Color Appearance and the Emergence and Evolution of Basic Color Lexicons

Paul Kay
U. of California, Berkeley
kay@cogsci.berkeley.edu

Luisa Maffi
Northwestern U.
maffi@nwu.edu

March 7, 1999

Abstract

Various revisions of the Berlin and Kay (1969) model of the evolution of basic color term systems have been produced in the last thirty years, motivated by both empirical and theoretical considerations. On the empirical side, new facts about color naming systems have continually come to light, which have demanded adjustments in the descriptive model. On the theoretical side, there has been a sustained effort to find motivation in the vision science literature regarding color appearance for the synchronic and diachronic constraints observed to govern color terminology systems. The present paper continues the pursuit of both of these goals. A new empirical question is addressed with data from the World Color Survey (WCS) and a revised model is proposed, which both responds to recently raised empirical questions and provides new motivation from the field of color vision for the observed constraints on color naming.

0 Introduction

The fact that different languages provide different lexical classifications of color has long been known. In the nineteenth century, it was not uncommon to infer from this observation that languages which fail to make a lexical distinction between what Europeans recognize as two qualitatively distinct colors, such as green and blue, do so because their speakers cannot discriminate the colors in question perceptually. For example, William Gladstone wrote, on the basis of philological investigations of Homeric Greek, "... that the organ or color and its impressions were but partially developed among the Greeks of the heroic age" (1858, cited by Berlin and Kay 1969: 135). Similar views were widespread among Gladstone's contemporaries (see Berlin and Kay 1969: 134-151). They did not, however, go entirely unchallenged. As early as 1880, the German opthalmologist, Hugo Magnus, recognized that a population's failure to impose a lexical distinction between colors does not necessarily reflect a deficit among its members in the perceptual ability to discriminate those colors (Magnus 1880: 34-35, discussed in Berlin and Kay 1969: 144ff).

While the nineteenth and early twentieth century students of color vocabularies worked mostly within the predominantly evolutionary approach to things social and cultural characteristic of the time, with the ascendance in the 1920s, '30s and '40s of linguistic and cultural relativity, spearheaded by Edward Sapir (e.g., 1921: 219) and B.L. Whorf (e.g., 1956 [1940]: 212 ff.), color came to be singled out as the parade example of a lexical domain in which the control of language over perception is patent, that is, of the view diameterically opposed to that of Gladstone and his fellows. Although neither Sapir nor Whorf ever wrote on color words, the presentation of the lexical domain of color as the empirical *locus classicus* of linguistic relativity and language determinism was reflected in a small number of highly influential empirical studies (Ray 1952, 1953, Conklin 1955) and in numerous survey and textbook presentations (e.g., Nida 1959: 13, Gleason 1961: 4, Bohannan 1963: 35ff, Krauss 1968).

Berlin and Kay (1969) used a set of stimulus materials developed earlier by Lenneberg and Roberts (1956) in a Whorfian-influenced study to assess the meanings of the basic color terms of twenty languages and extended their two main conclusions to another seventy-eight languages reported in the literature. These conclusions were (1) that there are universals in the semantics of color in (probably) all languages: all of the major color terms they found appeared to be based on one or more of eleven focal colors, and (2) that there exists an apparent evolutionary sequence for the development of color lexicons according to which black and white precede red, red precedes green and yellow, green and yellow precede blue, blue precedes brown and brown precedes purple, pink, orange and gray. While psychologists, including specialists in color vision, largely welcomed these findings (Bornstein 1973a,b, Brown 1976, Collier et al. 1976, Miller and Johnson-Laird 1976, Ratliff 1976, Shepard 1992, Zollinger 1972, 1976, 1979), anthropologists expressed skepticism, principally on methodological grounds (e.g., Hickerson 1971, Durbin 1972, Collier 1973, Conklin 1973).[1]

In the ensuing years, a number of empirical studies of color terminology systems in field settings confirmed the broad outlines of the Berlin and Kay findings, while amending many details (e.g., Heider 1972a,b, Heider and Olivier 1972, Heinrich 1972, Kuschel and Monberg 1974, Dougherty 1975, 1977, Hage and Hawkes 1975, Berlin and

Berlin 1975, among many others). These studies led to an early reformulation of the encoding sequence (Berlin and Berlin 1975, Kay 1975). Subsequently, Kay and McDaniel (1978) again reconceptualized the encoding sequence. This reformulation was based on (1) further empirical descriptive work, (2) earlier experiments of Chad K. McDaniel working with William Wooten (McDaniel 1972), which had established the identity of the green, yellow and blue Berlin and Kay semantic focal points with the corresponding psychophysically determined unique hues, and (3) the introduction of a fuzzy set formalism[2] (See now Zadeh 1996). The Kay and McDaniel model emphasized (1) the six primary colors of opponent theory (black, white, red, yellow, green, blue)[3], (2) certain fuzzy unions of these categories (notably, green or blue, red or yellow, black or green or blue, white or red or yellow), which are named only in evolutionarily early systems, and (3) the 'binary' colors of the vision literature (e.g., purple, orange), which Kay and McDaniel referred to as 'derived' categories. These are based on fuzzy intersections of primaries and tend strongly to be named only in systems in which all (or most) of the union- based (or 'composite') categories have already dissolved into their constituent primaries. Kay and McDaniel also related the universals of color semantics in this model, which was based squarely on the six psychophysical primaries of opponent theory, to the psychophysical and neurophysiological results of R. De Valois and his associates (De Valois et al. 1974 [psychophysics of macaque color vision], De Valois et al. 1966, De Valois and Jacobs 1968 [neurophysiology of macaque color vision]).

In recent years there have been two additional refinements of the model (Kay, Berlin and Merrifield 1991 [KBM], Kay, Berlin, Maffi and Merrifield 1997 [KBMM]), to which we will return. Also there have been two major empirical surveys, whose results largely support the two broad hypotheses of semantic universals and evolutionary development of basic color term systems. These are the World Color Survey, whose results are discussed in this paper and the Mesoamerican Color Survey (MacLaury 1997, and earlier publications cited there).[4] Throughout all these revisions, two of the original empirical generalizations of Berlin and Kay (1969) have been maintained.

I There exists a *small set of perceptual landmarks* (that we can now identify with the Hering primary colors: black, white, red, yellow, green, blue[5]) which individually or in combination *form the basis of the denotation of most of the major color terms* of most of the languages of world.[6]

II Languages are frequently observed to *gain basic color terms in a partially fixed order*. Languages are infrequently or never observed to lose basic color terms.[7]

The various revisions of the 1969 model have been motivated by both empirical and theoretical considerations. On the empirical side, new facts about color naming systems have come to light, which have demanded adjustments in the descriptive model. On the theoretical side, there has been a sustained effort to find motivation in the literature on color appearance for the synchronic and diachronic constraints observed to govern color terminology systems. The present paper continues the pursuit of both of these goals. A new empirical question is addressed with data from the World Color Survey (WCS) and a revised model is proposed, which responds to recently raised empirical questions and provides new motivation from the field of color vision for the observed constraints on color naming.

0.1 The Emergence Hypothesis

A tacit assumption made by Berlin and Kay (1969) and maintained throughout revisions of the model to date has been the proposition that "all languages possess a small set of words (or word senses) each of whose significatum is a color concept and whose significata jointly partition the psychological color space" (Kay in press 1: 1). This assumption has been challenged, explicitly by Maffi (1990a) and Levinson (1997), implicitly by Lyons (1995, in press, cf. Kay in press 2), and by Lucy and the team of Saunders and van Brakel.[8] The rejection of this assumption has been christened the Emergence Hypothesis (EH). According to the EH, not all languages necessarily possess a small set of words or word senses each of whose significatum is a color concept and whose significata jointly partition the perceptual color space. If we admit the EH as a working hypothesis, several questions immediately arise.

First, what proportion of the world's languages are non-partition languages, that is, fail to have lexical sets of simple, salient words whose significata partition the perceptual color space?

Secondly, in the case of partition languages, to what extent and in what manner do they conform to generalizations I and II above?

Thirdly, in the case of non-partition languages, to what extent and in what manner do they correspond to generalizations I and II?

Regarding the first question, it appears that in the ethnographic present non-partition languages are rare. The data from most languages studied in the WCS give no indication of non-partition status. (The exceptions are discussed in section 3 below.) Also, most reports on color term systems in the literature and in personal communications received by the authors give no suggestion that the language being reported fails to provide a simple lexical partition of the color space. One might object that such reports merely betray an unreflecting assumption, based on the reporter's own language, that every language partitions the color space with a simple lexical set. Such a conjecture is neither provable nor disprovable. In any case, the apparent paucity of non-partition languages in the ethnographic present may not be representative of human history. Specifically, just as there are no two-term ("Stage I" in the model to be introduced) languages in the WCS sample and very few reported in the literature[9], the relative lack of non-partition languages in the ethnographic present may reflect to an unknown degree the (putative) facts that (1) some extant partition languages were non-partition languages in the past and (2) some extinct non-partition languages may have left no non-partitioning descendants, or no descendants at all. Again, it is not obvious how empirical evidence may be brought to bear on such conjectures. We hope that the present paper will help stimulate field linguists and linguistic ethnographers to examine the color lexicons of the languages they encounter for evidence of non-partition status. It is unlikely at this point in world history that many more non-partition languages will be discovered, which makes the discovery and careful study of each one all the more important. Philological reconstructions of data on extinct languages (e.g., Lyons 1995, in press on Ancient Greek) and exegetical reanalyses of reports that were originally aimed at different goals (e.g., Lyons in press on Hanunóo, Lucy 1996, 1997 on Hanunóo and Zuni, Wierzbicka, 1996: 306-308 on Hanunóo) are unlikely to cast more than hazy light on the matter. Rather, carefully controlled, contemporary field studies aimed directly at EH issues, like that of Levinson 1997, are needed. (For discussion, see Kay 1997).

The answer to the second question (How do color-space-partitioning languages satisfy I and II?) will largely be provided, we hope, by a forthcoming monograph reporting the results of the WCS. That monograph will assess in detail the extent to which each of the 110 languages of the survey fits, or fails to fit, the new model presented here.

The present paper also provides an initial attempt to answer the third question (How might non-partition languages satisfy I and II?) by examining the data of Yélîdnye (Levinson 1977) and the relevant data from the WCS. The new model maintains the application of generalizations I and II to partition languages embodied in the KBMM model, while extending their application to non-partition languages. The goal of this paper is, therefore, to propose a general model of universals and evolution of basic color term systems, which (a) yields a slightly modified version of the KBMM model as the statistically predominant special case, partition languages, (b) accounts for non-partition (EH) languages and (c) derives these results from independent observations regarding (i) lexical structure and (ii) color appearance. Additionally, the proposed model provides an explanation for the hitherto recalcitrant puzzle posed by the existence of composite categories comprising both yellow and green (KBM, MacLaury 1987, 1997: 74, passim).

1 Principles of the New Model

The model is based on four principles. The first principle derives from linguistic observations, the other three from observations regarding color appearance.

