Chapter 9

THE WORLD COLOR SURVEY DATABASE

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Abstract

The World Color Survey (WCS) is a research project that was undertaken to validate, invalidate, or – most likely – modify the main findings of Berlin and Kay (1969) (B&K): (1) that there exist universal crosslinguistic constraints on color naming, and (2) that basic color terminology systems tend to develop in a partially fixed order. To this end, the WCS collected color naming data from speakers of 110 unwritten languages. The data have recently been compiled into a unified data archive, available online at http://www.icsi.berkeley.edu/wcs/data.html. In this chapter, we review the history of the WCS, including the creation of the online data archive, and describe our recent use of the archive to test the universality of color naming across languages.

1. Introduction

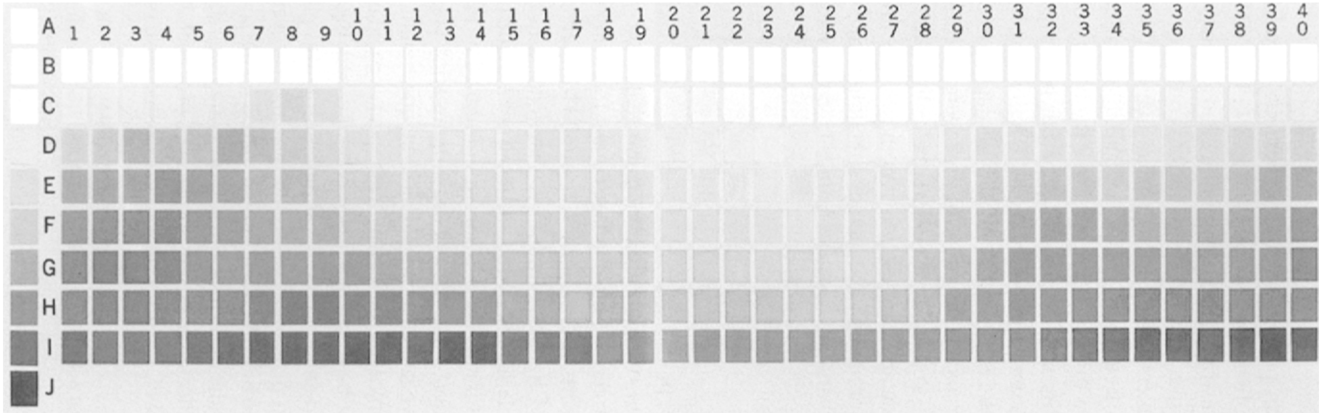
The World Color Survey (WCS) is a research project that was undertaken to validate, invalidate, or – most likely – modify the main findings of Berlin and Kay (1969) (B&K): (1) that there exist universal crosslinguistic constraints on color naming, and (2) that basic color terminology systems tend to develop in a partially fixed order. To this end, the WCS collected color naming data from speakers of 110 unwritten languages. The data have recently been compiled into a unified data archive, available online at http://www.icsi.berkeley.edu/wcs/data.html. In this chapter, we review the history of the WCS, including the creation of the online data archive, and describe our recent use of the archive to test the universality of color naming across languages. Section 2 recounts the general history and methodology of the WCS, Section 3 deals with data processing and analysis. Section 4 covers data checking and quality control procedures. Section 5 describes the original format of the data and steps taken to create the online database. In Section 6, we discuss the use of the online database to test two hypotheses: one involving universal tendencies in cross-language color naming and the other dealing with explanation of a particularly salient instance of variation in cross-language color naming. Section 7 constitutes a brief conclusion.

