CAN INDIVIDUALS RECAPITULATE THE EVOLUTIONARY DEVELOPMENT OF COLOR LEXICONS?[1]

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Cognitive anthropologists attempt to synthesize a psychologist's insight into individuals' cognitive processes with an anthropologist's understanding of a community's cultural knowledge. One route to such a synthesis is to explore how the purposive actions of individuals give rise to community culture. Thus, cognitive anthropologists commonly view culture as an information pool that emerges when communities of individuals attempt to make sense of the world and each other (Boster, in press; D'Andrade 1981; Goodenough 1957; Roberts 1964; Romney *et al.*, in press; Wallace 1761). This article is one of a series of papers that explores the relationship between the character of culturally shared understandings and the processes by which individuals come to share those understandings (Boster 1985, in press, ms.; Boster et al., in press). Here, I am concerned with how cultural regularities result from individual cognitive strategies in the domain of color classification.

Communities of people are often reported to share understandings that are different from those shared in other communities. In such cases, we can often attribute the source of this unique understanding to cultural transmission within the community; here, an individual's experience is strongly guided by what he or she has learned from other members of the community. Cultural understandings unique to a particular community are most likely in domains that are at some remove from direct experience. For example, religious understandings can be culturally shaped with little confirmation (or disconfirmation) from observation of the world. If individuals learned everything through verbal communication with other community members, one would expect few cases in which distinct communities came to the same understanding without communication with each other. In other words, if culture were entirely culturally transmitted, then to the extent that societies are isolated from one another, cross-cultural universals would be rare.

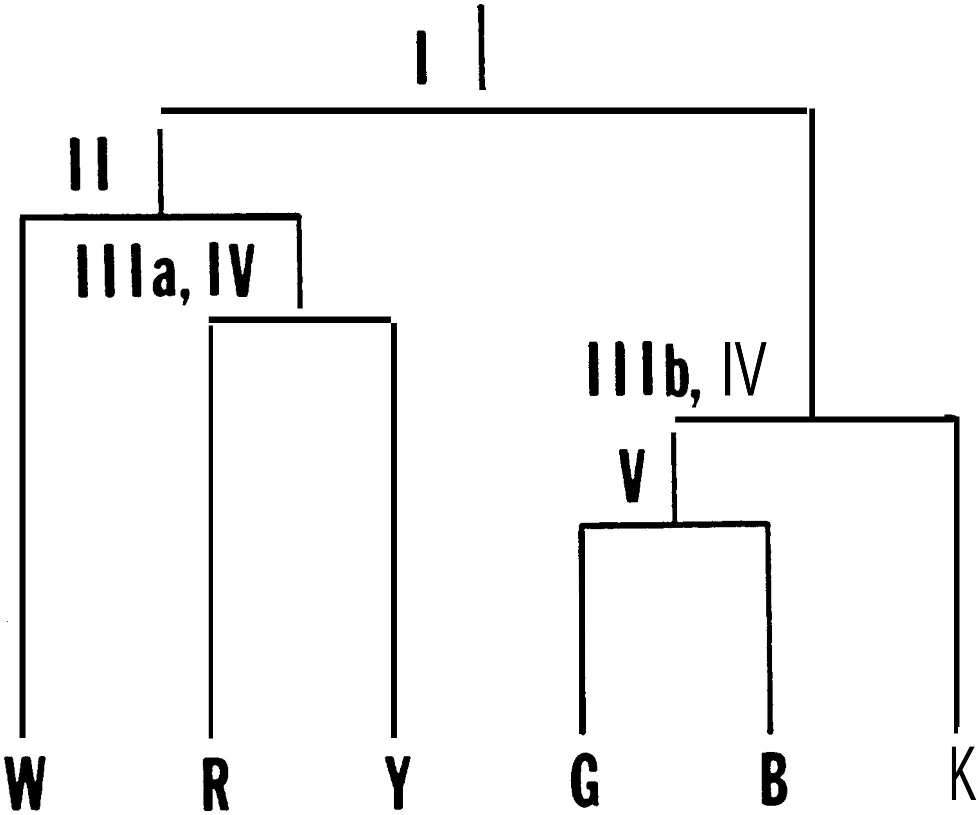
Thus, the existence of cross-cultural universals poses interesting questions about the way culture is learned. Cross-cultural universals are most likely in domains in which there is a strong structure in individuals' experience independent of cultural transmission. The independent structure allows individuals in different communities to construct the same picture of the world. In such cases, community sharing is a result of the similarities of individual experiences; in effect, individuals guide the group rather than vice-versa. The independent structure can have a variety of sources, including human perceptual physiology (e.g., universals in color classification: Berlin and Kay 1969; McDaniel 1974; Kay and McDaniel 1978), the natural order (e.g., universals in ethno-biological classification: Berlin 1973, Berlin et al. 1973, 1974; Boster et al., in press; Boster, ms.), and the concomitants of human social interaction (e.g., universals in personality descriptors: White 1980).