1.1 Partition

The *partition principle* subsumes under a broad generalization the specific tendency for languages to provide a small set of basic color terms which jointly partition the perceptual color space. Studies of other lexical domains by ethnographic semanticists and structuralist lexicographers have shown a tendency for languages to contain sets of lexical items which partition certain obvious notional domains, such as kin relations, locally observable living organisms, regions of human (and animal) bodies, periods of the solar day, cardinal directions, seasons of the solar year, conversational participants (e.g., as reflected in person/number/gender systems), and so on.[10] Ethnographic semanticists have often emphasized the differences in the ways distinct languages lexically partition a given notionally defined domain. Less often they have called attention to cross-language similarities in the ways certain notional domains are lexically partitioned. All such comparisons are based on the tacit assumption that each of the languages being compared partitions the domain lexically.

This widespread tendency for notionally salient domains to be partitioned by a set of lexemes is what we refer to as the *partition principle*.

(0) **Partition:** In notional domains of universal or quasi-universal cultural salience (kin relations, living things, colors, etc.), languages tend to assign significata to lexical items in such a way as to partition the denotata of the domain.[11]

The strong tendency of languages to conform to Partition accounts for the rarity of non-parition languages. The fact that Partition expresses a strong tendency, rather than an exceptionless rule, is consistent with the fact that non-partition languages do exist.

The amount of information carried by the colors of objects may affect the salience of the color domain. In a technologically simple society, color is a more predictable property of things than in a technologically complex one. Except perhaps for a few pairs of closely related species of birds or of fish, it is rare that naturally occurring objects or the artifacts of technologically simple societies are distinguishable only by color. In technologically complex societies, on the other hand, artifacts are frequently to be told apart only by color. The limiting case is perhaps color coding, as used in signal lights, electric wires and other color-based semiotic media. But almost every kind of material thing we encounter in daily life: clothing, books, cars, houses, ... presents us with the possibility that two tokens of the same type will be distinguishable only, or most easily, by their colors. As the colors of artifacts become increasingly subject to deliberate manipulation, color becomes an increasingly important dimension for distinguishing things and hence for distinguishing them in discourse. As technology develops, the increased importance of color as a distinguishing property of objects appears to be an important factor in causing languages to add basic color terms, i. e., to refine the lexical partition of the color domain (Casson 1997).

The same process provides a plausible reason for the transition from non-partition to partition languages. Specifically, non-partition languages, like early-stage languages, may be spoken in societies where color is of relatively low cultural salience.[12] If we assume that cultural salience is promoted by increased functional load in communication, we expect a rise in technological complexity to both push a non-partition language toward full partition status and cause a language that already has a full partition of the color space to refine that partition, that is, to move further along the (partially ordered) universal evolutionary trajectory. On this view, both the evolution *of* basic color term systems and the evolution *toward* basic color term systems result in large measure from increasing technological control of color: as technological control of color increases, its manipulation in the manufacture of everyday artifacts causes it to bear an increasingly greater functional load in everyday linguistic communication and thereby to achieve greater cultural salience.[13] Greater cultural salience of color induces partition of the color space where it does not already exist and leads to increasingly finer partitions of the color space where a partition already exists. This process may still be going on (Kay and McDaniel 1978, Chapanis 1965).

1.2 Principles of color term universals and evolution based on color appearance

The three remaining principles of the currently proposed model are color-appearance-based. All presuppose the elemental nature of (1) the four primary hue sensations of opponent theory: red, yellow, green and blue and (2) the two fundamental achromatic sensations black and white. The overwhelming majority of vision scientists interested in color appearance and categorization now accept the basic nature of these six color sensations on the basis of a wide range of psychophysical and cognitive psychological evidence.[14] The model of Kay and McDaniel (1978) mistakenly equated these six primary color sensations with the six classes of cells identified by De Valois et al. (1966) in the parvocellular layer of the macaque lateral geniculate nucleus (LGN), and called them fundamental *neural* response categories.[15] These six cell types cannot simply constitute the neural substrate of the six primary color sensations because, among other reasons, (1) they contain nothing corresponding to the short wavelength red response and (2) the points at which the spectrally opponent cells are neither excited nor inhibited are not in the right places to produce the observed unique hue points (Derrington et al. 1984, Abramov and Gordon 1994, Abramov 1997). We should note, however, that it is psychophysical experiments that have established the short wavelength red response and the unique hue points in a variety of ways, involving diverse techniques such as hue cancellation and hue scaling (Boynton and Gordon 1965, Jameson and Hurvich 1955, Hurvich and Jameson 1955, Ingling et al. 1995, Sternheim and Boynton 1966, Werner and Wooten 1979, Wooten and Miller 1997. See Hardin 1988, Chapter I for general discussion.) The elemental character of black, white, red, yellow, green and blue in human color sensation, within a conceptual framework that includes the notions of chromacy/achromacy, unique hues and opponent processes, is no longer thought to be grounded in macaque LGN neurons, but this framework is nonetheless broadly accepted by vision scientists as the best way to organize a wide range of psychophysical, cognitive-psychological and animal-behavioral observations (Abramov 1997, Abramov and Gordon 1997, Bornstein 1997, Hardin 1988, Ingling 1997, Kaiser and Boynton 1996, Miller 1997a,b, Sandell et al. 1979, Shepard 1994, Van Laar 1997, Werner and Bieber 1997, Wooten and Miller 1997, Sivik 1997.[16] For dissent, from two distinct points of view, see Jameson and D'Andrade 1997 and Saunders and van Brakel 1997).

1.2.1 Black and White

The first principle governing the refinement of lexical partitions of the color space is given by the fact that object recognition is possible without color, e.g., in black and white movies and photographs. In fact, it is often claimed – probably an exaggeration, according to Wooten and Miller (1997) – that the rods are only active in scotopic (low illumination, black and white) vision and contribute nothing to photopic (bright illumination, color) vision. Certainly, the cones transmit luminance as well as chromatic information (De Valois and De Valois 1975, 1993). It is clear nonetheless that objects can be distinguished rather well at levels of illumination too low to stimulate the cones to give rise to hue sensations. The distinction between spectral sensitivity (spectral opponency) and spectral non-sensitivity (spectral non-opponency) is also reflected in the anatomical and physiological distinction between the magna layer and parvo layer cells of the lateral geniculate nucleus. "The great majority, if not all, of the

P-cells in a macaque... have responses that are spectrally opponent ... while M-cells are generally spectrally non-opponent..." (Abramov 1997: 101, citing the primary literature for both observations.) Macaque color vision has been shown to be in essential respects like that of humans by De Valois et al. (1974). At a more phenomenal level we can observe that people with no color vision (those suffering from achromatopsia) often have no problem with object recognition (Davidoff 1997, Mollon 1989). In short, we have a black-and-white vision system that gives us most of shape discrimination and object recognition with color vision laid on top of it. Indeed, students of vision have occasionally been led to speculate how and why our species should have evolved color vision at all (e.g., Mollon 1989, Hardin 1992). A person lacking color vision is not blind. A person lacking the black-and-white vision necessary to recognize objects is blind.

The partitioning principle motivated by these observations is:

(1) **Black and White** (Bk&W): Distinguish black and white.

1.2.2 Warm and Cool

A distinction between "warm" and "cool" colors has long been recognized by color specialists from both the arts (e.g., art critics and historians and teachers of painting) and the sciences. Red, yellow and intermediate orange are "warm"; green and blue are "cool." Hardin (1988: 129ff) provides an excellent discussion of both experimental and philosophical considerations of the warm/cool distinctions, beginning with Hume and concluding, in part, "These explanations [of the warm/cool hue associations and cross-modal associations] are of varying degrees of persuasiveness, but they should at least caution us not to put too much weight on any single analogical formulation. However, they should not blind us to the striking fact that there is a remarkable clustering of oppositions which correlate with this hue division" (Hardin 1988: 129). Early experiments (e.g., Newhall 1941) established red as a warm hue. More recent experiments (Katra and Wooten 1995), controlled for brightness and saturation, have shown that English-speaking subjects' judgments of warm color peak in the orange region and cover reds and yellows, while judgments of cool color peak in the blue region and cover greens and blues. Judgments of warmth/coolness also correlate with saturation (saturated colors are judged warm), but not significantly with lightness. These groupings of basic hue sensations into warm and cool agree with those common in the art world. A recent study of color term acquisition in two-year-olds, besides finding surprising control of color terms in very young children, found no significant differences among colors in the age at which they were acquired but did find that "there was some evidence that our subjects maintained the warm-cool boundary; in general they make more within- than across-boundary errors" (Shatz et al. 1996: 197). Both artistic tradition and recent experimental evidence thus point to an affinity between red and yellow on the one hand and between green and blue on the other. A recent color model based on observed cone frequencies (De Valois and De Valois 1993, 1996) posits an intermediate stage of chromatic information processing that consists of two channels: one red/yellow and one green/blue (See Kay and Berlin 1997 for discussion of the possible relevance of this model to cross-language color naming). The psychological color space, so-called, is notoriously lacking in a reliable long-distance metric[17]. We take the facts mentioned in this paragraph to indicate, albeit indirectly, that red and yellow are experienced as in some respect similar and that green and blue are experienced as similar in that same respect.

The partitioning principle motivated by the warm and cool groupings of hues is:

(2) **Warm and Cool** (Wa&C): Distinguish the warm primaries (red and yellow) from the cool primaries (green and blue).

1.2.3 Red

The final principle we propose for explaining the ways languages go about lexically partitioning the color space is the apparent salience of red among the hue sensations. Despite the intuitive judgment, shared by vision specialists and lay people, that red is somehow the most salient of hues, non-anecdotal support for this idea is not overwhelming. Humphrey (1976) writes

> I shall list briefly some of the particular evidence which demonstrates how, in a variety of contexts, red seems to have a very special significance for man. (1) Large fields of red light induce physiological symptoms of emotional arousal – changes in heart rate, skin resistance and the electrical activity of the brain. (2) In patients suffering from certain pathological disorders, for instance cerebellar palsy, these physiological effects become exaggerated – in cerebellar patients red light may cause intolerable distress, exacerbating the disorders of posture and movement, lowering pain thresholds and causing a general disruption of thought and skilled behaviour. (3) When the affective value of colours is measured by a technique, the 'semantic differential', which is far subtler than a simple preference test, men rate red as a 'heavy', 'powerful', 'active', 'hot' colour. (4) When the 'apparent weight' of colours is measured directly by asking men to find the balance point between two discs of colour, red is consistently judged to be the heaviest. (5) In the evolution of languages, red is without exception the first colour word to enter the vocabulary – in a study of ninety-six [sic, actually ninety-eight] languages Berlin and Kay (1969) found thirty [sic, actually twenty-one] in which the only colour word (apart from black and white) was red. (6) In the development of a child's language red again usually comes first, and when adults are asked simply to reel off colour words as fast as they can they show a very strong tendency to start with red. (7) When colour vision is impaired by central brain lesions, red vision is most resistant to loss and quickest to recover (Humphrey 1976: 97f).

