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A Note on Color Nomenclature

By A. R. Lauer

Introduction

Students in advanced psychology are not adequately grounded in the fundamental principles of color. This is due in part to loose terminology of color concepts, and partly to the failure of instructors to make clear the exact nature of results obtained from mixing colored pigments as compared with mixing colored lights. Even among authorities in the field there is a tendency to fit experimental data to pre-existing theories, a practice which does not help make the facts clear to a beginning student of color who reads widely. More recently Munsell (8) has developed a very excellent system of color nomenclature which is most too complicated for the average textbooks in beginning psychology. The hypothesis is posed that there are no major conflicts in theory and application of colors if all the concepts are properly defined and understood.

Four basic concepts are necessary as a prerequisite to an understanding of the problems of color. These are:

1. The establishment of the concept of color as a subjective phenomenon. Its physical correlates are wave lengths of certain magnitude. Many physical scientists as well as psychologists are guilty of the stimulus error.
2. The integration of basic principles of color as a unitary system is necessary. Mixing of colored lights is not the same as mixing colored pigments and neither is there any conflict between the two. Different principles are involved which are in harmony although they appear to produce inconsistent results in some instances. The schism between tetrachromatic advocates and trichromatic proponents does not necessarily imply a dual system of description. The two may be reconciled by thorough understanding of basic principles involved and of the basic physical phenomenon obtaining.
3. Theory should be fitted to the data rather than the data fitted to the theory. Too much "armchair experimenting" has been done in the past in color as well as in some other areas in psychology.
4. A definitely objective terminology is suggested. Typical examples are given in the following section.

Definitions

The following definitions are suggested as a realistic basis for application of color concepts. They are based upon the best standard sources but some are amplified or restricted to establish a more consistent system of nomenclature.

Table 1

Color Nomenclature.

Term		Definition
1. stimulus	=	any interruption, disturbance, or change in media of the environment that is within perceptible range of the organism. Color is not a stimulus as such. In reality it is a response to a stimulus.
2. color	=	that part of the response known as experience made by an organism to certain traverse vibrations and characteristic wave lengths of an electromagnetic nature between the limits of 3900 Å and 7600 Å for certain individuals of normal vision. All color is subjective in nature.
3. white	=	the experience or reaction of an organism to transmitted light, or to smooth surfaces reflecting heterogenous wave lengths of uniform amplitude and visibility having a reflection factor of 85 per cent or greater as compared to a standard smooth white magnesium carbonate surface illuminated by a standard source of light giving at least 20 foot-candles incident to the surface. This is an arbitrary construct since any increase in illumination by direct comparison will indicate a tint of gray.
4. black	=	the experience or reaction of an organism to transmitted light, or to smooth surfaces reflecting heterogeneous wave lengths having a reflection factor of 5 per cent or less for the same conditions as described for white. The term is relative and is dependent to some extent upon the level of illumination or of adaption of the eye.
5. gray	=	the experience or reaction of an organism to transmitted light, or to smooth surfaces reflecting heterogeneous wave lengths having a reflection factor of from 9 per cent to 75 per cent for the same conditions as given above.
6. neutral gray	=	the experience of an organism to transmitted light, or to smooth surfaces reflecting heterogeneous wave lengths of uniform amplitude having a reflection factor of from 45 to 55 per cent under standard conditions of illumination.
7. *tint	=	experience or reaction to transmitted light, or to smooth surfaces emitting a characteristic wave length with a reflection factor greater than 50 per cent under standard conditions. It would apply particularly to surfaces reflecting at least 75 per cent of the impinging light.
8. *shade	=	experience or reaction to transmitted light, or to smooth surfaces emitting a characteristic wave length with a reflection factor less than 50 per cent under standard conditions. It would apply particularly to surfaces reflecting less than 35 per cent of the impinging light.

*There is a slight inconsistency in the differentiations made between these phenomena on logical grounds. Both are changes in the heterogeneity of wave lengths. A distinction might be made on the basis of the effect on the predominant wave length or peak of the visibility curve. Change in chroma assures variation in such a peak while change in brilliance does not.

