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THE MEANINGS OF COLOR* [1]

Department of Education, The University of Chicago, and Social Research, Inc., Chicago

BENJAMIN WRIGHT AND LEE RAINWATER

A. INTRODUCTION

There are both practical and theoretical reasons for being interested in the connotative effects of color experience. From the practical point of view, we want to know in what way people speak of color so that we can more effectively discuss and study its use in visual communication. Are there consistent connotations along which people discriminate colors? If so, what are they?

From the theoretical point of view, we want to know more about the relationship between perception and connotation—knowledge about this relationship is fundamental to an understanding of the development and structure of thought.

Thoughts and the words which mark them are manifestations of physiological functions, a central one of which is the perceptual system. Connotative or metaphorical meaning is a crucial aspect of thought. We would like to know if there are stable relationships between connotation and perception. Color experience can be fairly well specified perceptually. If there are general connotative dimensions along which colors are described, and if these dimensions are to some extent consistent from person to person and from culture to culture, then this is evidence bearing on the existence and character of such a relationship.

This is a report on a factor analytic study[2] of the connotative meanings of colors. The report is divided into three parts: first, a description of the mechanics of the study; second, a presentation of the six dimensions of connotative meaning found in the factor analysis; third, an analysis of the linear relation between these color connotations and the color perceptions of hue, lightness and saturation.

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B. The Study

Ss were middle and lower class men and women living in urban West Germany in 1957. Each *S* judged a single three-inch square of matte surface color presented in daylight against a neutral background. Judgments were expressed on an Osgood semantic differential (17, pp. 76-85) by circling one of seven positions between pairs of polar adjectives like this:

KALT ... . WARM
FROH ... . TRAURIG

For the purpose of scoring, the seven rating positions between each adjective-pair were weighted linearly one through seven.

Individual interviews were obtained on a door-to-door basis within the structure of an area probability sampling plan for West Germany. Each *S* rated just one of 50 colors on just one of two different 24 adjective-pair rating-forms. Sample size per color per rating-form varied from 20 to 70 with an arithmetic mean of 36. Altogether 955 men and 2705 women participated in these ratings. Age ranged from 16 to 65 with seventy per cent between 25 and 59. The age and sex compositions per individual color were comparable. Since the evidence for sex or age differences in color ratings among the *Ss* was minor, the data are reported for the group as a whole.

The 50 colors covered the gamut of hue, lightness and saturation. In Munsell color coordinates, hue had a mean of 31 and a standard deviation of 23; lightness had a mean of five and a standard deviation of 2.1; and saturation had a mean of nine and a standard deviation of 3.8.

The three color dimensions were also relatively uncorrelated with one another over the 50 colors. Hue had a correlation of —.1 and —.3 with lightness and saturation, and lightness had a correlation of .1 with saturation.

Thus the color solid was well filled by the 50 colors and the effect on the data analysis of an artificial dependence among color dimensions in the structure of this sample was small.

In this way a 48 row by 50 column matrix of average ratings was accumulated for 50 colors each judged on 48 adjective-pairs.

C. The Factor Analysis

The first step in our analysis was to determine whether the variation among average judgments for the 50 colors exceeded significantly the variation within colors and was thus evidence for some kind of color judgment consistency among subjects. To accomplish this we did a 50 cell one-

way analysis of variance on each of the 48 adjective-pairs. The 99.99th percentile of the variance ratio distribution with 40 and several hundred degrees of freedom is about two. The ratio of the variance among colors to the variance within colors for 31 of the 48 adjective-pairs exceeded two. We concluded that the differences among average color ratings were difficult to dismiss as only the product of individual differences.

Having satisfied ourselves that colors evoked judgments to some extent consistent among a wide variety of people, our second step was to analyze the covariation structure of the 48 by 50 matrix of average adjective-pair ratings to see if some simplification of these judgments could be achieved. This was done by what Cattell calls a "direct factor analysis" (3, pp. 414-416). A principal component method was used (12, pp. 10-19).