It is disquieting to note, however, that the only reference provided for the various claims in the passage just cited is to Berlin and Kay (1969) and that both of the numbers reported from that work are inaccurate.

Following the publication of Berlin and Kay (1969), Floyd Ratliff, a distinguished vision scientist, attempted to provide motivation from color science for the 1969 model (Ratliff 1976). Among the elements he sought to explain was the prominence of red. Ratliff noted that the long-wavelength cones are very frequent in the fovea and are much more sensitive in the long wave end of the spectrum than the other two cone types. This line of argument has not, to our knowledge, been found persuasive. For example, Wooten and Miller (1997: 86) point out that Ratliff established no link between the observation of a dense population of long-wavelength sensitive cones in the fovea and the subjective salience of red. They note further that subjective color sensations are linked quite indirectly to cone responses, probably at cortical levels beyond the primary visual area.

At this time, the firmest warrant we can find for the apparent prominence of red among the hue sensations comes from research on color term acquisition. There have been several studies of the acquisition of color terms in English-speaking children. Some of these have noted a weak correlation of the order of acquisition of basic color terms with the original Berlin and Kay 'encoding' sequence and others no such correlation. An observation that has not previously been made about these studies and other studies of acquisition of color terms by English-speaking children is that in every case in which acquisition data is reported by term, red is the first of the hue terms acquired (Wolfe 1890 [data reproduced in Descoeudres 1946: 119]; Winch 1910: 475, passim; Heider 1971: 453. Table 3; Johnson 1977: 309f, Tables 1, 3 and 4). The same fact – that red is the first hue term acquired by children – is also evidenced by studies on German (Winch 1910: 477); Spanish (Harkness 1973: 185, Figure 4); Russian (Istomina 1963: 42f, Tables 6, 7); Italian (Winch 1910: 456-457); French (Descoeudres 1946: 118f), Mam [Mayan] (Harkness 1973: 184, Figure 3 [red and green tied for first for 7-8 year olds]); Setswana [Bantu] (Davies et al. 1994: 701-702, tables 4 and 5 [Setswana terms only]); and West Futuna (Dougherty 1975, table 5.7[18]). In every study we have found in which a difference between colors was reported in the order with which children acquire terms for them, the term for red was the first hue term acquired.[19] The final principle of color naming expresses the primacy of red among the hue sensations.

(3) **Red**: Distinguish red.

2. The WCS Data to be Accounted For

The 110 basic color terminology systems of the WCS were classified by KBMM (p. 33, Figure 2.4) into eleven basic types, based on the combinations of Hering primary terms they contain. As shown in Figure 1, Stages I (two terms) and II (three terms) each correspond to a single type, Stage III (four terms) comprises three types, Stage IV (five terms) three types, and Stage V a single type. (Two stages hypothesized by KBMM, $\mathrm{III}_{\mathrm{Bk/Bu}}$ and $\mathrm{III}_{\mathrm{Y/G}}$, have been eliminated from the model because no instances of them have been discovered in the WCS data.[20]) In Figure 1, columns represent evolutionary stages, every stage containing one more basic color term than the preceding stage. KBMM recognized languages in transition between types. In Figure 1, an arrow indicates the transitions from the type occurring on its left to the type toward which it points. For example, Stage II systems can develop into either type $\mathrm{III}_{\mathrm{G/Bu}}$ or type $\mathrm{III}_{\mathrm{Bk/G/Bu}}$.[21] Stage $\mathrm{III}_{\mathrm{Bk/G/Bu}}$ systems can develop into systems of either Stage $\mathrm{IV}_{\mathrm{G/Bu}}$ or Stage $\mathrm{IV}_{\mathrm{Bk/Bu}}$, and so on.

Progression through successive stages, starting with a two-term systems and adding a term at each stage, results from the interaction of the Partition principle with the six Hering primaries. Initially, minimal application of Partition dictates division of the color space into two categories. Of course, Partition alone doesn't tell us what these categories will be, that is, how the primaries will be grouped in the cells of the resulting partition. That is the job of the three additional, color-appearance-based principles. Each of the three remaining principles is applied in order until an unequivocal result is determined. At each succeeding change point, this process is repeated: Partition is applied, minimally, to dictate that the number of cells (= named basic color categories = basic color terms) be increased by one. Then principles (1), (2) and (3) are applied in order until an uniquivocal result regarding the nature of the new partition is achieved. (Whenever application of a principle is decisive in determining the refinement of the partition, principles of lower priority are not consulted. Eventually there remains only one possible refinement of the existing partition, so application of principle (0) suffices to produce an unequivocal result and no other principles are consulted.)

The order of application (1) > (2) > (3) expresses an empirical hypothesis regarding the relative importance of the principles. This order seems to correlate – impressionistically speaking – with the wieght of the evidence we have been able to amass for principles (1), (2), and (3) in sections 1.2.1, 1.2.2, and 1.2.3, respectively. The ordering of Parition (0) before the other three principles follows from the fact that what we are using the principles for is to refine a partition and principle (0) is the one that says, "Refine the partition."

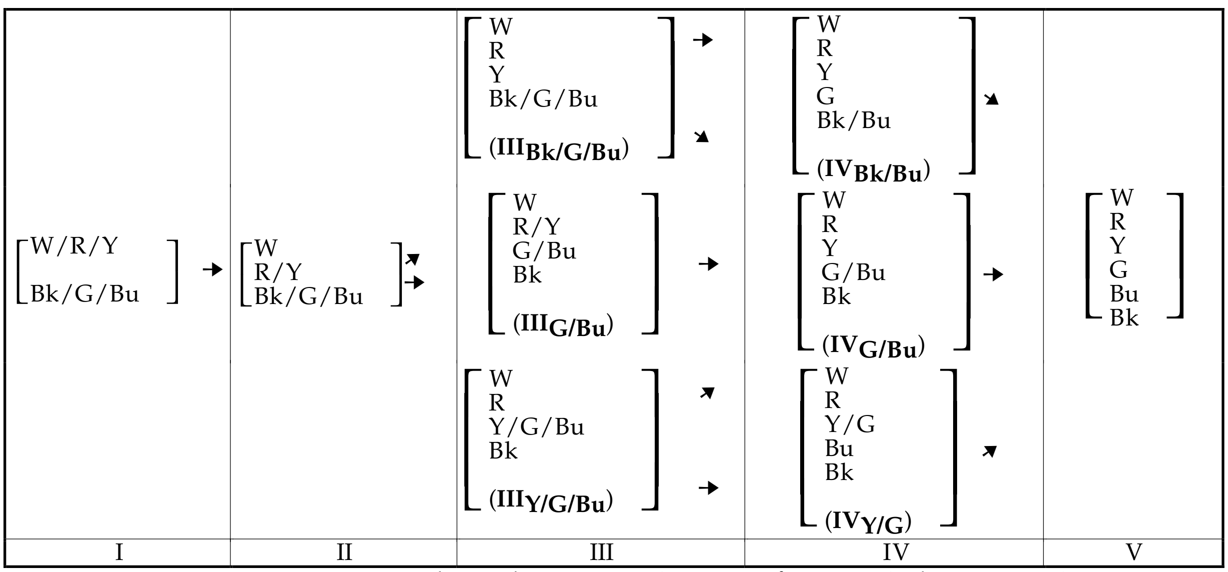

Figure 1. Types and Evolutionary Stages of Basic Color Term Systems (Adapted from KBMM, Figure 2.4, page 33)

2.1 The Main Line of Basic Color Term Evolution

The languages of the WCS indicate five possible paths ending in Stage V, which can be traced by following the arrows from stage to stage in Figure 1. These define five evolutionary trajectories, identified as A, B, C, D, E, in Table 1.

A:	I →	II →	$III_{G/Bu}$ →	$IV_{G/Bu}$ →	V
B:	I →	II →	$III_{Bk/G/Bu}$ →	$IV_{G/Bu}$ →	V
C:	I →	II →	$III_{Bk/G/Bu}$ →	$IV_{Bk/Bu}$ →	V
D:	?[22]	?	$III_{Y/G/Bu}$ →	$IV_{G/Bu}$ →	V
E:	?	?	$III_{Y/G/Bu}$ →	$IV_{Y/G}$ →	V

Table 1. Five Evolutionary Trajectories of Basic Color Term Systems

The evolutionary trajectories of Table 1 are not equally frequent in the WCS data. A single trajectory, which we call the *main line* of color term evolution, accounts for the vast majority of WCS languages. Ninety-one of the 110 WCS languages (83%) belong either to one of the five stages of Trajectory A or to a transition between two of these stages, as shown in Figure 2, where an outlined numeral within brackets represents the number of WCS languages found at the corresponding stage and an outlined numeral between brackets represents the number of WCS languages found in transition between the stages indicated.[23]

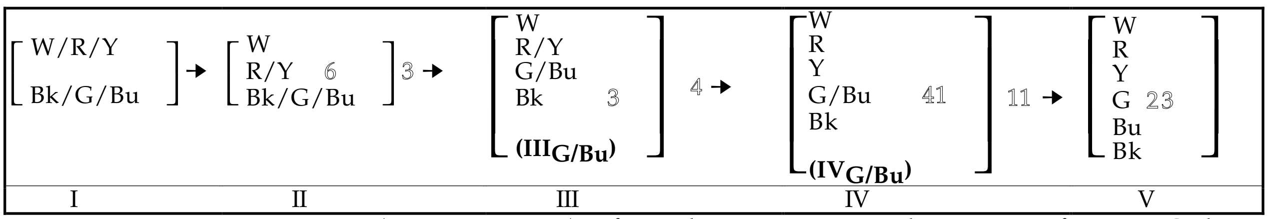

Figure 2. Main Line (Trajectory A) of Evolutionary Development of Basic Color Lexicons. Total number of languages represented is 91 (83% of WCS languages)[24].

2.2 Accounting for the Main Line of Color Term Evolution

Our internal representation of color, independent of language, appears to play an important role in determining the evolution of color term systems. Our task in the present section is to explain why Stage I systems have the particular shape they do and why each type of basic color lexicon on the main line (Figure 2) evolves into the succeeding type. The evolutionary sequence of the main line can be motivated by assuming, as we have above, that at each stage transition principles (0) Partition, (1) Bk & W, (2) Wa & C and (3) Red operate in that order until an uniquivocal result is reached. We assume that Partition acts minimally and incrementally. That is, we begin with the color space lexically partitioned into just two cells, that is, named categories, each cell (named category) representing a union of some subset of the six fuzzy sets corresponding to the primary colors and then at each new stage, reapplication of Partition and the other three principles adds a single new cell (i.e., term), until the six primaries have each received a distinct basic color term.