Regularities in folk color classification are probably the most widely cited and best studied case of a cross-cultural semantic universal. Berlin and Kay (1969) show that while the number of basic color terms in language may vary, there are strong cross-cultural patterns in the composition of color lexicons[2]. They interpret these regular patterns as a result of the evolution of color lexicons through the sequential encoding of color foci. Kay and McDaniel (1978) reinterpret this evolutionary sequence as the "successive differentiation of previously existing color categories" (Kay and McDaniel 1978: 640). Following McDaniel (1974), they argue that the universal sequence is based in the physiology of human color vision. In early stage color lexicons, color categories can name either individual foci or categories of foci. The six foci, white (*W*), red (*R*), yellow (*Y*), green (G), blue (*B*), and black (*K*), correspond to fundamental neural response categories, ultimately traceable to firing patterns of cells in the Lateral Geniculate Nucleus (*LGN*) in the optic nerve tract (Kay and McDaniel 1978:617-621). A tree diagram illustrating Kay and McDaniel's (1978) reformulation of the early stages of color lexicon evolution is shown in Figure 1. The Roman numerals to the left of each node indicate the stage at which a particular category of foci is differentiated. For example, at stage II, the light-warm category (W, R, Y) is split into light (W) and warm (R, Y).

By providing an account of the physiological basis of universals in color classification, Kay and McDaniel (1978) have provided an important link between cross-culrural universals and individual perception. But if the cross-cultural universals in color classification are indeed the outcome of pan-human cognitive strategies of categorizing fundamental neural responses, we would expect that first, differences between languages would be mirrored by variation between individuals in the same speech community, second, individuals' conceptions of the internal structure of color categories would be congruent with the evolution of color lexicons, and third, individuals would respond to the fundamental color foci in comparable ways regardless of the degree of advancement of their color lexicon, Recent research supports each of these expectations. First, the pattern of intracultural variation in color classification is consistent with Berlin and Kay's (1969) sequence; speech communities often contain speakers of adjacent stages in the evolutionary sequence and there is a tendency for speakers with more advanced color lexicons to be younger than others (Kay 1975; Dougherty 1977; Hage and Hawkes, ms.). Second, Burgess et al. (1983) present evidence that internal category structure presages evolutionary change; the bifocaliry of the Tarahumaran GRUE term in green and blue anticipates the next stage in which these foci receive separate lexical recognition. Third, Rosch (Heider 1972a, 1972b) shows that although the Dani of New Guinea only have two basic color terms (*mola*: warm-light W, R, Y and *mili*: cool-dark G, B, K), unnamed foci (e.g., Y, G, B) are more salient and more easily remembered than surrounding nonfocal colors (Heider 1972a, 1972b: 10-20). Figure 2 illustrates how Rosch's description would be cast in Kay and McDaniel's (1978) model. The Dani have named the superordinate nodes of this tree structure (i.e., W. R, Y and G, B, K) while the terminal nodes have been shown by Rosch to have the salience of unlabeled or "covert" categories.

These findings confirm three expectations arising from the idea that cross-cultural universals in color classification are a consequence of individual cognitive strategies. One can find reflections of the cross-cultural evolution of color lexicons in the responses of individuals, whether it be in interspeaker variation in number of basic color terms, the recognition of the internal structure of color

FIGURE 1: Kay and McDaniel's Reformulation



This **tree diagram** illustrates Kay and McDaniel's (1978) reformulation of the early stages of color lexicon evolution. The Roman numerals to the left of each node indicate the stage at which a particular category of foci is differentiated.

categories, or the perceived salience of unnamed foci. This paper rests a fourth expectation arising from this idea Individuals faced with the task of successively dividing color categories should recapitulate the evolutionary sequence (Berlin and Kay 1969; Kay and McDaniel 1978). Native English speakers are appropriate subjects for such a test since English basic color terms, unlike Dani, do not name categories of foci.

