The Structure of the Colour Lexicon

John Archibald
University of Calgary

In Archibald (1989) I proposed a model of colour space based on the colour lexicon. The research design involved having subjects sort a list of colour terms into a variety of categories. Most of the previous research on the linguistic structure of colour terms (Berlin & Kay, 1969; Mervis & Roth, 1981), had been done by having subjects perform various sorting tasks on colour chips. That is to say, most of the information came from the manipulation of visual stimuli based on the perception of colour. One of the standard models of describing colour space is shown in Figure 1. This is the model shown in Kay & McDaniel (1978).

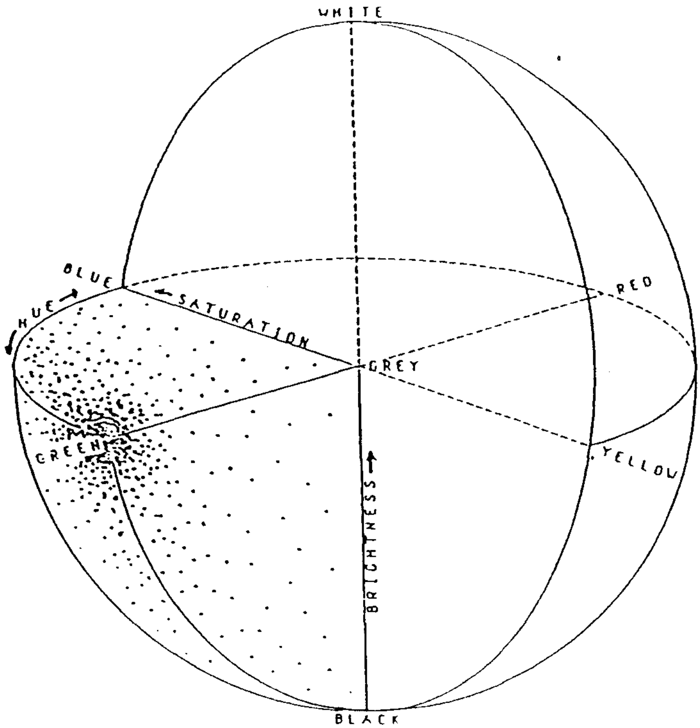


FIGURE 1: Kay & McDaniel's (1978) Model of Colour Space.

The spherical model, with its four points of equal status along the equator (*red, yellow, green, blue*), is justified physiologically (De Valois et al. 1966).

Let us briefly review Berlin & Kay's (1968) criteria for establishing whether a particular item was a *basic* term or not:

1) it must be monolexemic (ruling out *lime green*)
2) its signification must not be included in another colour term (ruling out *scarlet* which is a kind or *red*)
3) its usage must not be restricted to a narrow range of objects (ruling out *blond*)
4) it must be psychologically salient (ruling out *taupe*)

In Archibald (1989) I pointed out that the spherical model has great difficulty accounting for the distribution of basic colour terms on the colour solid. Consider the mid-points between the polar extremes and their lexical status (basic or non-basic). Between *blue* and *red* there is *purple*, a basic term. Between *red* and *yellow* there is *orange*, another basic term. But between *blue* and *green* there is *turquoise*, a non-basic term. And between *green* and *yellow*, there is *chartreuse*, another non-basic term. Just by looking at the equator of this colour model, we can see that it has no predictive power as to the lexical status of a colour term. The rest of the colour solid is likewise problematic. Similarly, the model cannot explain why terms at certain points on the model are basic while terms at other points are non-basic. Ultimately, we should like our model to be able to account for these lexical facts.

Further examination of this problem quickly reveals that it is the status of the colour terms centred on green (*chartreuse* and *turquoise*) which are problematic. Therefore, contrary to the predictions of the spherical model, I suggested that green has a different lexical status from *red, blue*, and *yellow*.

Essentially, I was investigating whether the two-level structure (basic versus non-basic) is enough. Do we need a third level of structure? To examine this question I divided the notion of basic colour term into two levels: primary basic and secondary basic. The primary colours are those which cannot be derived from combinations of other colours: *red, yellow, blue, black*, and *white*. The secondary colours are perceived as being derived from any two of the primaries[2]. For example:

red + blue = purple
red + yellow = orange
blue + yellow = green
red + white = pink
yellow + black = brown

[1] See Appendix B for another method of classification
[2] This is not an uncontroversial distinction. Theatrical lighting designers, in particular, were outraged..

The task then is to determine whether green, in sorting tasks, patterns as a primary colour (red, blue, and yellow) or like a secondary colour (purple and orange). We will see that by assigning green a different status from red, blue, and yellow, our model gains considerable power.