2.2.1 Stage I

Stage I is motivated as follows. Principle (1) [Bk&W] dictates that one cell of the two-cell partition shall contain B and the other W. Principle (2) [Wa&C] dictates that one cell shall contain both R and Y and the other shall contain both G and Bu. It remains to be determined whether the warm primaries will be grouped with W and the cool with Bk or vice versa. Yellow is an inherently light color. Perusal of the systematically arranged stimuli of any standard color order system, e.g., Munsell, NCS, or OSA, shows that low lightness colors of the same dominant wavelengths as yellow are not seen as yellow, but as orange, olive, brown, or something hard to name. To say that Y is an inherently light color it to say that Y and W have an inherent affinity. The fact that one of the warm colors, Y, is seen as similar to W correlates with, and partially explains, the apparently universal association of the warm hues with W and, therefore, of the cool hues with Bk in Stage I systems.[25]

Independent of the inherent lightness of Y, in discussing various cross-modal associations to the warm/cool distinction in hues, Hardin (1988: 129) notes that among these are active/passive, exciting/inhibiting, up/down, and positive/negative (in a non-evaluative sense). Hardin advances – cautiously – the speculation that we may have sensitivity to the polarity of opponent processes, in particular that we may have some neural level which records such facts as that R, Y and W each represent excitation of their opponent process, while G, Bu and Bk represent inhibition of the corresponding opponent mechanisms (1988: 130). Our interest here is not to evaluate Hardin's speculation regarding a possible neural basis for the white/warm, dark/cool and correlative cross-modal associations but simply to note the existence of the white/warm and dark/cool associations.

The strength of the association of warm hues with W and of cool hues with Bk is reinforced by experiments performed by James Boster (1986). In one experiment Boster gave twenty-one naive English-speaking subjects eight color chips, representing focal examples of the categories black, white, red, orange, yellow, green, blue and purple. The initial instruction was to sort the chips into two groups "on the basis of which colors you think are most similar to each other..." (Boster 1986: 64). The overwhelming preference was to put white, red, orange and yellow into one group and green, blue and black and purple into the other. Two thirds of Boster's subjects chose this exact division into two subsets. (There are 2,080 ways a set of eight elements can be divided into two non-empty subsets.) In a second experiment, the same instruction was given to a group of eighteen subjects, using as stimuli the eight color words rather than the colored chips. Substantially the same result was obtained.

2.2.2 From Stage I to Stage II

As indicated above, in deriving each stage from the preceding stage, we apply to the earlier system principles (0), (1), (2) and (3) in that order. Applying Principle (1) to a Stage I system means that either W and R/Y are given separate terms or that Bk and G/Bu are given separate terms. Principle (2) is irrelevant to the decision whether R/Y or G/Bu gets a separate term, so principle (3) is consulted. Principle (3) is relevant, dictating that the division be made between W and R/Y, since this choice promotes the distinguishing of R more than if the division were made between Bk and G/Bu. The result is a Stage II system, with terms for W, R/Y, and Bk/G/Bu.

2.2.3 From Stage II to Stage $III_{G/Bu}$

Applying Principle (1) to a Stage II system requires the extraction of Bk from Bk/G/Bu, since W already has a separate term. The result is a Stage $III_{G/Bu}$ system, with terms for W, Bk, R/Y and G/Bu. Principles (2) and (3) have no opportunity to apply because application of (1) has been sufficient to add a term, satisfying Partition.

2.2.4 From Stage III$_{G/Bu}$ to Stage IV$_{G/Bu}$

Principle (1) does not apply to a Stage III$_{G/Bu}$ system, since Bk and W already have separate terms. Principle (2) is uninformative with respect to breaking up R/Y or G/Bu. Principle (3) requires breaking up R/Y into R and Y. The result is a Stage IV$_{G/Bu}$ system, with terms for Bk, W, R, Y and G/Bu.

2.2.5 From Stage IV$_{G/Bu}$ to Stage V

Since a Stage IV$_{G/Bu}$ system contains only one composite category, G/Bu, application of Partition alone is sufficient to determine the result. To satisfy Partition, G/Bu must be divided into G and Bu, yielding a Stage V system with terms for Bk, W, R, Y, G, and Bu. Partition, Bk&W, Wa&C and Red, operating in that order, account for the evolution of eighty-three percent of the WCS languages.

2.3 Less Frequent Evolutionary Trajectories

As shown in Figure 1, there are also cases of WCS languages in which the transition from Stage II to Stage III involves separating R and Y, instead of Bk and G/Bu. The result is a Stage III$_{Bk/G/Bu}$ system. Such systems are involved in evolutionary trajectories B and C in Table 1. A Stage III$_{Bk/G/Bu}$ system can in turn develop into either a Stage IV$_{Bk/Bu}$ or a Stage IV$_{G/Bu}$ system, as shown in Figure 3. Figure 3 adds these types, and related transitions, to the main line of development shown in Figure 2.

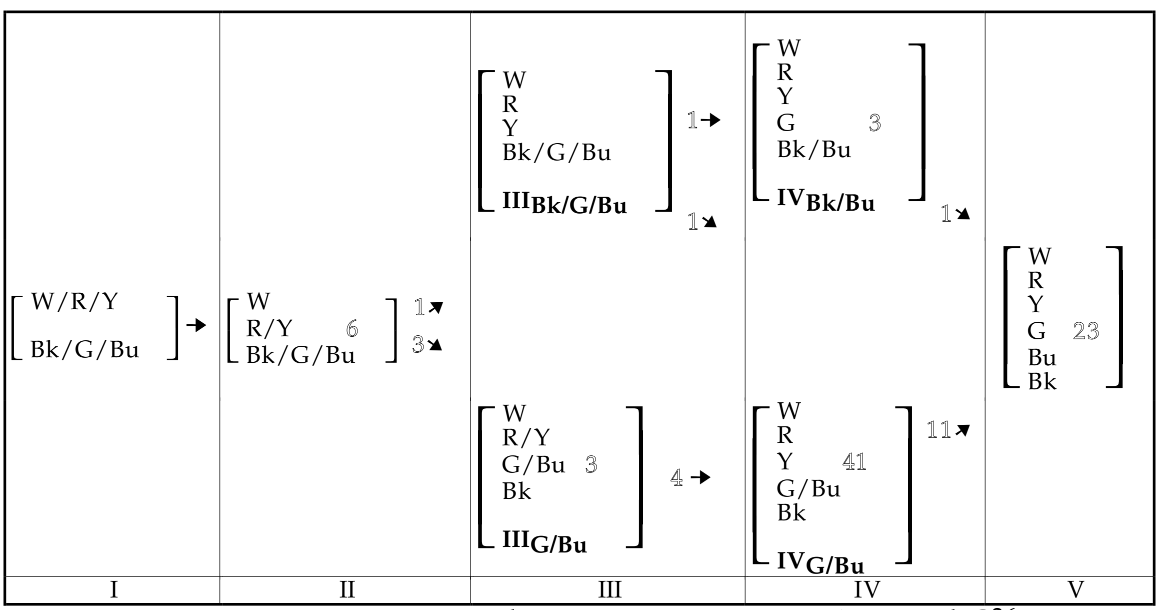

Figure 3, Evolutionary Trajectories A, B and C[26]

As shown in Figure 3 and note 26, an additional ten languages (10% of the WCS total) reflect the minority choice of splitting R and Y in going from Stages II to III, rather than dividing Bk/G/Bu into Bk and G/Bu. This amounts to promoting Principle (3) [Red] over Principles (1) [Bk&W] and (2) [Wa&C]. Of these ten languages, one is in transition from a mainline type (II) to a non-mainline type ($III_{Bk/G/Bu}$), while five are in transition from a non-mainline type to a mainline type.[27]

Summarizing to this point, 101 of the 110 WCS languages (92%) show exceptionless operation of Partition – that is, no evidence of the EH – either in their present condition or, by plausible inference, in a former state. Of these, ninety-one (90%) conform to the ordering of Partition and the three color-appearance-based principles, Bk & W, Wa & C, and Red: (0) > (1) > (2) > (3). Ten of these 101 languages (10%) order Principle (3) over Principles (1) and (2) at some point in their evolutionary development. We turn our attention now to the exceptional cases, the languages in which Partition appears to fail at least partially, and in which the EH consequently finds support.[28]

3 Predictions of the Model for Non-Partition (EH) Languages

The only thoroughly documented non-partition language of which we are aware is not a WCS language but Yélîdnye, a Non-Austronesian language of Rossel Island (Papua New Guinea), reported in Levinson (1997). Because Levinson undertook his investigation of Yélîdnye color naming with the EH specifically in mind and because he collected, in addition to the WCS color naming tasks, a fuller range of morphosyntactic and usage information than it was possible to ask the WCS field linguists to record, his report of a positive finding on the EH deserves close attention. In very brief summary, Yélîdnye has basic color terms for B, W and R and a secondary but well established simple term for a certain red color, specifically that of a shell used in traditional inter-island (Kula) trade.

The three basic terms *kpêdekpêde* 'black', *kpaapîkpaapî* 'white' and *mtyemtye* (or *taataa*) 'red' are recognizable as reduplications of nominal roots denoting a tree species, a pure white cockatoo and a "startling crimson" parrot, respectively. Levinson notes that there is a "regular", that is, partially productive, derivational pattern in this language according to which reduplication of a nominal root may derive an adjective denoting a salient property of the denotatum of the noun. For example, *mty:aamty:aa* 'sweet' < *mty:aa* 'honey'. Levinson points out that if one knows the white cockatoo and red parrot one might well guess the meanings of the reduplicated forms of their respective names to mean 'white' and 'red', though of course one could not be certain that some other salient property (such as the loud screech of the parrot) was not being picked out. One might wish to argue on the basis of these observations that the red and white words of Yélîdnye fail the first criterion of basicness of Berlin and Kay: "... [the] meaning [of the color word] is not predictable from the meaning of its parts" (1969: 6). Having raised the issue, and suggesting that it may be one that arises in many languages of Oceania and Australia, Levinson appears convinced in the end that the white and red terms of Yélîdnye should be considered basic color terms, whatever a narrow application to them of the Berlin and Kay criteria might yield. But he suggests that observations such as these might be interpreted as casting doubt on the claim that Yélîdnye has, aside from *kpêdekpêde* 'black', any basic color terms in the sense of Berlin and Kay (1969) and perhaps that some languages of Oceania or Australia have any basic color terms at all.

On closer examination, this fear appears to be groundless. Yélîdnye *kpaapîkpaapî* 'white' and *mtyemtye* (or *taataa*) 'red' do not fail the Berlin and Kay (1969: 6) criterion of non-predictability of meaning. At issue is the proper understanding of (non)-predictability of meaning. Makkai (1972) makes a relevant distinction between 'encoding idioms' and 'decoding idioms' (see also Fillmore, Kay and O'Connor 1988: 540f). An expression that a *speaker* would not know how to assemble from knowledge of everything else in a language is an encoding idiom. An expression that a *hearer* would not be able to interpret from knowledge of everything else in a language is a decoding idiom. There are many encoding idioms which are not decoding idioms, that is, there are many expressions which are interpretable on first hearing but that one wouldn't know how to form from knowledge of everything else in the grammar. For example, on first hearing one of the expressions *light as a feather, heavy as lead* or *quick as a wink*, any English speaker could probably figure out exactly what was meant, but one could not know in advance that these are conventional ways of saying 'very light', 'very heavy', 'very quick', even knowing that English contains a pattern [A *as a* N] for forming expressions meaning 'very A'. There is no way to know in advance that one may say, for example, *light as a feather*, *easy as pie* or *easy as duck soup,* but not **light as an ash*, **easy as cake* or **easy as goose fritters*, or that one may say *one (two, ...) at a time,* but not **one at the time* [as in French], **one to a time, *one by the time*, *etc*., without learning each separate fact.

