Latitude, Cultural Complexity and Color Terminology

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This brief report is based on a reanalysis of Bornstein's (1973a) and Berlin and Kay's (1969) color data and examines the validity of physiological and cultural explanations of the linguistic processes of color naming and codification. By using a number of statistical procedures, the authors examine the relative contributions of latitude and cultural complexity to the number of basic color terms present in a language. In addition, the report investigates which aspects of cultural complexity have the most significant impact upon the codification of basic color terms.

Anthropologists and cross-cultural psychologists have long been interested in cultural differences in color perception and color nomenclature. The existence of such differences is readily apparent when isolated cultures or extremely small samples are investigated (Conklin 1955; Lenneberg and Roberts 1957; Ray 1953). Such relativistic evidence has often been used as ethnographic support for an empiricist view of human perception and linguistic abilities. Nevertheless, when the color lexicons from a wide range of cultural and/or linguistic groups are examined, as Berlin and Kay (1969) have done, striking universals of color sequencing emerge. In examining the color lexicons from a sample of 98 societies, Berlin and Kay have discovered an invariant sequence of basic color terms. The findings indicate that if a culture has only two basic color designations, they will invariably be terms referring to black (plus most dark hues) and white (plus most light hues). If three basic color terms are present, they will always be terms for black, white, and red. For cultures having more basic color terms, a similar degree of predictability is present. Also, as more basic hue designations are added to the color lexicon, the terms for black and white retreat into the hueless domain. From their findings, Berlin and Kay construct an invariant model of color sequencing which can predict which colors will subsequently be added to a society's color lexicon and in what order. Despite this universal sequence, however, the number of basic color terms in a language will vary according to the level of cultural complexity. According to the authors, the finding that equatorial societies tend to have fewer basic color terms is due to the fact that these societies are less culturally complex than those societies at higher latitudes.

Since the appearance of their influential monograph, various modifications have been postulated in the sequencing model (Berlin and Berlin 1975; Kay 1975; Kay and McDaniel 1975; Witkowski and Brown 1977). Nevertheless, there appears to be widespread agreement over the fact that some kind of sequence does exist. At the present time, one of the main points of disagreement concerns the explanation of why some cultures have fewer basic color terms than others and are thus positioned in the more preliminary stages of the sequencing model. Although lacking quantitative data to support their position, Berlin and Kay (1969) attribute this to varying levelsof cultural complexity. Bornstein (1973a, 1973b, 1975), on the other hand, has proposed an alternative and rather intriguing physiological explanation for lexical variation in color terminology. According to his cross-cultural survey (Bornstein 1973a), dense retinal pigmentation, which is an adaptive trait in equatorial zones, results in a higher degree of ocular insensitivity to colors on the short wavelength end of the spectrum, specifically blacks, blues, and greens. Such tritonic or blue-green weak vision tends to cluster in and around the equator and becomes increasingly less frequent in higher latitudes. This physiological insensitivity results in the merger of blacks, blues, and greens into the same semantic color designations. This dense retinal pigmentation may be genetic for intraocular pigmentation, as well as dietary, for macular pigmentation resulting from the ingestion of carotenoids (Bornstein 1973a: 276). In both cases, the yellow pigment acts to absorb ultraviolet and visible short wavelength light, thus protecing the eye from harmful actinic rays. Consequently, if equatorial societies are documented as having fewer basic color terms, it is the result of physiological factors rather than cultural complexity. It appears that equatorial populations have made an evolutionary trade off between color sensitivity and the need to protect the visual system from harmful ultraviolet light. As dense retinal pigmentation acts to absorb harmful rays, it also absorbs visible short wavelength hues before the necessary "blue" and "green" photoreceptors are stimulated. Barring the effects of migration, latitude should have a significant effect upon color perception and ultimately color terminology.

These two explanations appear to represent the reappearance of the nativist-empiricist controversy, with Berlin and Kay (1969) being clearly empiricist and Bornstein (1973a, 1973b, 1975) being nativist. Both works have stimulated a great deal of debate and subsequent research on human perceptual and linguistic abilities.