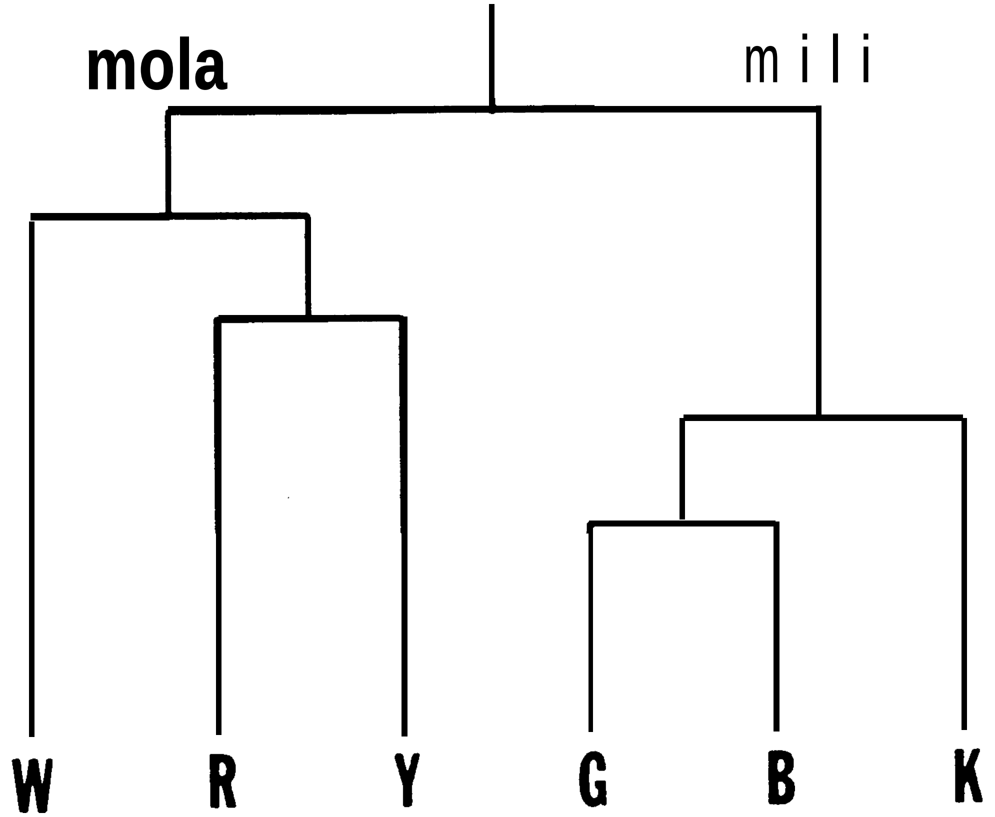
METHODS

Two sorting experiments were conducted to test this expectation: the first, a nonverbal task using color chips as stimuli; the second, a verbal task using color terms written on slips of paper. In both experiments, subjects were asked to sort colors into successively smaller groups, such that a complete hierarchical structure was elicited from each subject.

Experiment I: Non-Verbal Color Chip Sorting Task

Subjects were a convenience sample of 27 young adults living in Berkeley, California. All subjects were native English speakers and were unfamiliar with the

FIGURE 2: Dani Color Categories



This tree diagram illustrates Dani color categories (Heider 1972a) cast in Kay and McDaniel's (1.978) model.

findings of Berlin and Kay (1969). Data from six subjects were eliminated from the analysis; two did not complete the task and four did not completely order their divisions of the colors.

The stimuli used in this experiment included six Munsell color chips: red (5R4/14), orange (10R6/14), yellow (5Y8/14), green (5G5/10), blue (5PB4/12), and purple (10PB4/10). These particular chips were chosen to be as close as possible to the foci of their respective color categories (Berlin and Kay 1969). In addition, black and white chips were cut out of cardboard to the same size as the rest of the chips and used in the absence of true Munsell color chips of these colors.

The color chips were laid out in random order in front of subjects who were given the following initial instructions:

> What I would like you to do is sort these colors into two groups on the basis of which colors you think are most similar to each other. Now, I don't want you to do it on the basis of anything that you've learned in school, like the difference between primary and secondary colors, nor on the basis of any personal associations you might have with the colors, such as which colors you like and dislike. Just try to make two natural groupings. Imagine you speak a

> language that only has two color words, how would you choose to divide up the colors and which colors would you put together in each group.

After the initial groupings of chips were recorded, the subject was asked to continue to divide one of the remaining groups of chips. The subject continued to divide groups of chips until all chips were separated. There was no explicit naming of colors by the subject until after the sorting was through. After subjects had finished sorting the color chips, I often had an opportunity to ask them to describe their groups.

Experiment II: Verbal Color Term Sorting Task

Subjects were 32 undergraduates of the University of California, Berkeley, none familiar with Berlin and Kay (1969). Data from a total of fourteen subjects were eliminated from the analysis; two were not native English speakers, one did not complete the task, and eleven did not completely order their divisions of the colors. In other respects, however, the responses of these subjects did not appear to be systematically different from those of other subjects.