Analogously, Yélîdnye *could* have reduplicated forms of the word meaning leaf for 'green', of turmeric or banana for 'yellow', and of sky for 'blue', but it doesn't.[29] Even though this particular derivational process of Yélîdnye is used frequently (and is in that sense "regular"), the speaker of Yélîdnye nonetheless has to memorize separately each of the cases in which it is used, so each of these cases represents a separate encoding idiom although it is possible that none are decoding idioms. If we interpret the non-predictability criterion for basic color terms as requiring that such terms be encoding idioms – which seems appropriate since language users have to speak their language as well as understand it – then *kpaapîkpaapî* and *mtyemtye* (or *taataa*) meet the non-predictability criterion for basicness – as they meet all the other B&K criteria. Insofar as similar reduplication process are reflected in the color terms of other Oceanic and Australian languages, as Levinson suggests, the same argument applies to them.

The Bk, W and R terms of Yélîdnye are not extended; this is not a Stage II language, in which, for example, the term that includes Bk also includes G and Bu and the term that includes R also includes Y and orange. Interestingly, there are fixed phrasal expressions denoting each of the colors G, Y and Bu. The most highly conventionalized and widely shared of these is for G, then Y, then Bu – the last subject to a large number of phrasal expressions and considerable interspeaker variation. The Bk and W terms are somewhat more firmly established and subject to less interspeaker variation than the basic R terms (due perhaps to dialect synonymy in R, plus possible interference from the Kula-shell term). Much of the color space is simply unnamed by any expression Levinson was able to elicit.

Yélîdnye seems clearly to be a non-partition language, i.e., one testifying to the correctness of the EH. On the other hand, Yélîdnye has a very Berlin and Kay (1969) 'feel' to it: the best established terms are for Bk and W, then R, all basic, then non-basic G, Y, and Bu in that order, and after these nothing worth mentioning. Yélîdnye is not a partition language. It nevertheless exhibits the salience of Bk and W dictated by Principle (1) and the salience of R dictated by Principle (3). Principle (2) has no scope to operate in Yélîdnye, since in this non-partition language there are no composite terms for Principle (2) to apply to.

3.1 WCS Evidence for the EH

Levinson suggests strongly that for Yélîdnye we should think of Bk, W and R as receiving basic color terms (the last with two competing synonyms, deriving from different dialect names for the eponymous parrot), and these only. There are also several languages in the WCS with well-established words for BK, W and R (not extended), with varying ways of treating lexically the rest of the colors. We must caution here that the WCS data were not collected specifically to test the EH and that we lack for these data much information on the morpho-syntactic status of the terms and the kind of ethnographic observation of their use in natural discourse that would be very useful for assessing the applicability to these languages of the EH. Nevertheless, some patterns may be observed.

The existence of languages with basic terms only for (non-extended) Bk, W and R is consistent with the fact that Bk, W and R are singled out by Principles (1) and (3), while Y, G, and Bu are not distinguished *per se* by any principle of the model. Such languages are spoken in communities in which color as such may not have achieved sufficient cultural salience, and thus functional load in communication, for Partition to take full effect in the color domain, leaving the field open, as it were, for Principles (1) and (3) to cause only the inherently most prominent color sensations to receive simple names. So far our model has yielded an explanation for color systems with basic terms for Bk, W and R only, and which therefor do not partition the perceptual color space. If a language has gone this far and no farther, we will find well established terms for Bk, W and R and widespread variability on WCS tasks in the rest of the color space, with many competing terms and little agreement among speakers. To a significant degree, six of the seven of the WCS languages that remain to be discussed fit this description and the seventh, Cree, although a partition language in the present, may be inferred to have been non-partition in the reconstructable past..

3.2 The Residue Predicted: Y/G/Bu Terms

Suppose a language has developed non-extended terms for B, W, and R, ignoring Partition. If Partition now asserts itself, a composite term for Y/G/Bu appears, producing a Stage $\mathrm{III}_{Y/G/Bu}$ system. This type of system contains basic terms for Bk, W and R and a composite term covering Y, G and Bu. The WCS sample contains two clear example of such systems, Karajá (Brazil) and Lele (Chad).

Systems of this type are reported elsewhere in the literature. For example, Arrernte (Pama-Nyungan, Australia) apparently had such a system (David Wilkins, pc 1998, see also Spencer and Gillin 1927, noted in Berlin and Kay 1969: 67f).[30] Kinkade (1988) reconstructs a Proto-Salishan Y/G/Bu term because of clear etymological relatedness of terms including or restricted to Y and terms including or restricted to Bu in contemporary Salishan languages. (See also the discussion in MacLaury 1997: 74, passim) The notion that the $III_{Y/G/Bu}$ systems developed historically from systems like Yélîdnye – with basic color terms for Bk, W, and R and no lexical partition of the color space – is of course speculative. We have no historical record or detailed reconstruction of such a development for either WCS or non-WCS languages. But this conjecture fits the model to the available data very neatly, accounting for evolutionary trajectories D and E of Table 1. The questions signaled by the question marks in Table 1 have now been addressed.

3.2.1 The Yellow/Green Mystery Resolved

The development of a Y/G/Bu term as a delayed assertion of Partition provides a plausible explanation of the puzzle regarding the origin of Y/G terms.[31] In the Kay and McDaniel model, every language is assumed to start out as a Stage I (fully partitioned) system and to develop further via successive division of composites until all six landmark colors receive separate terms. Since Y and G belong to distinct composites at Stage I, it is a mystery under this model how Y/G composites ever come into being (See KBM for further discussion.) Under the present model, which allows for the EH and therefore does not assume that all languages start from a fully partitioned Stage I system, a plausible scenario for the genesis of Y/G composites suggests itself. Once a system with restricted Bk, W, and R plus a composite Y/G/Bu exists (Stage $III_{Y/G/Bu}$), it may develop further in either to two ways. If the Y/G/Bu composite splits into Y and G/Bu the result is a mainline Stage $IV_{G/Bu}$ system, with terms for Bk, W, R, Y and G/Bu (Trajectory D). But if the other possible split of the Y/G/Bu category occurs, into Y/G and Bu, the result is a Stage $IV_{Y/G}$ system, with terms for Bk, W, R, Y/G, and Bu (Trajectory E). Among WCS languages, Cree is an example (the sole example) of such a system and it is the only WCS language with a Y/G composite. To our knowledge, all other languages reported to contain Y/G composites are also of this type, Stage $IV_{Y/G}$. The developmental scenario just sketched, in which Y/G/Bu categories result from the late imposition of Partition on Bk-W-R (only) languages and in which Y/G composites result from the breakup of Y/G/Bu composites, eliminates from the theory the logically possible but unattested KBMM Stage $III_{Y/G}$ type, with terms for W, R, Y/G and Bk/Bu. MacLaury (1987) has documented Y/G terms in several Salishan languages, confirming the earlier reports of Kinkade and others. Kinkade (1988) and MacLaury (1997: 74, passim) conclude that some G/Bu, Bu and Y/G terms observed in modern Salishan languages reflect a Proto-Salishan Y/G/Bu term.

To summarize the Y/G story: Y/G/Bu terms arise when ascendency of the color-appearance-based priciples (1) and (3) over Partition and (2) leads to the naming of Bk, W and R, leaving the rest of the color space unnamed; then Partition exerts itself, resulting in the creation of a Y/G/Bu term to name the rest of the primary colors and partition the space. The inherently unstable Y/G/Bu category (containing the opponent colors Y and Bu) usually breaks down into Y and G/Bu, leaving no trace of its prior existence (since the resulting mainline Stage $IV_{G/Bu}$ type more usually arises from the breakup of R/Y in a mainline $III_{G/Bu}$ system). But occasionally Y/G/Bu breaks down into Y/G and Bu, producing a Stage $IV_{Y/G}$ system, with terms for Bk, W, R, Y/G and Bu.

3.2.2 Mopping Up: Four EH Languages?

Finally, the WCS files include four languages which appear to represent mixed cases of the patterns outlined above, in the sense of including terms clearly centered on Bk, W, and R, with two or more conflicting patterns competing for the remaining area. The single generalization that brings these cases together is that the regions of the color space corresponding to Bk, W and R are well named (including either a separate name or inclusion in a standard composite category like Bk/G/Bu), while the strategy for naming the remaining areas is some combination of (1) extension of the Bk, W, R terms according to the usual story of composites, (2) existence of a special Y/G/Bu (or Not-[Bk/W/R]) term, or (3) relatively strong secondary terms for Y, G, Bu, or G/Bu (or some subset thereof, akin to the Yélîdnye pattern). These languages tend also to be those in which there is unusual interspeaker variation in the use of shared terms and a marked degree of idiosyncrasy in the selection of terms used.

Culina (Peru, Brazil) is similar to Karajá and Lele in containing terms for W, R and an extended yellow term that covers much of G and Bu, especially in the lighter shades. There is, however, no Bk term, but instead an unmistakable Bk/G/Bu term. Mundu (Sudan) represents a similar situation. There are clear terms for W, R, and Bk/G/Bu, but there is also a highly salient term which includes Y, G and Bu, is somewhat focused in Y, and which seems to gloss best as 'everything which is not black, white or red'. Moreover, Mundu contains a secondary term largely synonymous with the one just mentioned but much less well established. Culina and Mundu both seem to mix the W, R, Y, Bk/G/Bu strategy (Stage $III_{Bk/G/Bu}$) with the W, R, Bk, Y/G/Bu strategy (Stage $III_{Y/G/Bu}$).

The final two languages, Kuku-Yalanji and Murrinh-Patha (both Australian) illustrate most clearly the pattern of Bk, W, R plus confusion. In this respect they come the closest in the WCS sample to the Yélîdnye pattern in which only restricted Bk, W and R receive basic color terms. Kuku-Yalanji has well-established terms for Bk, W, and R, although the Bk term shows some extension into Bu (as well as into Br, which is common). The R term, *ngala-ngala* (< *ngala* 'blood) does not include yellow. The language contains two additional major terms, although these are less well established than the first three. One, of these, *kayal*, is used regularly by only half of the speakers consulted, maps as a G/Bu term for the language as a whole, is focused in G, and denotes only G for some speakers. It also means 'unripe' according to the WCS field linguists, H. and R. Hershberger. Oates (1992: 126) gives *kayal* with the gloss '[color] green' only, indicating that the word is among those "not recognised by speakers today" [Recall that the WCS data were gathered fourteen years before the Oates dictionary was produced.] Oates also contains an entry *kalki* 'unripe'. Only nine of twenty WCS collaborators used *kayal* with a well-established green or grue sense; *kayal* is not a basic color term of Kuku-Yalanji. There is also a word used by seventeen of the twenty Kuku-Yalanji speakers for everything outside of Bk, W and R proper, *burrkul* (or *burkul*). However, it is clear that collaborators with well-established words for green or grue do not use *burrkul* for those colors. The Hershbergers gloss *burrkul* as 'non-descript', 'dirty' and 'anything which is not black, white or red'. The last gloss seems aimed less at the conceptual content of the word than at the way it is deployed in the WCS naming task. Oates lists *burkul*, not among the color words, but among "Describing Words Relating to Things", giving its gloss as 'not clear, not clean, murky or dirty, said about water, windows, mirrors, photos, skin' (Oates 1992: 83). *burrkul* is not a basic color term of Kuku-Yalanji.

