusion

Mixing concepts belonging to different **academic or professional traditions**, as in the photometrically defined measure *luminance* and the perceptually defined attribute *brightness*.

Confusing terms that have specific definitions in **perceptual science**, but at the same time have their different usages in **everyday language**, such as *lightness* and *brightness*.

General experiences or categories being further defined for **scientific or technological purposes**. These can be similar, but not exactly the same, in different conceptual systems (e.g. the many concepts of the *vividness of colour*).

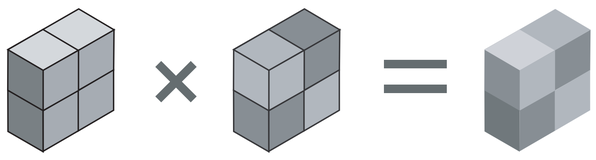
Words being given **alternative conceptual definitions** in science, while having a more or less stable and established meaning in everyday usage, as e.g. in the different meanings of *saturation*.

Generic words and terms having 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.

SOME CONCEPTS AND HOW THEY ARE CONFUSED

Lightness and brightness

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).



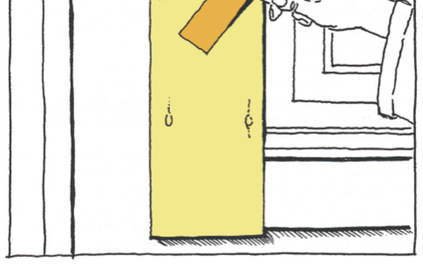
Illuminance image × reflectance image (lightness) = luminance image (brightness)
(After Adelson 2000)

Neither lightness nor brightness can be physically or psychophysically measured. Photometric units and measuring tools give 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.

Inherent, identity and nominal colour

Inherent colour: "... the colour that one imagines as belonging to a surface or a material, irrespective of the prevailing light and viewing conditions – – It can be operationally determined e.g. through comparison with a standardised colour sample." (Hård & Svedmyr 1995). 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).

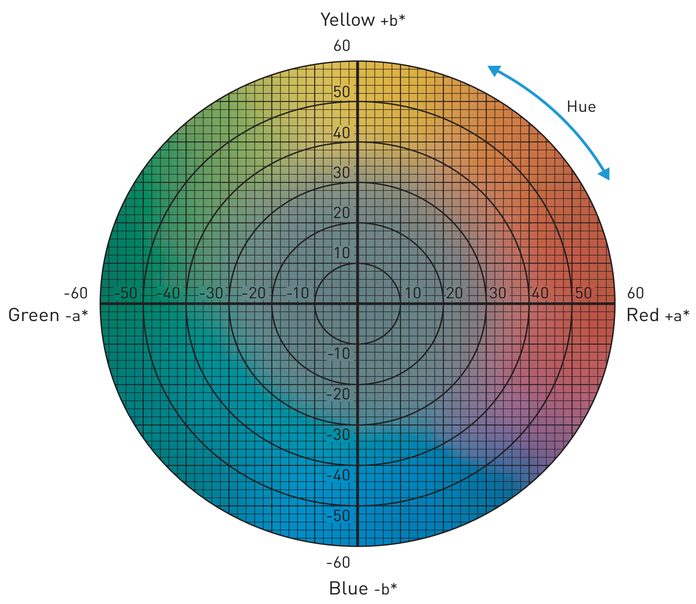


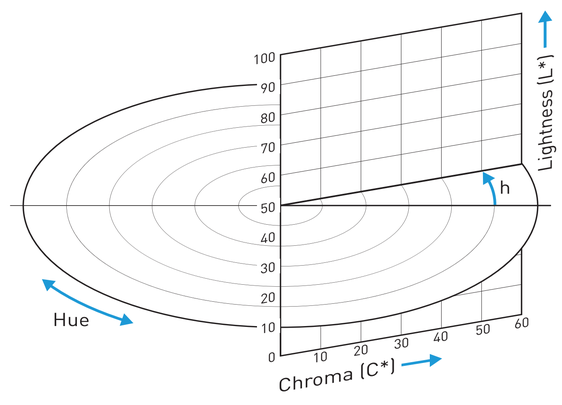
Fridell Anter 2000

We suggest, therefore, that to avoid confusion, the term **nominal colour** be used as a more fitting description of the concept behind inherent colour.

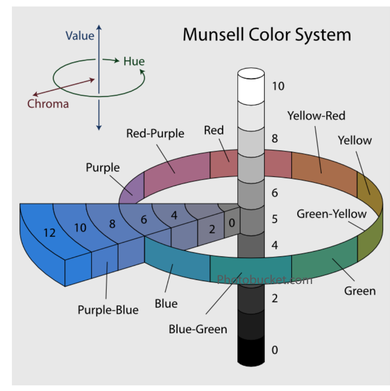
Identity colour: "… the main colour impression of surfaces or parts of a room that are perceived as uniformly coloured – – The perceived colour is analysed on two levels of reflective attention, one that can be called holistic and one that is more detailed." (Billger 1999).

Neither nominal colour nor identity colour claims to represent 'the real colour of the object'. 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.





CIELAB Hue, Lightness and Chroma



Munsell Hue, Value and Chroma

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.

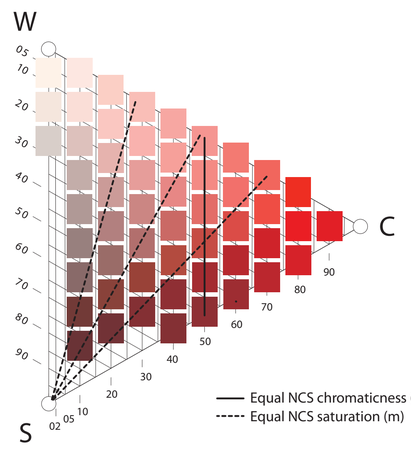
In related colours (surfaces, colour chips etc. viewed naturally) the scale of vividness is: neutral white, grey or black – fully vivid colour (optimal object colour).

Munsell colour system: Vividness is called **Chroma** and is judged in proportion to a neutral grey of the same value (lightness).

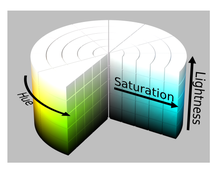
NCS: Vividness is called **Chromaticness** and is judged in proportion to the sum of the colour's blackness and whiteness. Colours that lie on a straight line connecting NCS black and any othercolour of the same hue display a constant relationship of whiteness and blackness and thus, according to this NCS definition, possess equal **Saturation**.

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.

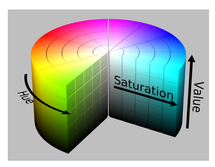
Chromaticity is defined as the hue and saturation of a colour without regard to its luminance. In the CIE chromaticity model a very dark green and a very bright green could have the same chromaticity. The difference between colours of equal chromaticity and equal saturation, then, is that colours of equal saturation may vary in hue whereas those of equal chromaticity may not. (Arnkil 2012).



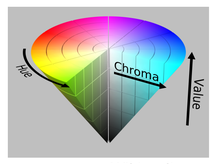
NCS Chromaticness and Saturation



HSL cylinder



HSV cylider (saturation)



Wikipedia.org

HSV cone (chroma)

To add to the confusion, the various three-part formulations of colour of computer programmes, such as HSV, HSL and HSB 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.

CONCLUSIONS

The key to communication and understanding is in identifying the differences in context and 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'.