9. *brilliance, intensity or value	=	the variation in reflection factors of from 5-85 per cent due to the difference in transmissions of reflection of heterogeneous wave lengths from a luminant of standard capacity.
10. achromatic	=	visual stimuli from the brilliance series giving heterogeneous wave lengths not possessing hue. This would infer a balance of all wave lengths according to thc normal curve of sensitivity of the eye.
11. chromatic	=	hues of the various spectral bands induced by an unbalance of amplitude in wave length of the visible spectrum giving a characteristic color.
12. *chroma or saturation	=	the experience from variations in degree of homogeneity in wave lengths under standard conditions. Theoretically a very narrow band of wave lengths such as the sodium line in the spectrum. Practically this is never attained.
13. hue	=	experience given by a relatively narrow band of wave lengths, sometimes erroneously considered as monochromatic. Length of the wave determines the hue.
14. color stimulus	=	a term to be used instead of color in scientific descriptions referring primarily to the objective datum. More precisely it should be referred to as a visual stimulus of specified wave lengths as described below:
15. red	=	a color stimulus consisting of electromagnetic wave lengths between 6221Å and 6881Å.
16. orange	=	a color stimulus consisting of wave lengths between 5887Å and 6220Å.
17. yellow	=	a color stimulus consisting of wave lengths between 5378Å and 5886Å.
18. green	=	a color stimulus consisting of wave lengths between 4861Å and 5377Å.
19. blue	=	a color stimulus consisting of wave lengths between 4462Å and 4860Å.
20. indigo	=	a color stimulus consisting of wave lengths between 4201Å and 4461Å.
21. violet	=	a color stimulus consisting of wave lengths between somewhat below 3798Å and 4200Å.
22. complementary	=	two areas or sources of light with wave lengths bearing the ratios of from 1:1.190 to 1:1.334 as follows:

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This is only a basic working vocabulary and the list of terms and is not intended to be comprehensive. Much confusion results from the concept of complementary colors. The following quantitative stimulus description after Helmholtz (6) would aid most teachers of art and psychology in reaching an agreement on what colors are complementary.

Table 2

A Quantitative Statement of Complements

Color	Wave length Å	Complimentary Color	Wave length Å	Ratio of Wave length 1:X
Red	6562	Green-blue	4921	1.334
Orange	6077	Blue	4897	1.240
Golden-yellow	5853	Blue	4854	1.206
Yellow	5739	Blue	4821	1.190
Yellow	5671	Indigo-blue	4650	1.221
Yellow	5644	Indigo-blue	4618	1.222
Green-yellow	5636	Violet	4300	1.301

Thus it will be seen that analogous colors have their respective comlements.

Units of Light Measurement for Color

There is considerable confusion in the methods of writing wave length designation. According to the best scientific practice it would be most logical to use the following:

micron	=	μ one one-thousandth of a millimeter or one one-millionth of a meter.
angstrom units	=	one ten-thousandth of a micron pegnated by Å or A.U.
common designation	=	one one-thousandth of a micron or m mu. The latter is ten times the length of an angstrom unit. Thus 555 m mu = 5550 Å.

Elaboration of the Concept of Complementary Colors

In the application of color complementary effects are not limited to the purely saturated colors. The following system of complementary colors is proposed. Colors would here refer to combinations which behave as colors. They might be considered as "pure" wave length colors and "mixed" wave length colors. Logically, this is stretching the basic meaning slightly since no color has a pure monochromatic character.

First order complements = those pairs of complementary colors on the color wheel, or those having highest saturation; for example, blue and yellow, red and green, etc.

Second order complements = those pairs of colors on opposite surfaces of the color pyramid which when mixed give neutral gray but which represent tints and shades; for example, cream and navy blue, pink and dark green, etc.

Third order complements = those pairs of colors on opposite surfaces of the color pyramid which represent two tints or two shades and which, when mixed, give a light or dark gray; for example, pink with light green, brown with dark blue, and light blue with light yellow, etc.

No aesthetic justification is offered for any of the proposed components of the system but it seems logical to assume that the science of color usage may well consider some such systematic extension of the principles of color contrast. The data presented have been gleaned from standard sources and published results. It is proposed that all color stimuli be described in terms of wave length and thus avoid confusion as to meaning when an experiment is duplicated. It is further suggested that grays be described in terms of the per cent reflection factor.

Summary and Conclusions

It is stated that the basic principles of color constitute a unitary system throughout although interpretations are sometimes at variance.

Color is a subjective phenomenon and, as such, often results in the stimulus error being made by psychologists as well as physicists and artists.

It is recommended that quantitative statements be used in describing color by using the wave lengths reflected by physical objects.

An extension of the concept of complementary colors to include all possible pairs is presented.

In general, a proper understanding and description of color phenomena would eliminate confusion in the science and application of principles of color.

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