The Testing

I will not go into details of the sorting tasks here (see Archibald, 1989 for further discussion). Suffice it to say that the following list of lexical items was given to a number of subjects who had to place the terms under given category headings. The terms were:

scarlet	turquoise
yellow	orange
burgundy	lavender
beige	lime
pink	navy
crimson	olive
gold	red
cream	blue
purple	peach
green	brown
mauve	emerald

This was the random order in which the terms were presented to the subjects. The data were then analyzed by means of a statistical procedure known as dual scaling.

Dual scaling is a technique used to reveal the structure of categorical data. The dual scaling technique looks at the data matrix and determines what, if any, patterns underly the organization of these data. The major pattern that it pulls out is referred to as the first solution or first dimension. The programme will then extract other patterns (referred to as the second and third dimensions, and so on). The technique is dual in that it determines patterns in both rows and columns. That is to say, it takes into account how subject one classified all the colours, and how all the subjects responded to, for example, pink.

All in all, the subjects performed fifteen sorting tasks with the following category headings:

1) Four unlabeled categories
2) Red-Green-Yellow-Blue
3) Red-Purple-Yellow-Blue
4) Red-Orange-Yellow-Blue
5) Three unlabeled categories
6) Red-Yellow-Blue
7) Red-Green-Blue (no Yellow)
8) Red-Yellow-Green (no Blue)
9) Green-Yellow-Blue (no Red)
10) Orange-Yellow-Blue
11) Red-Orange-Blue

12) Red-Yellow-Orange
13) Purple-Yellow-Blue
14) Red-Yellow-Purple
15) Red-Purple-Blue

All of these tests revealed two organizing principles of the primary and secondary terms:

1) The primary terms remain maximally distant.
2) The secondary terms exhibit an elastic behaviour between their source primaries.

I concluded that although both primary and secondary colours should be considered basic, they are perceived differently. This forced me to reject the standard spherical model of colour space. I proposed the model shown below to graphically depict the linguistic structure of the colour lexicon[3]. This model has the explanatory power that the standard model lacked. There is now a way of classifying a colour as basic or non-basic by looking at its position on the model. The apices of the dual-tetrahedron have the potential to be encoded as basic terms, as do the midpoints of each of the sides. This is not to say that every language will encode all of these positions as basic; we know this is not the case.

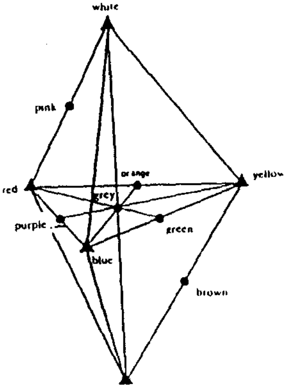


FIGURE 2: A Model of the Colour Lexicon

[3] Thanks to John Giesbrecht for drawing Figures 2 and 3.

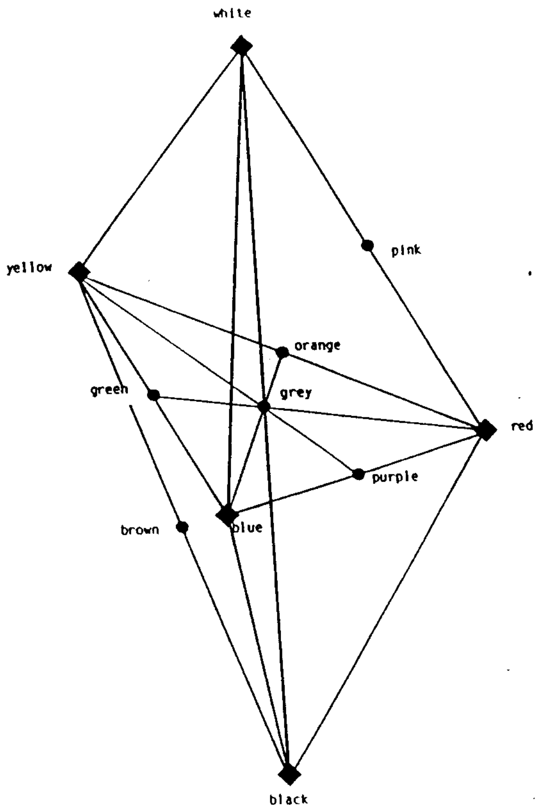


FIGURE 3: Model of the Colour Lexicon Incorporating Perceptual Distance

But while the apices and mid-points both have the potential to be encoded as basic terms, they also reflect the differing lexical status of the primary basic terms (the apices) and the secondary basics (the mid-points). Thus, this model can account for the difference in behaviour between red, yellow, and blue versus green, purple, and orange as the model assigns them different status.