2. The WCS: History and methodology

The WCS was begun in 1976 to check and expand B&K's findings in a full-scale field study. B&K had investigated the color terminology systems of 20 languages in the following way. The stimulus array used by Lenneberg and Roberts (1956), consisting of 320 Munsell chips of 40 equally spaced hues and eight levels of lightness (Value) at maximum saturation (Chroma) for each (Hue, Value) pair, was supplemented by nine Munsell achromatic chips (black through gray to white) – the resulting stimulus array is shown in Figure 1a[2], Figure 1a is Plate 9.1a in the Separate Color Plate section. First, without the stimulus array present, the major color terms of the collaborator's native language were elicited by questioning that was designed to find the smallest number of simple words with which the speaker could name any color (*basic color terms*)[3]. Once this set of basic color terms was established, the collaborator was asked to perform two tasks. In the *naming* task, the stimulus array was placed before the speaker and for each color term *t*, a piece of clear acetate was placed over the stimulus board and the collaborator was asked to indicate, with a grease pencil on the acetate sheet, all the chips that he or she could call *t*. In the *focus* task, the stimulus array was shown as before and the collaborator was asked to indicate the best example(s) of *t* for each basic color term *t*. The boundaries of categories showed great variability, perhaps because of the

[2] Actually, Figure 1a shows the very slightly modified stimulus palette used in the WCS. The B&K stimulus array lacked achromatic chip A0.

[3] For a review of the B&K basicness criteria, as well as of the notion of basic color terms in B&K and other literature, see Maffi (1990).



(a)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	18	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
A	0																																									9.5
B	0	2	2	2	2	2	2	2	2	4	6	6	6	6	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	9.0
C	0	6	6	6	6	6	6	8	14	16	14	12	12	12	10	10	8	8	6	6	6	6	4	4	4	4	4	4	4	6	6	4	4	4	4	6	6	6	6	6	6	8.0
D	0	8	8	10	10	10	14	14	14	12	12	12	12	12	12	10	10	10	8	8	8	8	8	6	6	6	6	6	8	8	8	6	6	6	6	8	8	10	10	8	8	7.0
E	0	12	12	12	14	16	12	12	12	10	10	10	10	10	10	12	12	10	10	10	10	8	8	8	8	8	8	8	10	10	10	8	8	8	8	10	10	10	10	12	12	6.0
F	0	14	14	14	16	14	12	10	10	8	8	8	8	8	8	10	12	12	10	10	10	10	8	8	8	8	8	8	10	12	12	10	10	10	10	10	12	12	12	14	14	5.0
G	0	14	14	14	14	10	8	8	6	6	6	6	6	6	6	8	8	10	10	10	10	8	8	8	8	6	6	8	8	10	10	12	10	10	10	10	10	10	10	10	10	4.0
H	0	10	10	12	10	8	6	6	6	4	4	4	4	4	4	6	6	8	8	10	8	6	6	6	6	6	6	6	8	10	10	12	10	10	10	10	10	10	10	10	10	3.0
I	0	8	8	8	6	4	4	4	2	2	2	2	2	2	2	4	4	4	6	6	6	4	4	4	4	4	4	6	6	6	8	10	8	8	8	6	6	8	8	8	8	2.0
J	0																																									1.5
		2,5	5	7,5	10		5		10		5		10		5		10		5		10		5		10		5		10		5		10		5		10		5		10	
			R				YR				Y				GY				G				BG				B				BP				P				RP			

(b)

Fig. 1 (a) The WCS stimulus array. (b) Munsell and WCS coordinates for stimulus palette. The leftmost column and the top row give the WCS coordinates for lightness and hue, respectively. The rightmost column and the bottom two rows give the Munsell coordinates for Value and Hue, respectively. Entries in the body of the table show the corresponding Munsell Chroma numbers. [With regard to the A and J rows, there are no Munsell hues at the extremes of Value (lightness): 9.5 (white) and 1.5 (black).]

vagueness of the instruction for the naming task: probably some subjects took the instruction to call for all the chips that were more *t* than anything else, while others appear to have taken it to call for all chips in which any trace of *t* was visible[4]. The focal choices of the B&K subjects were much more clustered and led to the conclusion that

> ... [1] the referents for the basic color terms of all languages appear to be drawn from a set of eleven universal perceptual categories, and [2] these categories become encoded in the history of a given language in a partially fixed order. *Berlin and Kay* (1969, pp. 4–5)[5].