First the row, or adjective-pair means were removed to standardize the observations for average adjective-pair rating level. Then the factor analysis was accomplished by finding the largest proper vectors of the product of this standardized matrix and its transpose. Vectors were normalized by setting the squared length of each vector equal to the corresponding proper value.

The six largest principal components were computed, but the sixth accounted for less than 2.5 per cent of the total variation in the standardized matrix, while the first five claimed altogether 80 per cent. To succeed in gathering 80 per cent of the variation in a 48 by 50 matrix into five uncorrelated components is a substantial simplification. In addition 2.5 per cent is little more than the average variance of a single row. From a substantive point of view this indicates that no real "cluster" of adjective-pairs can have been overlooked. Further analysis was confined to these five largest components.

The loadings on these five components for those 18 adjective-pairs which dominated the covariation structure of the standardized data matrix are given in Table 1. Every adjective-pair with at least one loading of .30 or more was included. With respect to the one-way analyses of variance mentioned earlier, the ratios of variance among colors to variance within colors for every adjective-pair in Table 1 exceeded a value of three.

As can be seen in Table 1, the connotative nature of the five components can be characterized as "happiness," "forceful-strength," "warmth," "elegance," and "calming-strength."

Six clusters of adjective-pairs can be identified on the basis of these five components. Each cluster suggests a somewhat different dimension of connotative meaning. The first and dominant cluster with loadings on only

the first principal component contains the leading adjectives *happy, young, fresh, clear, social,* and *graceful.* This dimension will be referred to as "happiness."

A second cluster is identified by loadings on both the first and the second principal components. This cluster contains the adjectives *outstanding, showy,* and *exciting,* and will be referred to as the dimension of "showiness."

The third cluster, identified by major loadings on only the second principal component, contains *strong* and *forceful* and will be referred to as the dimension of "forcefulness."

TABLE 1
THE LOADINGS OF SALIENT ADJECTIVE-PAIRS ON THE FIVE LARGEST PRINCIPAL COMPONENTS OF THE STANDARDIZED[a] MATRIX OF AVERAGE COLOR JUDGMENTS OVER FIFTY COLORS

Adjective-pairs	Principal component loadings				
	I	II	III	IV	V
Froh/traurig	.66	—.18	.20	—.09	—.10
Jung/alt	.63	—.15	—.04	—.15	—.11
Frisch/abgestanden	.56	—.08	.13	—.02	.01
Rein/trüb	.48	—.06	.07	.10	.14
Gesellig/einsam	.44	.06	.11	.00	.03
Anmutig/plump	.44	—.20	.02	.11	.04
Auffällig/unauffällig	.71	.39	—.13	.10	—.03
Auffallend/normal	.66	.38	—.21	.11	—.08
Erregend/beruhigend	.52	.32	—.15	—.12	—.32
Stark/schwach	.13	.52	.15	—.06	.32
Energisch/zaghaft	.16	.42	.07	—.07	.00
Warm/kalt	.19	.12	.47	—.12	—.11
Voll/leer	.16	.23	.33	—.08	.11
Gesund/krank	.24	—.05	.32	—.07	—.03
Festlich/alltäglich	.33	.11	—.03	.47	—.04
Vornehm/einfach	.25	.06	.03	.40	—.05
Stark/schwach	.13	.52	.15	—.06	.32
Beruhigend/erregend	—.52	—.32	.15	.12	.32
Proportion of total variation[b]	.462	.142	.087	.059	.050[c] = .800

[a] Standardized by removing row, or adjective-pair, means over the 50 colors.
[b] Given in the proportion this component's sum of squares forms of the total sum of squares of the standardized observation matrix, computed over all 48 adjective-pairs.
[c] The next largest component accounted for .025 of the variation.

Each of the remaining three clusters is located by a succeeding principal component. These dimensions of meaning will be referred to as "warmth," defined by *warm, full,* and *healthy;* "elegance," defined by *splendid* and *elegant;* and finally a second kind of strength dimension, namely "calmness,"

defined by the fourth order residual association of the *calming* side of *calming/exciting* with the strong side of *strong/weak.*

In order to clarify as much as possible the face value of each dimension, two prominent adjective-pairs were selected from each of the six clusters to embody a dimension of connotative meaning. A dimension score was then formed by averaging color ratings on just these two adjective-pairs. The adjective-pairs selected and the correlation structure within and among the six dimensions over these 50 colors are given in Table 2.

