Colour Nomenclature.

By Dr. L. C. MARTIN.

THE content and meaning associated with any word is always liable to vary with the mental outlook of an individual. Thus the word "distance" may convey to a psychologist the idea of a psychological experience developed by various means through the senses; to a physicist the same term conveys the idea of a magnitude to be expressed in centimetres or other arbitrary units. In practice, however, this causes very little inconvenience. The fundamental concepts are identical; it is the principle of measurement which varies.

Up to comparatively recent times the discussion of colour had connexion almost exclusively with the use of pigments, precious stones, and the like, in the decorative arts. Individual pigment names were satisfactory and not too numerous to remember, while the vast range of aniline dyes was unknown, but at the present time the use of colour names is in confusion. We recall the words of Locke: "Men take the words they find in use amongst their neighbours, and that they may not seem ignorant what they stand for, use them confidently without troubling their heads about a certain fixed meaning." We all suffer to some extent from this over-confidence. There is now a great need for some manner of measuring and specifying colour, which avoids the employment of these individual names.

The early work of thinkers and experimenters such as Newton, Young, Tobias Mayer, Johann Lambert, Runge, Grassman and Goethe cannot be reviewed here. We must begin with Helmholtz, who, inheriting the result of their labours, started with the basic idea of a three-dimensional continuum of colour sensations, the sensation being clearly differentiated from the stimulus. He was solely concerned with sensations when he described them ("Physiological Optics," 1856–66) as variable in terms of hue (Farbenton), saturation (Farben Sättigung), and brightness (Helligkeit). The subject of colour vision attracted great attention about this time, the work of Chevreul being translated (1854) into English by Charles Martel, who made in the introduction a plea for the more accurate standardisation of colour names by reference to the spectrum. Chevreul did not, however, trouble to distinguish between the sensation and the object seen; he describes colour variations by reference to the effects obtained by mixing white and black with various colours, but he uses the terms "tint" and "tone," which have not found acceptance for scientific work. Helmholtz had this in common in Chevreul, that he carefully described the physical conditions which would cause illustrative variations in the three sensation variables mentioned above.

Several other books, dealing with the subject mainly from the physical point of view, followed in the latter half of the nineteenth century. Benson (1871), having the benefit of Helmholtz's work, starts his account with the three fundamental sensations of the Young-Helmholtz theory of colour vision; this affords a radically different machinery with which to discuss colour sensation phenomena. It is still three-dimensional, but not so directly related to ordinary experience as the hue, saturation, and brightness. Rood ("Modern Chromatics" 1883) discusses "hue, luminosity, and purity," and describes experimental means of varying them in physical stimuli. His "luminosity" corresponds to the "Helligkeit" of Helmholtz, and his "purity" to "Sättigung." He takes even less care than other authors to distinguish between sensation and the stimulus, as the following quotation shows: "the hue of the colour or, as the physicist would say . . . the wave length." Abney ("Colour Measurement and Mixture," 1891) speaks of the "luminosity" of a coloured object, and the "purity" of coloured light, but when giving the results of some of the first actual colour measurements in such units he is sufficiently cautious to give: "Wave length of dominant ray," "percentage of white light," and "percentage of luminosity as compared with white." While he was very sparing in the use of terms which might have a psychological meaning, such as "purity" and the like, he thought it quite legitimate to connect sensation and stimulation in quite an arbitrary way, as Helmholtz did, by the postulate that equal stimulation of all three primary sensations of the trichromatic theory shall produce white. Moreover, the white was perfectly arbitrary; in Abney's case it was the white sensation evoked by the light from the crater of his carbon arc.

In passing, the distinction between various meanings of "white" may be made clear. A surface which reflects diffusively and non-selectively, and has a high albedo or reflection coefficient, is usually described colloquially as white. To the psychologist, however, white is sometimes a hueless sensation of light which happens to be brighter than any other sensation present in consciousness. Frequently, the distinction is not pointed out, and misunderstanding results. To the present writer the simplest conception to appeal to a physicist seemed to be that of the "whiteness" of sunlight (probably a psychologist would prefer to speak of "greyness"), which we learn to recognise in the whiteness of clouds and mist, and in the appearance of all diffusely reflecting and non-selective surfaces. The sensation due to the *light* is the first thing to grasp.

The importance of the "hue, saturation, and brightness" classification of colour is revealed in the colour charts which have been prepared on this basis, and the corresponding commercial colour notations. One of the most notable is that of Munsell, who employs the terms "hue," "chroma," and "value," where the latter two terms correspond to our previously used "saturation" and "brightness." This colour chart, which I have described elsewhere,[1] is in use for commercial purposes. Others on similar lines are also extant.

It will be realised from the foregoing notes that some co-ordination in the use of terms is extremely desirable, and to this end a committee of the Optical Society of America, under the chairmanship of Prof. L. T. Troland, published a report[2] in August 1922 which suggests

[1] "Colour and Methods of Colour Reproduction." Blackie, 1923.
[2] Journal Opt. Soc. Amer., Vol. 6, No. 6, 1922.

definitions for the three variables of colour *sensation*. They are as follows :

1. Brilliance is that attribute of any colour in respect of which it may be classed as equivalent to some member of a series of greys ranging between black and white.