Murrinh-Patha presents perhaps the most confusing array of terms in the WCS. In addition to standard Bk, W, and R terms (with the Bk term *thipmam* extended a bit into Bu, as well as into Br, and the R term *bukmantharr* not extended into Y), there are four other widely used terms: *ngatin* (used by twenty-one of the twenty-five WCS collaborators), *wudanil* (twenty-four speakers), *tumamka/tupmanka* (nineteen speakers) and *wipmanarri* (fifteen speakers). *ngatin* appears in the pooled data to be a Y/G term, but it is used by some speakers for yellow/orange/(brown) only, by some others for G/Bu only, and by some for G only. *wudanil* is used by one or another speaker for virtually everything outside of Bk, W, and R. Its distribution on the WCS tasks lead one to infer that it might be a non-color term, like Kuku-Yalanji *burrkul* ('non-descript, not clear, not clean,...') and could be used for any surface appearance for which the speaker does not have an apt descriptor. However, Michael Walsh (pc 1998) is unable to corroborate that gloss. "[*wudanil*] could be a verb form which as been conventionalized to refer to colours but could also have an independent (verbal) life of its own." *tumamka/tupmanka* appears to be a widely extend, low consensus G/Bu term if one considers the aggregate mapping, but there is great interspeaker variation in how the term is used. For some speakers *tumamka/tupmanka* is blue, for some G/Bu, for many nothing so easy to describe. Walsh writes (pc 1998) that *tumamka/tupmanka* also appears to be a verbal form. Finally, *wipmanarri* covers approximately the same range of colors as Warlpiri *walyawalya* (< *walya* 'earth'), which can denote deep browns, reddish browns, lighter – yellowish– browns and oranges, yellowish salmons, pinkish purples and other light purples. This is just about the range of colors earth takes on in the central Australian desert, where Warlpiri is located (although we don't have comparable information for the area in which Murrinh-Patha is spoken). However, there is no indication in Walsh's information that *wipmanarri* has an etymological relation to earth, possibly being related instead to the body-part word for 'back'. The Murrinh-Patha Bk, W and R terms are much better established than the last four discussed (and some less frequent terms that we haven't discussed here). Murrinh-Patha fits the best of any language in the WCS sample the formula Bk, W, R plus confusion[32].

4 Summary

This paper presents a model of color term evolution employing one language-based principle, Partition, and three color-appearance-based principles: Bk&W, Wa&C and Red. The Emergence Hypothesis is defined as the possibility that not all languages obey Partition perfectly in the color domain. Straightforward application of these four principles, with the ranking: Partition > Bk&W > Wa&C > Red, defines the main line of color term evolution (Trajectory A of Table 1, Figure 2), accounting for 91 (83%) of the languages in the WCS sample. When Red supersedes Bk&W and Wa&C at the transition from Stage II to Stage III, the possibility of two additional types is created, accounting for an additional 10 WCS languages, bringing the part of the total WCS sample accounted for to 101 (92%) (Figure 3, Trajectories B and C.) Two more languages depart non-wildly from any of the nine types in Figure 1 but do not challenge the EH (See note 22), bringing the number of non-EH languages to 103 (94% of the WCS total). The remaining seven languages show, to varying degrees, evidence for the possible operation of the EH. Two of these, Karajá and Lele are $III_{Y/G/Bu}$ languages, illustrating Trajectory D. One language, Cree, illustrates Stage $IV_{Y/G}$ (Trajectory E). The remaining four languages (Culina, Mundu, Kuku-Yalanji and Murrinh-Patha) all show Bk, W, and R prominence, with a mixture of other strategies, combined with considerable interspeaker variability.

A plausible solution to the apparent mystery of Y/G composites is provided by the current model: EH languages may develop somewhat along the lines of Yélîdnye, assigning basic terms, according to principles (1) [B&W] and (3) [Red], only to restricted Bk, W, and R, violating Partition. Subsequently, Partition comes into play and a Y/G/Bu term appears, covering the remaining primary colors.[33] (There is some suggestive evidence that Y is the most common focus for this term, but the data are so sparse that no reliable conclusion can be drawn here.) In some cases, the Y/G/Bu term may then divide into Bu and Y/G terms. According to Kinkade (1988) and MacLaury (1997: 74, passim) this appears to have happened in some Salishan languages.[34]

Since the original Berlin and Kay (1969) study, there have been numerous field studies by linguists and anthropologists which have added data to test and refine the theory of universals and evolutionary development of basic color term systems. To this we can add the Mesoamerican Color Survey and the WCS. This line of research has resulted in several reformulations of the evolutionary model and will probably continue to do so. Recently, a striking aspect of this tradition of research has consisted in the complex of observations and speculations we have referred to globally as the Emergence Hypothesis. The reformulations of the evolutionary model have, since 1978, also been guided by an effort to explain whatever universals in color semantics we can by independent findings from the vision literature. It is encouraging that the present reformulation of the model (1) covers a wider range of partitioning languages than any model hitherto, (2) is based more more firmly on independent principles governing color appearance than previous models, (3) sheds some new light on non-partitioning languages and on what the relation of these may be to the partitioning languages, their evolutionary sequence, and the color appearance factors that appear to underly it and (4) goes some way toward solving the hitherto unresolved problem of composite (fuzzy union) categories comprising both yellow and green.

References

Abramov, I.

1997 Physiological mechanisms of color vision. In Hardin and Maffi (1997) 89-117. [See below]

Abramov, I. and J. Gordon

1994 Color appearance: On seeing red – or yellow, or green, or blue. Annual Review of Psychology 45: 451-485.

Abramov, I. and J. Gordon

1997 Constraining color categories: The problem of the baby and the bathwater. Behavioral and Brain Sciences. 20 (2): 179-180.

Berlin, Brent

1992 Ethnobiological classification : principles of categorization of plants and animals in traditional societies. Princeton, N.J. : Princeton University Press.

Berlin, Brent and Elois Ann Berlin

1975 Aguaruna color categories. American Ethnologist 2: 61-87.

Berlin Brent and Paul Kay

1969 Basic Color Terms: Their Universality and Evolution. Berkeley and Los Angeles: University of California.

Bohannon, Paul

1963 Social Anthropology. New York: Holt, Rinehart and Winston.

Bornstein, Marc H.

1973a The psychophysiological component of cultural difference in color naming and illusion susceptibility. Behavioral Science Notes 1: 41-101.

1973b Color vision and color naming: A psychophysiological hypothesis of cultural difference. Psychological Bulletin 80: 257-285.

1997 Selective vision. Behavioral and Brain Sciences 20 (2): 180-181.

Boster, James

1986 Can individuals recapitulate the evolutionary development of color lexicons? Ethnology 26 (1): 61-74.

Boynton, R.M. and J. Gordon

1965 Bezold-Brücke shift measured by color-naming technique. Journal of the Optical Society of America 55: 78-86.

Brown, Roger W.

1976 Reference. Cognition 4: 125-153.

Casson, Ronald W.

1997 Color shift: evolution of English color terms from brightness to hue. In Hardin and Maffi (1997) 224-239.

Chapanis, Alphonse

1965 Color names for color space. American Scientist 53: 327-346.

Collier, George A.

1973 Review of Basic Color Terms. Language 49: 245-248

1976 Further evidence for universal color categories. Language 52: 884-890.

Conklin, Harold C.

1955 Hanunóo color categories. Southwestern Journal of Anthropology 11: 339-344.

1973 Color categorization: Review of Basic Color Terms, by Brent Berlin and Paul Kay. Language 75: 931-942.

Davidoff, Jules

1997 The neuropsychology of color. In Hardin and Maffi (1997) 118-134.
Davies, Ian, Greville Corbett, Harry McGurk and David Jerrett
1994 A developmental study of the acquisition of colour terms in Setswana. Journal of Child Language 21: 693-712.
Derrington, A.M, J. Krauskopf and P. Lennie (1984)
Chromatic mechanisms in lateral geniculate nucleus of macaque. Journal of Physiology 357: 241-265.
Descoeudres, Alice
1946 Le développement de l'enfant de deux à sept ans. Neuchatel et Paris: Delachaux & Niestlé.
De Valois, Russell 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.
De Valois, Russell L. and G.H. Jacobs
1968 Primate color vision. Science 162: 533-540.
De Valois, Russel L. and Karen K. De Valois
1975 Neural coding of color. In E.C. Carterette and M.P. Friedman (eds) Handbook of Perception. Vol V. New York: Academic. 117-166.
1993 A multi-stage color model. Vision Research. 33: 1053-1065.
` 1996 A three-stage color model – comment. Vision Research. 36:833-836.
De Valois, Russell L., Herman C. Morgan, Martha C. Polson, William R. Mead, and Elaine M. Hull
1974 Psychophysical studies of monkey vision–I. Macaque luminosity and color vision tests. Vision Research 14: 53-67.
Dougherty, Janet D.
1975 A universalist analysis of variation and change in color semantics. Berkeley Ph. D. dissertation.
1977 Color categorization in West Futunese: Variability and change. In Sociocultural Dimensions of Language Change. B.G. Blount and M. Sanches, eds., New Yor/London: Plenum. pp. 133-148.
Durbin, Marshall
1972 Review of Basic Color Terms. Semiotica 6: 257-278.
Fillmore, Charles J., Paul Kay and M.C. O'Connor
1988 Regularity and idiomaticity in grammatical constructions: the case of let alone. Language 64 (3) 501-538.
Gladstone, William E.
1858 Studies on Homer and the Homeric Age. London: Oxford University Press.
Gleason, H.A.
1961 An Introduction to Descriptive Linguistics. New York: Holt, Rinehart and Winston.
Hage, Per and Christen Hawkes
1975 Binumarien color categories. Ethnology 24: 287-300.
Hård, A. and L. Sivik
1981 NCS-Natural Color System: a Swedish standard for color notation. Color Research and Application 6 (3): 129-138.
Hardin, C.L.
1988 Color for Philosophers: Unweaving the Rainbow. Indianapolis, IN: Hackett.
Hardin, C.L.