TABLE 2
CORRELATIONS WITHIN AND AMONG THE SIX DIMENSIONS OF MEANING OVER FIFTY COLORS

Dimension	Dimension					
	A	B	C	D	E	F
A. Happiness (froh & frisch)	(.89)[a]	.60[b]	.10	.43	.39	—.38
B. Showiness (auffällig & auffallend)		(.90)	.49	.24	.56	—.34
C. Forcefulness (stark & energisch)			(.61)	.50	.16	.37
D. Warmth (warm & voll)				(.70)	.11	.18
E. Elegance (festlich & vornehm)					(.81)	—.19
F. Calmness (beruhigend & stark)						(—.22)

[a] Correlations on the diagonal are those between the two adjective-pairs composing each dimension.
[b] Correlations off the diagonal are those among dimensions.

On Table 2 we see that *happy* and *fresh* correlated .89 with each other, that *outstanding* and *showy* correlated .90, *strong* and *forceful* .61, *warm* and *full* .70, *splendid* and *elegant* .81, but that *strong* and *calming* in the sixth dimension correlated —.22.

The correlations among the six dimensions are also given. "Happiness" and "forcefulness" are nearly uncorrelated. The same is true for "warmth" and "elegance." Otherwise, there are moderate relationships among the dimensions and in particular "showiness" shares about sixty per cent of its variation between "happiness" and "forcefulness" and is thus strongly associated with the combined meaning of these two dimensions. This corresponds closely with the implications of Table 1.

The status of the sixth and last dimension, "calmness," is somewhat equivocal. The two adjective-pairs do not form a cluster in any simple sense.

While the fourth order residual covariation between these two adjective-pairs is the major determinant of the fifth largest principal component in the factor analysis, and while their association in meaning has a certain face validity, little communality shows up in their first order correlation. Their communality depends on first factoring out the other four connotations.

For this reason we take the other dimensions of meaning more seriously at present, and in particular we propose the four least correlated dimensions of "happiness," "forcefulness," "warmth," and "elegance" as the best bet for a four-dimensional framework within which to study further the connotative effects of color.

D. The Relation Between Color Connotation and Color Perception

The next question is, "In what way are these fairly consistent color connotations related to the three basic color perceptions of hue, lightness, and saturation?" The data on this question are to be found in Table 3. There the partial regression coefficients of each of the six dimensions of color connotation on each of the three dimensions of color perception are given along with their standard errors.

When we come to compare these regression coefficients across different color perceptions, we will want to remember that while the ranges of possible hue, measured in terms of Munsell units, and lightness values are about the same, the range of possible saturation values can be nearly twice as much. If we use the standard deviations of hue, lightness, and saturation found in this set of 50 colors as a rough index of this difference in variability, we will boost the regression coefficients on saturation by a factor of at least one and a half when comparing them to those on lightness and hue.

The first things to observe in Table 3 are the multiple correlations given there. It is remarkable how much of the variation among average color connotations can be accounted for by a linear function of the three color perceptions. Although Guilford's work (8, 9, 10) indicates that fundamental relations between color perceptions and color "pleasantness" may not be linear, the data in Table 3 suggest that a linear model may nevertheless be a useful beginning for understanding the relation between color perception and color connotation.

What, then, are the linear effects of hue, lightness and saturation on these six dimensions of color connotation?