The stimuli consisted of a packet of eight randomly shuffled slips of paper, each with a different color term written on it. The color terms were "white," "red," "orange," "yellow," "green," "blue," "purple," and "black." In addition, pieces of construction paper in these eight colors were placed in random order on a blackboard in front of the subjects as a memory aid.

The procedure and instructions were the same as those used in the chip sorting task, except that subjects recorded their own divisions of the color slips.

SUBJECTS' DESCRIPTIONS OF THEIR INITIAL GROUPS

Before proceeding with the formal analysis of the experimental results, I would like to review the nonverbal subjects' descriptions of their initial groups of color chips. Although there are 162 ways of dividing eight colors into two groups, the subjects in this task only divided the chips in the five patterns shown in Table 1. Two thirds of the non-verbal subjects (N = 14) made a first division of the "light" colors (W, R, 0, Y) versus the "dark" colors (G, B, P, K), thereby exactly following the Kay and McDaniel (1978) model. These subjects tended to complete the task more rapidly than other subjects. They tended to describe the W, Y, 0, R group as "light," "bright," or "warm" colors, and less frequently, as "brash" "vibrant," "loud," and "glowing." They most often described the (G, B, P, K) group as "dark" or "cool" colors, and less often "soothing," "receding," "relaxing," "deep," "subdued," "shady," "quiet," and "drab." In general, most of the descriptions of the "light" colors connote energy and irritation, while the descriptions of the "dark" colors are almost uniformly tranquil.

Most of the remaining subjects (N = 6) placed red together with the dark chips (G, B, P, K), sometimes replacing either green or purple. These subjects tended to describe their initial groups using textural rather than visual metaphors. The group of chips including (W, Y, 0) were often described as "soft" or "weak" while the group of chips including (R, B, K) were described as "hard" or "strong." I believe this is due to the presence of the most highly saturated primaries (i.e., unmixed with gray, e.g., R, B) in the "hard" group and the most desaturated primary (Y) in the "soft" group. The remaining subject paired white and black and placed them among the "dark" colors.

ANALYSIS

The analysis of the experimental results has three steps: first, recording the subjects' hierarchical sorts in both experiments; second? computing similarity matrices among the colors; and third, comparing these similarity matrices with

Table 1

Patterns of first splits.

	Non-verbal experiment		Verbal experiment	
Chips in first split	N of subjects	% of subjects	N of subjects	% of subjects
WYOR, GBPK	14	67%	11	61%
WYO, RGBPK	2	10%	4	22%
WYOG, RBPK	2	10%	1	6%
WYOP, RGBK	2	10%	0	0%
YOR, GBPWK	1	5%	0	0%
WYORB, GPK	0	0%	1	6%
WYORGHP, K	0	0%	1	6%
Totals	21	102%	18	101%

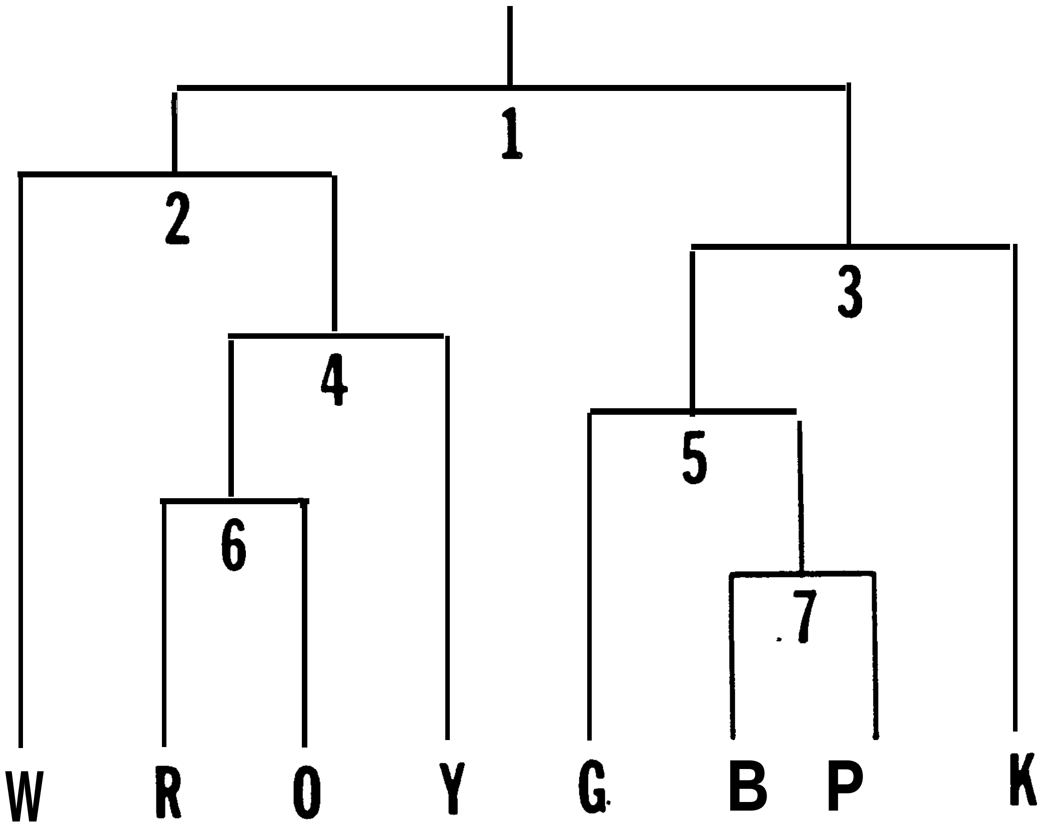
one derived from Kay and McDaniel's (1978) model of the evolutionary sequence.