1992 The virtues of illusion. Philosophical Studies 67: 153-166.
Hardin, C.L and Luisa Maffi (eds).
1997. Color Categories in Thought and Language. Cambridge, UK: Cambridge University Press.
Harkness, Sara
1973 Universal aspects of learning color codes: A study in two cultures. Ethos 1(2): 175-200.
Heider, Eleanor Rosch
1971 "Focal" color areas and the development of color names. Developmental Psychology 4 (3): 447-455.
1972a Universals in color naming and memory. Journal of Experimental Psychology 93: 1-20.
1972b Probabilities, sampling and the ethnographic method: The case of Dani colour names. Man 7: 448-466.
Heider, Eleanor Rosch and Donald C. Olivier
1972 The structure of the color space for naming and memory in two languages. Cognitive Psychology 3: 337-354.
Heinrich, Albert C.
1972 A non-European system of color classification. Anthropological Linguistics 14: 220-227.
Hering, Ewald
1964 [1920] Outlines of a theory of the light sense. Translated by L. M. Hurvich and D. Jameson. Cambridge, Mass: Harvard.
Hickerson, Nancy
1971 Review of Berlin and Kay (1969). International Journal of American Linguistics 37: 257-270.
Humphrey, N.K.
1976 The colour currency of nature. In T. Porter and B. Mikelides (eds) Color for Architecture. New York: Van Nostrand.
Hurvich, L.M. and D. Jameson
1955 Some qualitative effects of an opponent-colors theory: II. Brightness, saturation and hue in normal and dichromatic vision. Journal of the Optical Society of America 45: 602-616.
Ingling, C.R., Jr.
1997 Constraints on the definitions of "unique hues" and "opponent channels". Behavioral and Brain Sciences. 20 (2): 194-195.
Ingling, C.R., Jr., Jonathan P. Barley, and Nadeem Ghani
(1995) Chromatic content of spectral lights. Vision Research 36 (16): 2537-2551.
Istomina, Z. M.
1963 Perception and naming of color in early childhood. Soviet Psychology and Psychiatry 1 (2): 37-45.
Jameson, D. and L.M. Hurvich
1955 Some quantitative aspects of an opponent-colors theory: I. Chromatic responses and spectral saturation. Journal of the Optical Society of America 45: 546-552.
Jameson, K. and R.G. D’Andrade

1977 It's not really red, green, yellow, blue: An inquiry into perceptual color space. In Hardin and Maffi (1977) 295-319.
Johnson, E. G.
1977 The development of color knowledge in preschool children. Child Development 48: 308-311.
Katra, E. and B.R. Wooten
1995 Perceived lightness/darkness and warmth/coolness in chromatic experience. ms.
Kaiser, Peter K. and Robert M. Boynton
1996 Human Color Vision, 2nd edition. Washington, D.C.: Optical Society of America
Kay, Paul
1975 Synchronic variability and diachronic change in basic color terms. Language in Society 4: 257-270.
In press 1 The emergence of basic color lexicons hypothesis: A comment on "The vocabulary of colour with particular reference to Ancient Greek and Classical Latin" by John Lyons. The Language of Colour in the Mediterranean, Alexander Borg (ed) Wiesbaden: Otto Harrassowitz.
In press 2 Sur la méthodologie de l'étude comparative des termes de couleur. Anthropologie et Sociétés. [English version available at www.icsi.berkeley.edu/~kay/color.meth.ps]
Kay, Paul and Brent Berlin
1997 There are non-trivial constraints on color categorization. Behavioral and Brain Sciences 20: 196-202.
Kay, Paul, Brent Berlin, Luisa Maffi and William Merrifield
1997 Color naming across languages. In Color Categories in Thought and Language. C.L. Hardin and Luisa Maffi, eds., Cambridge, England: Cambridge University Press.
Kay, Paul, Brent Berlin and William Merrifield
1991 Biocultural implications of systems of color naming. Journal of Linguistic Anthropology 1: 12-25.
Kay, Paul and Chad K. McDaniel
1978 The linguistic significance of the meanings of basic color terms. Language 54: 610-646.
Kinkade, M. Dale
1988 Proto-Salishan color. In W. Shipley (ed) In Honor of Mary Haas. Berlin: Mouton de Gruyter.
Krauss, Robert M.
1968 Language as a symbolic process. American Scientist 56: 265-278.
Kuschel, Rolf and Torben Monberg
1974 'We don't talk much about colour here': A study of colour semantics on Bellona Island. Man 9: 213-242.
Lenneberg, Erik H. and John M. Roberts
1956 The Language of Experience: A study in Methodology. Memoir 13 of International Journal of American Linguistics.
Levinson, Stephen A.

1997. The theory of basic color terms and Yélîdnye. Working papers of the Cognitive Anthropology Group, Max Plank Institute for Psycholinguistics. Nijmegen.

Lucy, John A.

1996 The scope of linguistic relativity: An analysis and review of empirical research. In J. Gumperz and S. Levinson (eds) Rethinking Linguistic Relativity. Cambridge University Press. 37-69.

1997 The linguistics of color. In Hardin and Maffi (1997) 320-346.

Lyons , John A.

1995 Colour in language. In T. Lamb and J. Bourriau (eds) Colour: Art and Science. Cambridge University Press.

In Press The vocabulary of colour with particular reference to Ancient Greek and Classical Latin. In The Language of Colour in the Mediterranean, Alexander Borg (ed) Wiesbaden: Otto Harrassowitz.

MacLaury, Robert.E.

1987 Color-category evolution and Shuswap yellow-with-green. American Anthropologist 89: 107-124.

(1997) Color and Cognition in Mesoamerica. Austin, Texas: University of Texas Press.

Maffi, Luisa

1988a World Color Survey report. Department of Anthropology, U.C., Berkeley. ms. 33 pp.

1988b World Color Survey typology. Department of Anthropology, U.C., Berkeley. ms. 29 pp.

1990a Cognitive anthroplogy and human categorization research. Department of Anthropology, U.C., Berkeley. ms. 113 pp.

1990b Somali color term evolution: Grammatical and semantic evidence. Anthropological Linguistics 32: 316–334.

Magnus, Hugo

1880 Die geschichtliche Entwickelung des Farbensinnes. Leipzig: Viet.

Makkai, Adam

1972 Idiom Stucture in English. The Hague: Mouton.

McDaniel, Chad K.

1972 Hue Perception and Hue Naming. Unpublished B.A. thesis. Harvard University.

Miller, David L.

1997a Beyond the elements: investigations of hue. In Hardin and Maffi eds (1997) 151-162.

1997b Over the rainbow: The classification of unique hues. Behavioral and Brain Sciences 20 (2): 204-205.

Miller, George A. and P. Johnson-Laird

1976 Language and Perception. Cambridge, Massachusetts: Harvard University Press.

Mollon, J.D.

1989 "Tho' she kneel'd in that place where they grew ...": The use and origins of primate color vision. Journal of Experimental Biology 146: 21-38.

Newhall, S.M.

1941 Warmth and coolness of colors. Psychological Record 4: 198-212.

Nida, Eugene A.
1959 Principles of translation as exemplified by Bible translating. In On Translation. Reuben A. Brower, ed., Cambridge, Massachusetts: Harvard University Press.
Oates, Lynette F.
1992 Kuku-Yalanji Dictionary. Alsbury, NSW: Graeme van Brummelen.
Palmer, Stephen A.
in press Color, Consciousness and the isomorphism constrain. Behavioral and Brain Sciences.
Pokorny, Julius,
1948-69 Indogermanisches etymologisches Worterbuch. Bern: A. Francke .
Ratliff, Floyd
1976 On the psychophysiological bases of universal color terms. Proceedings of the American Philosophical Society 120: 311-330.
Ray, Verne
1952 Techniques and problems in the study of human color perception. Southwestern Journal of Anthropology 8: 251-959.
1953 Human color perception and behavioral response. Transactions of the New York Academy of Sciences (series 2) 16: 98-104.
Sapir, Edward
1921 Language. New York: Harcourt, Brace.
Sandell, J.H., Gross, C.G., and Bornstein, M.H.
1979 Color categories in macaques. Journal of Comparative and Physiological Psychology 93: 626-635.
Saunders, B.A.C and J. van Brakel
1988 Re-evaluating basic colour terms. Cultural Dynamics 1: 359-378.
1995 Translating the World Color Survey. In Geuijen, K., D. Raven and J. de Wolf (eds) Post-Modernism and Anthropology. Assen, Netherlands: van Corcum.
1997 Are there non-trivial constraints on colour categorization? Behavioral and Brain Sciences 20: 167-228.
Shatz , Marilyn, Douglas Behrend, Susan A. Gelman, and Karen S. Ebeling
1996 Colour term knowledge in two-year-olds: evidence for early competence. Journal of Child Language 23: 177-199.
Sivik, Lars
1997 Color systems for cognitive research. In Hardin and Maffi (1997: 163-193).
Shepard, Roger
1992 The perceptual organization of colors. In The Adapted Mind. J. Barkow, L. Cosmides and J. Tooby, eds., Oxford: Oxford University Press.
1994 Perceptual-cognitive universals as reflections of the world. Psychonomic Bulletin and Review 1 (1): 2-28.
Spencer, B. and F.K. Gillin
1927 The Arunta: A Study of a Stone Age People. London: Macmillan.
Sternheim, C.E. and R.M. Boynton
1966 Uniqueness of perceived hues investigated with a continuous judgmental technique. Journal of Experimenal Psychology 72: 770-776.
Taylor, John R. and Robert E. MacLaury, eds

1995 Language and the cognitive construal of the world. (Trends in linguistics. Studies and monographs 82). Berlin, New York: Mouton de Gruyter

Van Laar, D.
1997 Ekphrasis in colour categorisation: Time for research, or time for revolution? Behavioral and Brain Sciences. 20 (2): 210.

Werner, J.S. and M.L. Bieber
1977 Hue opponency: A constraint on colour categorization known from experience and experiment. Behavioral and Brain Sciences. 20 (2): 210.

Werner, J.S. and B.R. Wooten
1979 Opponent chromatic mechanisms: Relation to photopigments and hue naming. Journal of the Optical Society of America 69: 422-434.

Wierzbicka, Anna
1996 Semantics: Primes and Universals. Oxford: Oxford University Press.

Whorf, Benjamin L.
1956 [1940] Science and Linguistics. In Language, Thought and Reality: The Collected Papers of Benjamin Lee Whorf, John B. Carroll, ed., Cambridge, Massachusetts: MIT Press. Originally published in Technology Review 42: 229-231, 247-248.

Winch, W.H.
1910 Color-names of English school-children. American Journal of Psychology 21 (3): 453-482.

Wolfe, H.K.
1890 On the color-vocabulary of children. Nebraska University Studies 1 (3) July 1890.

Wooten, B.R. and D. Miller
1997 The psychophysics of color. In Hardin and Maffi (1997) 59-88.

Zadeh, Lotfi A.
1996 Fuzzy sets, fuzzy logic, and fuzzy systems: selected papers by Lotfi A. Zadeh (Editors: George J. Klir & Bo Yuan). Singapore, River Edge, N.J.: World Scientific.