Beginning with the rows in Table 3 we see that the connotation of

"happiness" is found to depend quite a bit on lightness and saturation, but hardly at all on hue. For example, on the basis of the partial regression coefficient of "happiness" on color lightness given in Table 3, namely $b_{L.HS} = .194$, we might estimate for populations like the one sampled here that an increase in lightness of five Munsell units will be accompanied on the

TABLE 3
THE LINEAR REGRESSION OF THE SIX DIMENSIONS OF MEANING ON HUE, LIGHTNESS AND SATURATION OVER FIFTY COLORS

Dimension	Partial regression coefficients and standard errors[a] on each color dimension[b]						Multiple correlation[c]
	Hue		Lightness		Saturation		
	$b_{H.LS}$	s_b	$b_{L.HS}$	s_b	$b_{S.HL}$	sb	R_{HLS}
A. Happiness (froh & frisch)	.014	.045	.194	.049	.102	.028	.67
B. Showiness (auffällig & auffallend)	.034	.041	.118	.045	.262	.026	.87
C. Forcefulness (stark & energisch)	.017	.028	—.190	.031	.142	.017	.84
D. Warmth (warm & voll)	—.088	.037	—.115	.040	.069	.023	.62
E. Elegance (festlich & vornehm)	.084	.040	.061	.043	.099	.025	.57
F. Calmness (beruhigend & stark)	.075	.033	—.200	.036	—.008	.020	.71

[a] Based on mean square residuals from regression with 46 degrees of freedom.
[b] Measured in Munsell units with hue expressed in tens.
[c] With 3 and 46 degrees of freedom.

average by a shift of about one rating scale position nearer "happiness." Since the saturation of a color in Munsell units can vary at least one and a half times as much as its lightness, we see by the coefficient of "happiness" on saturation, namely $b_{S.HL} = .102$, that saturation also makes a substantial contribution to "happiness."

Thus the lighter or the more saturated is a color, the more "happiness" it connotes.

The connotation of "showiness" depends on lightness and saturation, but now the emphasis is different. Saturation is the color perception which contributes the most to the connotation of "showiness."

Turning to the third connotation in Table 3, we see by the negative regression coefficient that it is color darkness upon which "forcefulness" most depends. Saturation also plays a part, and so the darker or the more saturated is a color, the more it connotes "forcefulness."

"Warmth" is the first connotation in Table 3 to have much of a linear dependence on hue. Since the Munsell color coordinates increase with decreasing wavelength, the negative regression coefficient signifies, as one might expect, that greater redness is the hue change which corresponds with greater "warmth."

However, both lightness and saturation also affect the connotation of "warmth." Thus in addition to the effect of redness, the darker or the more saturated a color, the more it connotes "warmth."

"Elegance," the next connotation, also depends on hue. This time greater blueness is what seems to cause greater "elegance." Saturation, however, has even more of an effect. And so it is first of all saturation and second greater blueness which correspond with a greater connotation of "elegance."

The last connotation in Table 3 is the combination of *calming* and *strong*. This connotation, probably because of its strength component, depends mostly on color darkness, but hue also seems to make a contribution. The darker or the more blue is a color, the more it connotes this kind of "calmness."

E. Earlier Research

How do these results compare with previous work on color meaning? Most other studies have been confined to over-all ratings of color preferences. The gist of these studies is that within reasonable bounds greater lightness and greater saturation each correspond with greater color preference (1, 2, 4, 5, 7, 8, 9, 10, 11, 14, 15, 17, 18, 19, 20, 21, 22).

However, these studies vary widely in the way a color preference or "pleasantness" was operationally defined. In many cases the definitions were quite broad, allowing for such leeway in interpretation on the part of both subject and researcher. One wonders in what sense lightness and saturation are preferred—in the same sense or in senses quite different from each other?

There are also some inconsistencies; for example, Guilford found that the increase of "pleasantness" with increasing lightness and saturation tended to be concave up (10, p. 457), while Granger found that the increase of "preference" tended to be concave down (7, pp. 14-15). Indeed, Eysenck suggested that perhaps there were two different types of subjects—those who liked saturated colors and those who liked light colors (6, p. 388). Thus, in spite of the large number of studies stretching over sixty years and two continents, knowledge concerning the specific effects of color lightness and saturation has remained rather vague.

This study provides some specification of these color effects. In Table 3 we see that greater lightness and greater saturation do correspond with

greater "happiness" and "showiness," but that there they part company. Greater saturation corresponds with *more* "forcefulness" and "warmth," while greater lightness corresponds with *less*. Finally, greater saturation corresponds with more "elegance," while greater lightness corresponds with less "calmness."