The responses of each subject to these hierarchical sorting tasks can be economically represented by a tree-string of alternating letters and numbers that specifies the order in which colors were split apart. The order is indicated by the numbers 1 to 7 while the colors are symbolized by the letters W, R, 0, Y, G, B, P, and K. For example, the string W-2-R-6-O-4-Y-1-G-5-B-7-P-3-K corresponds to the tree shown in Figure 3. The responses of subjects in both experiments are presented in Table 2.

Each tree-string can be converted to a similarity matrix by recording the lowest order number that falls between a pair of color-letters in the string as the similarity of that pair of colors. This corresponds to the order in which the pairs of colors were split apart. For example, considering the substring R-6-O-4-Y-1-G, the similarity of R and 0 is 6, the similarity of R and Y is 4, and the similarity of R and G is 1. An aggregate measure of the similarity between the colors can be computed by averaging the order numbers across all subjects for all pairs of colors. The BASIC program shown in the Appendix accomplishes this step. Table 3 shows the observed data matrices of similarities among the colors calculated using this procedure for both experiments.

The similarities among the colors derived from Kay and McDaniel's model (1978) can be calculated in an analogous fashion. There are two paths through the evolutionary sequence to the point at which all six fundamental foci are split apart. These paths differ in whether yellow is split from the warm category before GRUE is split from the cool dark category or vice versa. These two paths are

FIGURE 3: Hierarchical Sort of Colors



This tree diagram illustrates the hierarchical sort of colors corresponding to the tree-string W-2-R-6-0-4-Y-1-G-5-B-7-P-3-K.

represented by the strings W-2-R-6-O-3-Y-1-G-5-B-7-P-4-K (IIIa) and W-2-R-6-0-4-Y-1-G-5-B-7-P-3-K (IIIb). (Here, orange and purple are treated as part of red and blue respectively.) Similarity matrices were computed and the cell values averaged to derive the model matrix of expected similarities among the colors shown in Table 4.

The final step in evaluating how closely English speakers recapitulate the evolutionary sequence is to compare the similarity matrices based on subjects’ responses in the two experiments with the matrix derived from Kay and McDaniel’s (1778) model. This was done by computing the Pearson correlation between corresponding off-diagonal cells in the matrices,’ the Quadratic Assignment Program (QAP) z score (Hubert and Schultz 1976), and gamma (Blalock 1972:224-5).

RESULTS

The results are shown in Table 5. For both experiments, all measures indicate an exceptionally strong correspondence between the observed data and the model matrices; native English speakers apparently closely recapitulate the evolutionary sequence of color lexicons (Berlin and Kay 1969; Kay and McDaniel 1978) as they successively divide colors. It appears to make little difference

Table 2

Tree-string representations of subjects' responses
to the hierarchical color sorting tasks.