Zollinger, Heinrich
1972 Human color vision: An interdisciplinary research problem. Palette 40: 1-7.
1976 A linguistic approach to the cognition of colour vision. Folia Linguistica 9: 265-293.
1979 Correlations between the neurobiology of colour vision and the psycholinguistics of colour naming. Experientia 35 :1-8.

ACKNOWLEDGMENTS

Brent Berlin provided much appreciated comments on an earlier draft. He and William Merrifield have been valued colleagues throughout the World Color Survey. We also acknowledge with gratitude the advice of David Nash regarding the interpretation of the WCS Warlpiri, Kuku-Yalanji and Murrinh-Patha data, David Wilkins regarding the interpretation of his Arrernte data, as well as the WCS Warlpiri, Kuku-Yalanji, and Murrinh-Patha materials, and Michael Walsh regarding the interpretation of the WCS Murrinh-Patha data. David Wilkins also allowed us to review original data on Arrernte color naming, focal choices, and discourse use, collected by him in 1997. Our heartfelt thanks to all these colleagues. Errors are the contribution of the authors.

NOTES

[1]It is perhaps worthy of passing note that the qualms regarding experimental method were expressed almost exclusively by non-experimentalist anthropologists, while interested psychologists, all of whom were experimentalists, apparently accepted the rough-and-ready experimental procedures of Berlin and Kay because of the robustness of their results (See, for example, Boynton 1997:135f). Collier, both an anthropologist and an experimentalist, is a special case. In (1973) he expresssed the suspicion that the Berlin and Kay results might be an artifact of their stimuli providing maximum available saturation at each hue/lightness coordinate. Subsequently, Collier et al. (1976) reported an experiment in which this hypothesis was examined and rejected, confirming the Berlin and Kay results at a non-maximal, uniform level of saturation.

[2] Fuzzy sets allow for degrees of membership. For example a yellowish orange color can be thought of as, say, 25% red and 75% yellow, that is a member of the fuzzy set red to the degree .25 and of the fuzzy set yellow to the degree .75. The membership of an individual x in the union if two fuzzy sets, A, B, is the maximum of its membership in either. The membership of an individual in the intersection of two fuzzy sets is the minimum of its membership in either. For a non-technical introduction to the basics of fuzzy set theory, see Kay and McDaniel (1978); for full technical detail see Zadeh (1996).

[3] Contemporary color vision theory recognizes the six primary colors, originally posited in the opponent theory of Ewald Hering (1964 [1920]), as arranged in three opponent pairs: black/white, red/green, yellow/blue. Any color percept can be formed by combining two or more of these colors perceptually (not as pigments). Red, yellow, green and blue are the unique hues. That is, these four hues and only these can be seen as unmixed. Orange is seen as a mixture of red and yellow, chartreusse is seen as a mixture of yellow and green, but yellow, although it falls between orange and chartreuse on the hue circle, is not seen as a mixture of orange and chartruese. Along with black and white, the four unique hues provide the primary landmarks, or cardinal points, of perceptual color space, with other colors located in relation to these six. The chromatic opponent pairs are perceptually privative. That is, we cannot see red and green in the same part of the visual field and the same for blue and yellow. (That a green *pigment* can be produced by mixing blue and yellow pigments is irrelevant.) Hering inferred that there must be a neural process which signals red in one state and green in another (analogously for yellow and blue), hence the appelation "opponent" process. The achronmatic pair, black and white, are opposed, but not privative. We do see black and white simultaneously in various shades of gray. See Kaiser and Boynton (1996 23 f, 250-258) and, for a non-technical introduction to opponent theory, Wooten and Miller (1997).

[4] MacLaury's investigations of basic color term systems have led him to develop a theory of cognitive points of view, 'vantages', involving alternating attention to similarities and dissimilarities among cognitive categories. MacLaury's (1997) interpretation of the evolution of basic color term systems is formulated largely within the vocabulary of vantage theory. Vantage theory makes broad claims in the field of cognitive psychology (MacLaury 1997, Taylor and MacLaury 1995), which are beyond the scope of the present paper.

[5] Abbreviated below Bk, W, R, Y, G, Bu.

[6] Some critics of this tradition of research have misconstrued as an *a priori* assumption the empirical finding that semantic universals in color names are substantially based on the universal primary color sensations. See, for example, Saunders and van Brakel (1988, 1995, 1997), Lucy (1996, 1997). Compare Maffi (1990a), Kay and Berlin (1997), Kay (in press). Generalization I is broader than the narrow claim of Berlin and Kay (1969) (abandoned since Kay and McDaniel 1978) that "a total universal inventory of exactly eleven basic color categories exists from which the eleven or fewer basic color terms of any given language are always drawn" (Berlin and Kay 1969: 2).

[7] We do not mean by this that basic color words are not frequently *replaced* by other words denoting the same category, often borrowed words. We mean that in a given language a category once named by a basic color term rarely if ever becomes unnamed.

[8] See references in the previous note.

[9] Dani is the only thoroughly studied case (Heider 1972a, 1972b, Heider and Olivier 1972).

[10] With regard to observable living organisms, probably few languages push this tendency to the extreme of a literally exhaustive *lexical* partition of the entire domain (Berlin 1992).

[11] In the case of color, where the categories are gradient and overlapping, in the way treated formally by Kay and McDaniel (1978), by 'partition' we intend 'fuzzy partition' as it is there defined (Kay and McDaniel 1978: 641ff).

[12] For example, Kuschel and Monberg (1974), in reporting a careful ethnographic investigation of a Stage II color system, make much of their impression to this effect, going so far as to entitle their report "'We don't talk much about color here'; a study of colour semantics on Bellona Island."

[13] Development due to culture contact is doubtedless the major engine of increased technological complexity in recent – perhaps in all – times. Culture contact often provides new artifacts and manufacturing techniques, which render color a less predictable attribute of objects. Moreover, contact with a more complex technology is often accompanied by contact with a language whose lexicon names more distinct color categories (Maffi 1990b).

[14] See, for example, Abramov and Gordon (1994), Hård and Sivik (1981), Wooten and Miller (1997), Hardin (1988: 29f, passim). The primacy of these six color sensations has been challenged by the post-modernists Saunders and van Brakel (1995, 1997), who reject Kay and McDaniel's (1978) "reductionist argument... [to] six basic or atomic colour categories" on the epistemological grounds, among others, that "there is no privileged discourse in which what is true is independent of our choices, hopes and fears" (Saunders and van Brakel 1995: 170).

[15] The misleading expression "fundamental neural response category" was retained in KBM.

[16] "Eventually someone may actually locate cells that carry out these operations" (Abramov 1997: 115).

[17] For example, if you wish to assess one the one hand the "distance" between a yellowish red and a greenish blue and on the other the "distance" between a yellowish green and a purplish red, there is no well-defined, overall metric defined in color space that can tell you which of these "distances" is the greater.

[18] Of the forty-seven children reported on in Dougherty (1975), eight had a term for red and lacked a term for at least one of Y, G and Bu, while one child had terms for G and Bu but lacked a term for R (also Y).

[19] Not all of these differences were subjected to statistical test. A few other studies of color term acquisition were found. One reported presence and two reported absence of correlation with the full Berlin and Kay 1969 sequence, but age of acquisition for individual terms was not reported. The remainder also did not record acquisition data for individual colors.

[20] In KBM two languages, Kuku-Yalanji and Murrinh-Patha, were represented as having terms for W, R, Y/G and Bk/Bu, that is, as Stage $\mathrm{III}_{\mathrm{Y/G}}$ languages. These languages are reanalyzed in section 3, where they are discussed along with other languages showing strong naming for Bk, W, and R, with variable naming elsewhere.

[21] The antecedents of Stage $\mathrm{III}_{\mathrm{Y/G/Bu}}$ languages are discussed in section 3.2.

[22] The question marks appearing in this figure are explained in section 3.2.

[23] The concentration of of WCS languages on this single evolutionary path was first noted by Maffi (1988a,b).

[24] Since a given type may figure in more than one trajectory (e.g., type $\mathrm{IV}_{\mathrm{G/Bu}}$ appears in trajectories A, B and D), our assignment of ninety-one languages to the main line represents the maximum number of types compatible with this trajectory, not the number of types uniquely assignable to this trajectory.

[25] There is independent evidence that blue is an inherently cool color (Palmer in press).

[26] Three languages not shown on Figure 3 are in apparent transition directly from Stage $\mathrm{III}_{\mathrm{Bk/G/Bu}}$ to Stage V.

[27] As may also be seen in Figure 3 (and note 26), the WCS sample does not contain any simple cases of $\mathrm{III}_{\mathrm{Bk/G/Bu}}$ languages, although it does contain six cases of apparent transitions either into or out of that type.

[28] Two of the languages in the WCS sample do not fit perfectly any of the types discussed so far, but also show no evidence of the EH. Gunu (Cameroon) has terms for W, R/Y, Bk/G/Bu and Bu. It thus represents a standard Stage II system except for the presence of the blue term. The blue term is stronger than the Bk/G/Bu term in the blue area, requiring that it be considered basic and therefore that Gunu be considered a violation of the model *sensu strictu*. Waorani (Ecuador) is an anomalous Stage $\mathrm{III}_{\mathrm{G/Bu}}$ system; it contains

terms for Bk, W/Y, R and G/Bu (rather than the standard Bk, W, R/Y and G/Bu). These two cases bring to 103 (95%) the number of WCS languages which offer no support for the EH.

29 And, similarly, it could have had the reduplication of a form denoting a white blossom for white or a reduplication of blood for red. That is, the (hypothetical) coiner of the color term not only has to chose to form it by reduplication, but then has to chose which of several plausible bases to use. Some languages choose blood, others fire, yet others – like Yélîdnye – choose a red bird.

30 Recent unpublished data on Arrernte color terms, collected by Wilkins using the WCS stimuli, suggest strongly that the putative Arrernte Y/G/Bu term is focused in G by all speakers and extended into both Y and Bu by a minority. One of several hypotheses consistent with the available data is that historically the Arrernte term now focused in green denoted a Y/G/Bu category, as reported by Spencer and Gillen (perhaps focused in green, perhaps not) and has retracted for some speakers under pressure from English.

31 Maffi (1990a) raises the question whether certain Y/G/Bu (and other) terms might not profitably be regarded as 'interstitial'.

32The word 'confusion' here, and above, does not, of course, indicate that speakers are confused about how to use their language, but that the results of the WCS naming task are confused because the language does not appear to have a single, widely shared lexical strategy for naming certain regions of the color space. The EH is, of course, about just such circumstances.

33 Yélîdnye, however, does not show evidence of developing a Y/G/Bu term.

34 As KBM point out, Latin had a G/Bu term *viridis* while Ancient Greek had a Y/G term *khlôros*. If these words were related, the situation would be comparable to that of the Salishan family. They are not related. The former probably comes from a PIE root denoting a surface appearance – perhaps shiny or brilliant, the latter a PIE root related to growth (Pokorny 1948).