What about hue? Several studies report data which suggest that the relationship between hue and color preference may not be linear (1, 7, 8, 9, 10, 14, 21, 22). But only Guilford has dealt with this problem explicitly.

Guilford tried to identify the underlying function by fitting a trigonometric series to the relation between hue and color pleasantness observed in his data (8, 9). His results suggest that color pleasantness may be representable in terms of the combination of a first order preference for blue over yellow with a second order preference for primary red, green and blue over in-between hues. This is a particularly provocative preference pattern because of its congruence with physiological theories of color vision.

Insofar as the relation between hue and connotation is usefully appproximated by a linear model, however, the preference for blue-green over yellow-red in our data is specified by the regression coefficients in Table 3 as due to the connotations of "elegance," "calmness," and possibly "coolness" rather than to those of "happiness," "showiness," or "forcefulness."

A few previous studies have investigated connotations other than preference or unpleasantness. Several researchers (5, 14, 16, 17, 19, 23) reported that differences in hue corresponded with differences in warmth, activity, and excitement—red being warmer, more active, and more exciting than blue. This is in part confirmed by our data.

Greater redness does correspond with greater "warmth" and less "calmness" in our data. But on the German adjective-pair *activ/passiv,* not included in Table 3 but one of the original 48 adjective-pairs, the partial regression coefficients on hue and lightness were nearly zero. Only saturation, with a coefficient of .094 and a standard error of .021, seemed to have some consistent influence on average *activ/passiv* color judgments.

This is of interest since Osgood (17, p. 302) reported that differences in the connotation of "activity" in his data corresponded most of all with differences in hue! Our data suggest, on the other hand, that while excitement may be a linear function of hue, actual activity is a function of saturation.

Both Ross (19) and Osgood (17) report data which suggest that greater lightness corresponds with greater passivity and coolness. The data in Table 3 do confirm this. Greater color lightness corresponds with less "forcefulness" and with less "warmth."

Finally Collins (5), Ross (19), and Osgood (17) among them related greater saturation to greater warmth, activity and strength. This is confirmed by our data in Table 3, where greater saturation is found to be followed by greater "warmth," "forcefulness," and "showiness."

Reviewing the over-all picture presented in Table 3, we were impressed by how minor the linear effect of hue was compared to the linear effect of saturation. Hue is the color perception which first appears in primitive language —the one most familiar to all of us, the one most commonly used to explain the emotional effects of color. Saturation, on the other hand, is the color perception last to receive a word designation and generally least familiar. Yet it is saturation which manifests itself most powerfully in this analysis of the relations between connotations and perceptions. This is a finding, we feel, worth thinking about.

Why is it that the least familiar color perception has the strongest linear influence on color connotation? Is this because there is more of an underlying relationship between saturation and connotation than between hue and connotation—a kind of generalized color response? Or is it because the basic hue-connotation relation is more complex, as Guilford suggested for color pleasantness—more complex in a way poorly approximated by a linear model?

With respect to the possibility of a more complex model, the color variables of saturation and lightness have approximately the same form physically and psychologically. This is not true for hue. Physically hue is a manifestation of wavelength, a magnitude; but psychologically hue is perceived as a location on a circle. For example, although blue represents the shortest wavelength and red represents the longest, and there are no clear-cut dominant wavelengths corresponding to the purples, we "see" continuous steps of color from blue through purple to red, as though there were a continuous variable connecting them. This perceptual phenomena suggests that the relation between hue and connotation might indeed be represented better by a periodic rather than a linear model. We are looking into that possibility further.

What do these relationships between color perception and color connotation mean? Are there underlying physiological processes which are stimulated by color and to which we respond in some regular connotative manner? Or are there early conditioning experiences which are more or less common to all of us? If we can lay bare an orderly relationship between color perception and connotation, then perhaps the character of this relationship will help us to decide.

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Department of Education
University of Chicago
Chicago 37, Illinois