Non-verbal experiment	Verbal experiment
W 2 Y 7 O 1 G 5 B 4 P 6 R 3 K	W 3 O 5 Y 1 B 7 R 6 G 2 P 4 K
W 3 R 7 O 4 Y 1 G 6 B 5 P 2 K	W 3 O 6 Y 1 G 2 R 5 B 7 P 4 K
W 2 R 6 O 4 Y 1 G 7 B 3 P 5 K	W 6 Y 4 O 1 G 2 R 5 P 3 B 7 K
W 6 Y 3 O 5 G 1 R 7 P 2 B 4 K	W 6 Y 2 O 4 R 1 G 5 B 3 P 7 K
W 5 Y 2 O 6 R 1 G 7 B 3 P 4 K	W 4 Y 6 O 3 R 1 G 2 B 7 P 5 K
Y 7 O 5 R 1 G 4 B 6 P 2 W 3 K	W 3 R 4 O 7 Y 1 G 5 B 6 P 2 K
W 3 Y 4 0 6 R 1 G 5 B 7 P 2 K	W 3 R 5 O 7 Y 1 G 2 B 6 P 4 K
W 4 Y 2 O 7 R 1 G 5 B 3 P 6 K	W 4 B 2 R 5 O 7 Y 1 G 6 P 3 K
W 6 Y 3 O 5 P 1 R 4 G 2 B 7 K	W 7 Y 5 O 6 R 1 G 2 B 4 P 3 K
W 2 Y 6 O 1 R 4 G 5 B 7 P 3 K	W 6 Y 4 O 2 R 1 G 3 P 5 B 7 K
W 5 Y 3 O 7 R 1 G 4 B 2 P 6 K	W 2 R 4 O 6 Y 1 G 5 B 7 P 3 K
W 7Y 30 5 R 1 G 6 B 2 P 4 K	W 2 R 4 O 6 Y 1 G 7 B 5 P 3 K
W 5 Y 2 O 7 P 1 G 4 B 6 R 3 K	W 3 R 7 O 5 Y 1 G 3 B 5 P 2 K
W 5 Y 3 O 7 R 1 G 4 B 2 P 6 K	W 4 R 5 O 6 Y 3 B 7 P 2 G 1 K
W 3 Y 2 O 4 G 1 B 7 P 5 R 6 K	W 3 R 5 O 6 Y 1 G 2 B 7 P 4 K
W 5 Y 2 O 7 R 1 G 6 B 3 P 4 K	W 2 Y 4 O 3 G 1 R 6 B 7 P 5 K
W 5 Y 2 O 7 R 1 G 3 B 6 P 4 K	W 2 R 7 O 5 Y 1 G 6 B 4 P 3 K
W 7 Y 2 O 5 R 1 G 4 P 3 B 6 K	W 4 Y 7 O 1 G 6 B 2 R 5 P 3 K
W 6 Y 2 O 7 R 1 G 5 B 3 P 4 K	
W 4 Y 2 O 7 R 1 G 6 B 3 P 5 K	
W 5 Y 3 O 6 R 1 B 7 P 2 G 4 K	

Table 3

Similarity matrix derived from subjects' responses
to the hierarchical sorting task.

Non-verbal experiment

	White	Red	Orange	Yellow-	Green	Blue	Purple	Black
W	8.0000	4.3333	2.3333	1.9524	1.1905	1.0476	1.1905	1.0952
R	4.3333	8.0000	3.2381	2.3333	1.1429	1.0000	1.1429	1.0000
O	2.3333	3.2381	8.0000	4.8095	1.3333	1.0000	1.4762	1.0000
Y	1.9524	2.3333	4.8095	8.0000	1.5714	1.8095	1.8571	1.6190
G	1.1905	1.1429	1.3333	1.5714	8.0000	4.3333	2.8571	2.5238
B	1.0476	1.0000	1.0000	1.8095	4.3333	8.0000	3.8095	3.1905
P	1.1905	1.1429	1.4762	1.8571	2.8571	3.8095	8.0000	3.5238
K	1.0952	1.0000	1.0000	1.6190	2.5238	3.1905	3.5238	8.0000

Verbal experiment

	White	Red	Orange	Yellow	Green	Blue	Purple	Black
W	8.0000	3.6111	3.0556	2.2778	1.1111	1.2778	1.1111	1.0000
R	3.6111	8.0000	5.4444	3.2778	1.1667	1.1667	1.1111	1.0000
O	3.0556	5.4444	8.0000	3.6667	1.1667	1.1667	1.1111	1.0000
Y	2.2778	3.2778	3.6667	8.0000	1.5000	2.1667	2.1111	1.6667
G	1.1111	1.1667	1.1667	1.5000	8.0000	3.4444	2.9444	2.2222
B	1.2778	1.1667	1.1667	2.1667	3.4444	3.0000	4.8889	3.3889
P	1.1111	1.1111	1.1111	2.1111	2.9444	4.8889	8.0000	3.5556
K	1.0000	1.0000	1.0000	1.6667	2.2222	3.3889	3.5556	8.0000

Table 4

Similarity matrix derived from Kay and McDaniel's (1978) model of the evolution of color lexicons.