However, there are still gaps on the model. Why is there not a basic term at the mid-point of *white* and *yellow*, or *white* and *blue*, or *red* and *black*? I proposed a principle of maximal perceptual distance to account for these gaps. To predict whether a colour has the potential to become basic, we must note the following four facts:

1) If we lighten a dark colour we produce the potential for a basic colour term (e.g. *pink*).
2) If we darken a light colour we produce the potential for a basic colour term (e.g. *brown*).
3) If we lighten a light colour we do not produce the potential for a basic colour term (e.g. *canary yellow*).
4) If we darken a dark colour we do not produce the potential for a basic colour term (e.g. *burgundy*).

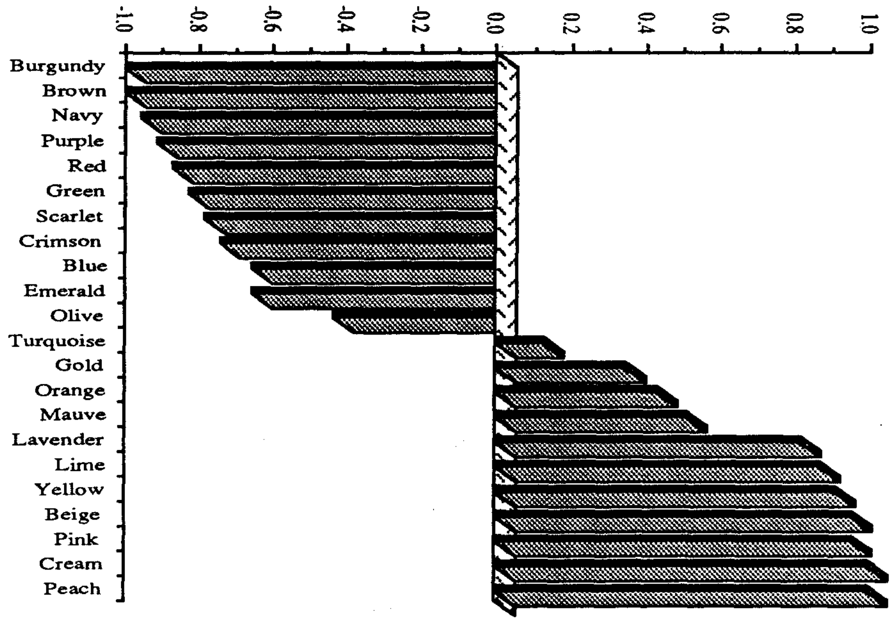
The principle of perceptual distance is graphically represented in Figure 3 (the central plane of Figure 2 has been inclined thereby altering some of the distances between colour points).

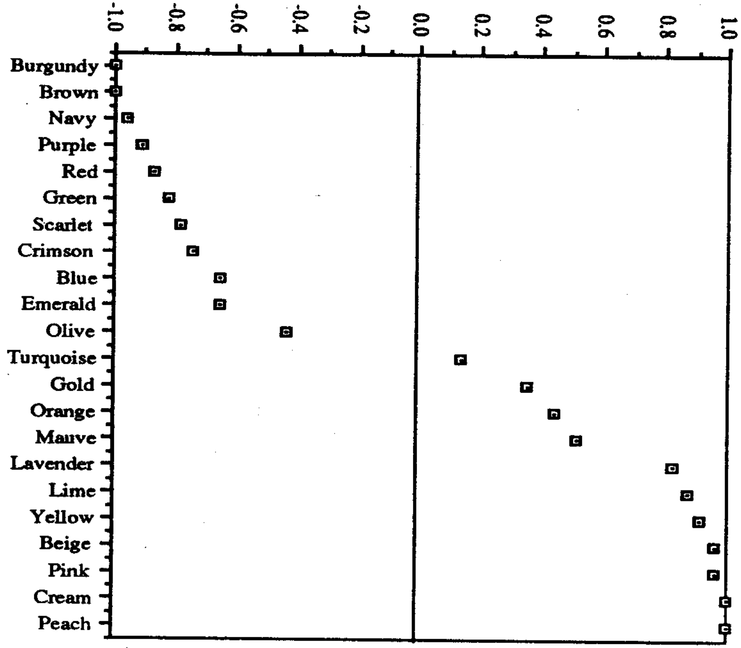
Now, this accounts for three of the four gaps but it does not account for the gap between white and blue. Here we are lightening a dark colour and we would expect a basic colour term. This, however, is an accidental gap in the lexicalization of English colour space. Languages such as Russian and Ukrainian have basic terms for light blue. The model, thus, allows for this. This fact can also be accounted for by the fact that Russian 'blue' is focussed closer to black, thus increasing the distance from blue to white. Consequently, there is greater perceptual distance and another basic term can be encoded.

I had, however, no empirical justification for assuming that the subjects actually treated light and dark colours differently. I needed some support for maintaining that this was, in fact, a psychologically relevant distinction.