Given this brief background, the present report has two primary goals. The first objective is to determine which components of cultural complexity, if any, are most important in predicting the range of color terms in any society. The second objective is to determine which of the aforementioned variables explains more of the cross-cultural variance in the range of color terms—latitude or cultural complexity.

Method

For the present investigation, the researchers used Berlin and Kay's (1969) sample on the basic color terms of 98 societies. For as many of these societies as possible, data was gathered on latitude, number of color terms, sequence of color terms, and cultural complexity. Measures of latitude were obtained from Bornstein's (1973a) data and cross-checked by using a Rand-McNally World Atlas (1976) for each geographic region. Using Murdock's *Measurement of Cultural Complexity* (Murdock and Provost 1973), it was possible to obtain measures of cultural complexity for 23 of the 98 societies in the sample. Despite the admittedly small sample, a relatively good distribution of world societies was obtained. For each of these 23 societies, measures were obtained for the following subscales of cultural complexity—writing and records, fixity of residence, agriculture, urbanization, technological specialization, land transportation, money, density of population, level of political integration, and social stratification.

Cultural Complexity and the Range of Color Terms

Although Berlin and Kay have suggested that the number of basic color terms in a society is a function of the level of cultural complexity, they offer no empirical evidence to support their contention. If this is in fact the case, one would expect to find a statistically significant correlation between number of color terms in a society and various measures of cultural complexity. For this report, we have taken the 10 subscales of cultural complexity as well as an overall measure of complexity which is a combination of the 10 subscales and correlated them with the number of basic color terms. Since these subscales are largely ordinal in nature, Spearman rank-order correlations were used to test the relationship. The resulting correlations are presented in Table 1.

Table 1. Correlations Between Subscales of Cultural Complexity and Range of Color Terms (n=23).

Subscale	Rank Order Corr.	Significance (2-5ailed)
Land Trans.	.71	.001
Writing	.65	.001
Urbanism	.51	.012
Technological Specialization	.47	.022
Agriculture	.44	.035
Money	.40	.058
Social Strat.	.31	.153
Political Integ.	.22	.310
Residence	.20	.361
Density	.06	.780
Overall Complexity	.43	.039
Economic Complexity	.72	.001

An examination of these results reveals, first of all, that the measure of total cultural complexity does correlate significantly with the range of color terms present in a society. It is interesting to note, however, that not all the subscales are significant. Those that did correlate significantly are (in order of magnitude) land transportation, writing and records, urbanization, technological specialization, and agriculture. The presence and use of money appears to have borderline significance. One thing in common among all these subscales of complexity is that they are all factors related to increased economic activity, perhaps in the form of trade and commerce. Those that did not correlate significantly with number of color terms—density, social stratification, political integration, and residence—do not appear to be directly relevant to increased economic activity. This finding not only confirms the relation between cultural complexity and number of color terms, but also isolates this relationship to variables which reflect increasing economic activity.

Retinal Pigmentation and the Range of Color Terms

Since it is difficult to measure retinal pigmentation for a sample of societies, Bornstein (1973a) had used the variable of geographic latitude as an indirect measure of pigmentation. Since retinal pigmentation roughly parallels mesodermic pigmentation (Silvar and Pollack 1967), this assumption is believed to be valid as long as the effects of migration can be controlled for. According to Bornstein, societies which are situated close to the equator receive a great deal more exposure to ultraviolet light. Dense retinal pigmentation is seen as an adaptation to these potentially harmful rays. If Bornstein's argument is true, we would expect equatorial societies to have fewer basic color terms than societies situated at higher latitudes.

A simple statistical test for this hypothesis was conducted. Latitude readings were obtained for 93 societies in the original Berlin and Kay sample. These were then dichotomized into two equal groups, equatorial and non-equatorial societies, and a point biserial correlation was computed between this variable and number of color terms. The result was a correlation of .41 ($n=93$; $p<.001$) with equatorial societies exhibiting significantly fewer color terms. Thus, Bornstein's hypothesis regarding the relation between color terminology and retinal pigmentation (as inferred from geographic location) seems justified.