	White	Red	Orange	Yellow	Green	Blue	Purple	Black
W	8.0000	2.0000	2.0000	2.0000	1.0000	1.0000	1.0000	1.0000
R	2.0000	8.0000	3.5000	3.5000	1.0000	1.0000	1.0000	1.0000
O	2.0000	3.5000	8.0000	6.0000	1.0000	1.0000	1.0000	1.0000
Y	2.0000	3.5000	6.0000	8.0000	1.0000	1.0000	1.0000	1.0000
G	1.0000	1.0000	1.0000	1.0000	8.0000	5.0000	5.0000	3.5000
B	1.0000	1.0000	1.0000	1.0000	5.0000	8.0000	7.0000	3.5000
P	1.0000	1.0000	1.0000	1.0000	5.0000	7.0000	8.0000	3.5000
K	1.0000	1.0000	1.0000	1.0000	3.5000	3.5000	3.5000	8.0000

whether the stimuli are color chips or written color terms. The gammas of .86 and .90 indicate that it is from 13 to 19 times more likely for subjects to order their divisions of the colors as predicted by the model than contradictory to it. Monte Carlo simulation, as described by Hubert and Schultz (1976), was used to gauge the extent to which the observed and the model similarity matrices were more similar than would be expected by chance. In the nonverbal experiment, the observed and model matrices were more similar than were randomly permuted pairs in 999 of 1000 simulation trials and in the verbal experiment, these matrices were more similar in 998 of 1000 trials. These correspond to one-tailed probabilities of .001 and .002 respectively.

A technique developed by Hubert and Golledge (1981) was used to determine whether the observed data matrices are completely accounted for by the Kay and McDaniel (1978) model (cf. Nakao and Romney 1984). First, the observed data and model similarity matrices were standardized by subtracting the mean of the elements from each element and dividing by the standard deviation. The standardized model matrix was then subtracted from each of the standardized data matrices to yield residual matrices reflecting that portion of the data that is not accounted for by the model. Finally, the original data matrices and the residual matrices were compared, again using Pearson r, QAP z score, and gamma. The results of this comparison are also shown in Table 5. The observed and the residual matrices in the nonverbal experiment were more similar than were randomly permuted pairs in 909 of 1000 Monte Carlo simulation trials, corresponding to a one-tailed probability of .091. The observed and the residual matrices in the verbal experiment were more similar than were randomly permuted pairs in 921 of 1000 simulation trials, corresponding to a one-tailed probability of .079. These are rejected as nonsignificant.

Table 5

A comparison of the observed, model, and residual similarity matrices for both non-verbal and verbal color sorting experiments.

	QAP z score	Pearson r	Gamma	Monte Carlo prob.
Observed versus model				
Non-verbal sorting experiment	4.12	.84	.90	.001
Verbal sorting experiment	4.02	.81	.86	.002
Observed versus residual				
Non-verbal sorting experiment	1.38	.28	.39	.091
Verbal sorting experiment	1.63	.31	.36	.079
Comparison of two experiments:				
Observed versus observed	4.13	.87	.80	.000
Residual versus residual	3.34	.63	.52	.000

In sum, there is a strong correspondence between the Kay and McDaniel (1978) model and subjects' responses in both color sorting experiments. Only a negligible portion of the observed data in both experiments is unaccounted for by this model.

This dramatic result-subjects faced with the task of repeatedly subdividing colors recapitulate the evolution of color lexicons-supports the position that the source of cross-cultural universals can often be found in the cognition of individuals.

But it is important to emphasize the task-dependent nature of this result. These results should not be interpreted as evidence that English speakers have proto-color categories in their heads, only that they will reconstruct them if faced with an appropriate task. Although the results are apparently not affected by the choice of stimuli, they almost certainly would be affected by a change in the underlying logic of the task. There is ample evidence that if English speakers are given the alternative task of directly judging the similarities among colors, they respond quite differently. In experiments using similarity ratings of pairs of color stimuli (Shepard 1962) or a bottom-up variant of a hierarchical sort (Fillenbaum and Rapoport 1971), the representation of informants' similarity judgments takes the form of a ring. That is, red is judged similar to orange, orange to yellow,

yellow to olive, olive to green, green to aqua, aqua to blue, blue to purple, and purple to red.

Kay and **Kempton** (1984) arrive at a comparable result in their examination of the effects of category boundaries on color similarity judgments. In a triad task that allowed subjects to view color chips simultaneously, thereby inviting categorization, English speakers overwhelmingly overrode perceptual affinities (as measured by minimal perceptible differences) in favor of categorical ones. For example, they were more likely to group chips that they called blue together even if one of the pair was more similar in hue to a chip just across the category boundary in green. In a triad task that allowed the subject to view only two of the three chips at a time, thereby thwarting categorization, English speakers responded according to the perceptual distances between the chips; color category boundaries had little influence on their response patterns. Thus Kay and **Kempton** (1984) demonstrate that a **Whorfian** effect of category structure on perception of similarities among colors depends on the nature of the task presented to subjects.