In order to determine whether this was the case, I presented the same list of 22 colour terms to forty-six subjects, and asked them to sort the terms into two categories labelled Light and Dark. A score of +1 was assigned if the term was placed in the *light* column, and a score of -1 was assigned if the term was placed in the *dark* column. Mean scores were then calculated for each colour term. The closer the mean score was to zero, the more variability in placement. That is to say, if twenty-three subjects placed *gold* in the *dark* column and twenty-three subjects placed *gold* in the *light* column, the mean score would be zero. The following are the results[4]:

[4] See Appendix A for the numerical data.


-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Burgundy
Brown
Navy
Purple
Red
Green
Scarlet
Crimson
Blue
Emerald
Olive
Turquoise
Gold
Orange
Mauve
Lavender
Lime
Yellow
Beige
Pink
Cream
Peach


-1.0
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Purple
Red
Green
Scarlet
Crimson
Blue
Emerald
Olive
Turquoise
Gold
Orange
Mauve
Lavender
Lime
Yellow
Beige
Pink
Cream
Peach

References

Archibald, J. (1989). A lexical model of color space. In: R. Corrigan, F. Eckman, & M. Noonan, eds. Linguistic Categorization. Dordrecht: John Benjamins.

Berlin, Brent and Paul Kay. 1969. Basic Color Terms: Their Universality and Evolution. University of California Press.

De Valois, R.L., I. Abramov, and G.H. Jacobs. 1966. "Analysis of response patterns of LGN cells". Journal of the Optical Society of America, 56: 966—977.

Gottesman, Greg. 1991. Laundry and Ironing. In: College Survival. New York: Prentice Hall.

Kay, Paul and Chad McDaniel. 1978. "The linguistic significance of the meanings of basic colour terms". Language, 54. 610—646.

Mervis, Carolyn and E.M. Roth. 1981. "The internal structure of basic and non-basic colour categories". Language, 57. 384—405.

Nishisato, S. 1980. Analysis of Categorical Data: Dual Scaling and its Applications. University of Toronto Press.

Tide detergent (box). 1991. Cincinnati: Procter & Gamble.

APPENDIX A: MEAN SCORES

Burgundy	-1.000
Brown	-1.000
Navy	-0.957
Purple	-0.913
Red	-0.870
Green	-0.826
Scarlet	-0.783
Crimson	-0.739
Blue	-0.652
Emerald	-0.652
Olive	-0.435
Turquoise	0.130
Gold	0.348
Orange	0.435
Mauve	0.511
Lavender	0.822
Lime	0.870
Yellow	0.913
Beige	0.957
Pink	0.957
Cream	1.000
Peach	1.000

APPENDIX B

By: Ken Shirriff, Oakland, California

Diverse languages classify colours in generally the same way. Why do languages follow these rules? My hypothesis is that cultures find it necessary to develop words for colours in order to do their washing. That is, "language follows laundry." This is a bold claim, but the evidence is compelling: The rules of laundry directly account for the rules of colour terms.

Previous Research

Berlin and Kay (1969) examined 98 languages from several families and found that although languages have different numbers of basic words for colours, the colours described by these words fall into a universal system of eleven categories. Moreover, languages with fewer than eleven basic colour terms obey the following rules (Berlin and Kay, 1969):

1. All languages contain terms for white and black. (To be precise, these terms distinguish light shades from dark shades)
2. If a language contains three terms for colours, then it contains a term for red.
3. If a language contains four terms, then it contains a term for either green or yellow, but not both.
4. If a language contains five terms, then it contains terms for both green and yellow.
5. If a language contains six terms, then it contains a term for blue.
6. If a language contains seven terms, then it contains a term for brown.
7. If a language contains eight or more terms, then it contains a term for purple, pink, orange, or some combination.

Laundry and Colour Terms

A typical detergent box (Tide, 1991) states that colours must be separated for laundry. This is elaborated by Gottesman (1991), who gives a basic rule of laundry: "Always separate darks and lights". An obvious conclusion is that in order to wash clothing, a culture must first have words to distinguish darks and lights. This is in perfect agreement with colour rule 1.

The second rule for laundry separation is: "Never wash red with anything even remotely white" (Gottesman, 1991). According to my hypothesis, cultures must next develop a word to describe red. This is in agreement with rule 2.

For more advanced laundry, bright colours such as green and yellow should be washed separately. This corresponds to rules 3 and 4.

Next, cultures discover that washing blue jeans separately is beneficial, resulting in rule 5. Finally, the remaining colours are named, resulting in rules 6 and 7.

Although I consider the merits of my hypothesis to be obvious, additional research can be done to confirm it. An examination of primary dyes might reveal why greens and yellows are separated. Anthropological studies could prove the match between a culture's word for colour and its washing habits.