Complexity, Latitude, and Range of Color Terms

The data analyses from the preceding sections indicate that both geographic latitude and economic complexity are good predictors of the number of color terms in a society. Some writers (e.g., Berlin and Kay) have proposed that this is so because the variables of geographic location and cultural complexity are confounded; that is, equatorial societies tend to be lower on a scale of cultural complexity than non-equatorial societies. One may still pose the question, however, if latitude were to be held constant, how much of an effect would complexity have upon the range of color terms? Conversely, if complexity were held constant, how much of an effect would lattude have? By isolating these two variables, it should be possible to determine which of the two has a greater effect upon color terminology. To examine these questions a factorial analysis of variance was performed. Using this procedure, the effects of each independent variable (latitude and complexity) can be assessed in isolation as well as in combination with one another. To conduct the analysis, the sample was dichotomized in terms of latitude (equatorial vs. non-equatorial) and then in terms of economic complexity (high vs. low), followed by an assessment of their mean and interaction effects. The results of this analysis are presented in Table 2 and the corresponding cell means in Table 3.

Table 2. Analysis of Variance: Effects of Latitude and Complexity on the Range of Color Terms.

Source	SS	df	MS	F
Latitude (L)	51.18	1	51.18	18.17**
Complexity (C)	63.46	1	63.46	22.53**
L x C	25.13	1	25.13	8.92*
Residual	53.51	19	2.82	
Total	199.83	22	9.08	

*significant at p=.01

An examination of these results indicates that the two main effects are, in fact, statistically significant. This implies, as the means in Table 3 corroborate, that latitude and complexity affect color terminology independently of one another. Perhaps the most interesting finding is the significant interaction effect. This shows that although complexity and latitude have independent effects upon color terminology, the combination of the two in any society has an even more significant impact. This is clearly demonstrated by an examination of the means in Table 3. A low complexity, equatorial society would have an average of roughly four basic color terms. A highly complex, equatorial would have approximately five terms, as would a low complexity, non-equatorial society. When a society is non-equatorial *and* highly complex, it would be expected to have approximately 11 basic color terms.

Table 3. Latitude x Complexity: Mean Number of Color Terms.

	Latitude	
Cultural Complexity	Equatorial	Non-Equatorial
Low	4.17 n=6	4.83 n=6
High	5.17 n=6	11.0 n=5

Discussion

The results and conclusion of this research should be viewed with some caution, especially when considering the possibility of causal connections. The observed relationships between color terminology, complexity, and latitude should not be interpreted as absolute causal sequences but as probalistic models. The primary aim of this report is to point out the importance of considering the crucial interaction between cultural and physiological processes in human cognition and perception. While the causal sequence of color sensitivity and retinal pigmentation has been adequately investigated (Ishak 1951, 1952; Ekman 1954; Sperling and Hsia 1957; Dodt, Copenhaver, and Gunkel 1959; Ruddock 1965; Silvar and Pollack 1967), the*exact* effect this has upon the linguistic process of color codification remains to be accurately explored. On the other hand, cultural complexity is an extremely amorphous concept which defies accurate measurement. The findings of this report may be confounded by measurement problems for cultural complexity as well as by problems involved in the investigation of the basic color terms of a large sample of societies. One such problem is the distinction between primary and secondary color designation that some aspects of cultural complexity are more clearly related to the range of color terms than other subscales. Our tentative explanation is that the significant subscales are clearly economic in nature and deal in some way, either directly or indirectly, with trade and commerce. There is reason to believe that trade and commerce, especially when carried out over large areas that incorporate numerous language and dialect regions, must act to facilitate a process of standardization and codification of weights, measurements, currency, writing, etc. This general codification process will naturally extend itself to other areas, including color nomenclature, as an adaptive cultural response to increasing economic activity. Writing and records may also be affected by general economic growth. Again, it is important to emphasize the fact that we are dealing with basic color terms and not color terminology as a whole. The onset of writing may result in a process which distinguishes secondary color terms, which are uncoded and highly variable, from primary or basic color terms, which are encoded and highly salient. The development of some system of writing and/or recording, as a possible response to increased economic activity requiring the use of record keeping, may act to facilitate the encoding of certain color terms in such a way that they become easy to speak, easy to write and commonly understood by at least a certain percentage of the population.

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