In sum, the experimental results reported here do not prove that primitive color systems lurk in the deep recesses of our minds. Instead, it appears that if an individual tackles a task analogous to the one that communities face in the course of color lexicon evolution, one of successively subdividing color categories, the individual will tend to solve the problem in much the same way that cultural communities do. This is probably no accident; communities are made up of individuals employing the same sorts of strategies tapped in these experiments[3]. These results support the generalization that cultural universals result from pan-human communalities in individuals' responses to structure. In this case, that structure has its source in the physiology of human color vision.

APPENDIX

BASIC Program for producing similarity matrix from tree-strings.

```
10 OPTION BASE 1
20 PRINT “THIS PROGRAM ANALYZES DIVIDING TASK DATA”
30 INPUT “What is the name of the input file?“, DATAFILENAME$
40 INPUT “What is the name of the output file?“, OUTFILENAME$
50 N = 8
60 DIM SIM(N,N),TOKEN%(N),CUT%(N)
70 COLOR$ = “WYORGBPK”
80 OPEN “O”,2,OUTFILENAME$
90 OPEN “I”, 1,DATAFILENAME$
100 FOR I = 1 TO N
110 FOR J = 1 TO N
120 SIM(I,J) = 0
130 NEXT J
140 NEXT I
150 RECNUM% = 0
160 WHILE NOT EOF(1)
170 RECNUM% = RECNUM%+1
180 LINE INPUT #1,DATAIN$
190 REM
200 REM PAD THE INPUT STRING WITH ZEROS SO THAT THE LAST
ELEMENT OF THE
210 REM CUT ARRAY WILL HAVE SOMETHING IN IT
220 REM
230 DATAIN$ = DATAIN$+“O”
240 REM
```

```
250 REM TRANSLATE THE DATA STRING INTO AN ARRAY OF N
MATRIX INDICES
260 REM AND AN ARRAY OF N-1 CUT NUMBERS
270 REM
280 FOR I = 1 TO N
290 TOKEN%(I) = INSTR(COLOR$,MID$(DATAIN$,I*2-1,1))
300 CUT%(I) = VAL(MID$(DATAIN$,I*2,1))
310 NEXT I
320 FOR I = 1 TO N-1
330 MINCUT = N
340 FOR J = I+1 TO N
350 REM
360 REM FIND THE HIGHEST ORDER CUT NUMBER THAT SEPA-
RATES THEM
370 REM THIS NUMBER WILL BE THE MINIMUM OF THE PRESENT
CUT NUMBER AND
380 REM THE MINIMUM OF THE PREVIOUS CUT NUMBERS.
390 REM
400 IF CUT%(J-1)< MINCUT THEN MINCUT = CUT%(J-1)
410 REM
420 REM ENTER THE CUT NUMBER AS THE RANK SIMILARITY
430 REM BETWEEN THOSE ELEMENTS
440 REM
450 SIM(TOKEN%(I),TOKEN%(J)) =
MINCUT+SIM(TOKEN%(I),TOKEN%(J))
460 SIM(TOKEN%(J),TOKEN%(I)) =
MINCUT+SIM(TOKEN%(J),TOKEN%(I))
470 PRINT USING "## ## ##"; RECNUM%;I;J;:PRINT STRING$(40,8);
480 NEXT J
490 NEXT I
500 WEND
510 FOR I = 1 TO N
520 SIM(I,I) = N*RECNUM%
530 FOR J = 1 TO N
540 PRINT #2, USING "###.####"; (SIM(I,J)/RECNUM%);
550 NEXT J
560 PRINT #2, USING "##";I
570 NEXT I
580 CLOSE #1
590 SYSTEM
```

NOTES

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2. Berlin and Kay (1969) observed that if a language has two basic color terms, these will name the black and white foci; if three terms, they will name the black, white, and red foci; if four terms, either black, white, red, and green or black, white, red, and yellow; if five, black, white, red, green, and yellow; if six, black, white, green, yellow, and blue; if seven, black, white, red, green, yellow, blue, and brown, and if more than seven, the additional terms will name pink, purple, orange and grey in no particular order.

3. Nerlove and Romney (1967) make a similar argument in their discussion of universals patterns in sibling terminology. They view "sibling terminology as an outcome of a "natural" cognitive experiment" (Nerlove and Romney 1967:181), similar to the cognitive tasks performed by individual subjects in a psychologist's laboratory.

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