2. Hue is that attribute of certain colours in respect of which they differ characteristically from the grey of the same brilliance and which permits them to be classed as reddish, yellowish, greenish, or bluish.

3. Saturation is that attribute of all colours possessing a hue, which determines their degree of difference from a grey of the same brilliance.

The reason for discarding the terms brightness and luminosity is that both these terms have received technical definitions [3] in connexion with photometric measurements. The Committee would retain the term saturation for the subjective attribute of colour sensation, while allocating the word purity to the "ratio of homogeneous to total radiation in the stimulus." According to the report, any definite physical application of these terms (brilliance, etc.) will "corrupt" them. Many other colorimetric matters and experimental methods are also dealt with in the report.

For practical colour measurement it is necessary to distinguish between the measurement of a colour stimulus such as obtained from the field in a spectroscope, and the measurement of reflected body colour. For the latter case the report describes the specification of colour in terms of (1) luminosity, (2) dominant wave length, (3) per cent. hue. Presumably the former case would best be met by using the term "brightness," but the use of the physical terms is still very variable. The colloquial use of the word "luminosity" is a little against its use as a contraction for "relative luminosity as compared with white."

We have not up to this point discussed the scales of measurement. Just as temperature may be measured in the mercury scale, the hydrogen scale, the platinum scale, and so on, it is possible to measure quantities like brightness on various scales.

The physicist will undoubtedly adopt the ordinary photometric luminosity scale for all colorimetric purposes in which instrumental measurement is required. On the other hand, other scales more nearly related to psychological experience, but still essentially arbitrary, will be far more valuable in the preparation of colour charts, as Ostwald points out.

The nomenclature of Ostwald [4] seems at first somewhat different. He is concerned only with body colours having reflection coefficients between 0 and 1. A grey reflects a fraction w of the incident white light as compared with a quantity 1 reflected by a perfectly reflecting and diffusing surface. The other portion s is absorbed; then $w+s=1$, where w can be called the white content and s the black content of the grey. Ostwald adopts a scale of greys in which the white contents vary geometrically; these are called a, b, c, d, etc.

In the case of a colour showing hue, the reflected portion is divisible into two parts, v due to the pure hue and w to more or less white. Hence the equation above becomes $v+w+s=1$. w and s are the white and black contents as before. Colour is specified by its dominant hue and its contents of "full colour" (Vollfarbe), and white. Ostwald criticises Helmholtz for not realising that the "black content" is an essential factor in the appearance of a surface in an ordinary case where colour contrasts are manifest in the field of vision, but Helmholtz was concerned only with the variation of the elements of sensation, and his employment of the term "Helligkeit," signifying absolute light strength, was therefore quite correct while a single sensation was discussed apart from contrast effects. Ostwald's system has been employed in his "Farbenatlas," which gives 2500 indexed colours. A system of colour measurement has also been developed.

While the report of the Colorimetry Committee has put psychological nomenclature in order, the physicist will feel that the use of terms such as white, grey, and the like in fundamental definitions is highly unsatisfactory. For purposes of colorimetry psycho-physical measurements are necessary, and it seems necessary to choose units and formulate definitions which, although possibly arbitrary, are founded securely in physical facts wherever this is possible. In thinking over the matter for the purposes of the book to which reference was made, it appeared to the present writer that the only way to discuss a sensation for purposes of measurement is by reference to an arbitrary physical stimulus which evokes this sensation (or something near it) in the normal subject. Hence white was defined by reference to the colour of sunlight, an arbitrary but definite step. The alternative is the adoption of the results of such lengthy statistical work as that of Priest on "the spectral distribution of energy required to evoke the grey sensation" (Bureau of Standards, Scientific Papers, No. 417). The term "brightness" can be given its usual photometric significance, but there is still the difficulty of finding a suitable term for the relative brightness of a diffusely reflecting surface. It seemed that the term brilliance suggested by the American report gave the term required.

Since the issue of the book, this step has been criticised on the ground that the intent of the American definition of the term brilliance is to exclude the idea of a quantity specified or measurable by any reference to stimuli. Certainly if this appropriation of the term is of importance to psychology, physicists must agree upon some other word such as luminosity or value when dealing with body-colour measurement; but unfortunately the multiplication of terms for identical mental concepts is quite likely to lead to the confusion which the report seeks to avoid. The present writer prefers the careful use of *one* word provided that the manner of its use is indicated, just as is necessary in the case of terms like "temperature" and "distance," which themselves carry no implied reference to any special mode of physical measurement, but are in perfectly arbitrary use in physics. The question needs more discussion before it is finally settled, but the whole matter is of great importance for purposes of colour standardisation and measurement. Until matters are definitely settled we might do far worse than follow Abney in the non-committal terminology mentioned above.

[3] The *Illuminating Engineer*, Vol. xv. No. 8, p. 227. The definition of "brightness" is given there, but "luminosity" is not defined in British practice. Colloquially, it refers to self-luminous surfaces. The American report says: "*Relative* light quantities are called *luminosities*."

[4] For a concise statement of Ostwald's theory see "Die Grundlage der messenden Farbenlehre." (Barth, Leipzig, 1921.)