In retrospect, the B&K study – only 20 languages directly assessed with calibrated color stimuli and all the work done in the San Francisco Bay Area – can be viewed as a pilot project for the WCS[6]. The B&K results were immediately challenged, mainly by anthropologists, on the grounds that the sample of experimental languages was too small, too few collaborators per language were questioned (sometimes only one), all native collaborators also spoke English, the data were collected in the San Francisco Bay area rather than in the homelands of the target languages, certain regions of the world and language families were underrepresented or overrepresented in the sample of 20, and the sample of 20 had too few unwritten languages of low-technology cultures [Hickerson (1971), Durbin (1972), Collier (1973), Conklin (1973)]. The results were nevertheless supported by various ethnographic and experimental studies conducted after 1969[7] and were largely accepted by psychologists and vision researchers [e.g., Brown (1976), Miller and Johnson-Laird (1976), Ratliff (1976). See also Boynton (1997, p. 133 ff), Kaiser and Boynton (1996, p. 498 ff).

In the late 1970s, through the cooperation of SIL International (then the Summer Institute of Linguistics), which maintains a network of linguist-missionaries around the world, data on the basic color term systems of speakers of 110 unwritten languages representing 45 different families and several major linguistic stocks were gathered *in situ*. Fieldworkers were provided with a kit containing the stimulus materials (330 individual chips in glass 35-mm slide sleeves for the naming task and the full stimulus board for the focus task) as well as coding sheets on which to record collaborators' responses. The

[4] MacLaury later demonstrated that speakers can often be induced to increase the number of chips they will indicate as belonging to a given term simply by asking them if there are "any more"; speakers frequently increase the size of a named category several times in response to this "mapping" task [MacLaury (1997, pp. 77–84 *et passim*)].

[5] B&K extended their findings on the 20 languages assessed experimentally to another 78 reports of color terminology systems they found in the literature.

[6] Initial support for the WCS was in the form of NSF grant BNS 76-14153. Subsequent NSF support was furnished by grants BNS 78-18303, BNS 80-06808, SBR 94-19702, BCS 01-30420, and BCS 04-18283. NSF support of the WCS project is gratefully acknowledged, as is additional support by the University of California, Berkeley, the Summer Institute of Linguistics (now SIL International), and the International Computer Science Institute. We would also like to express our most sincere gratitude to the many field linguists of the SIL who unselfishly devoted long hours to what for many must often have been an unwelcome task.

[7] For example, Berlin and Berlin (1975), Dougherty (1975, 1977), Hage and Hawkes (1975), Harkness (1973), Heider (1972a, 1972b), Heider and Olivier (1972), Heinrich (1972), Kuschel and Monberg (1974), MacLaury (1986, 1987, 1997), Maffi (1990), Monberg (1971), Senft (1987), Snow (1971), and Turton (1978, 1980).

instructions requested that fieldworkers collect data from at least 25 speakers, both males and females, and urged them to seek out monolingual speakers insofar as possible. The modal number of speakers actually assessed per language was 25 and the mean number was 24. (A facsimile of the WCS instructions to fieldworkers and of the original coding sheets is available at http://www.icsi.berkeley.edu/wcs/images/WCS_instructions-20041018/jpg/border/index.html.) The aim was to obtain names, category extent and best examples of basic color terms in each language – basic color terms being described in the instructions as *"the smallest set of simple words with which the speaker can name any color."*

The WCS methodology coincided with that of the B&K study in the use of a standardized set of Munsell color chips, consisting of 320 chromatic chips representing 40 equally spaced hues at eight levels of lightness (Munsell Value), each at maximum available saturation (Munsell Chroma). One white chip was added in the WCS study that was whiter than any chip available at the time of the B&K study, making for a total of 10 achromatic chips and an overall total of 330 chips, as shown in Figure 1a. The Munsell notations of the chips employed and the simplified notation used for precisely this palette by the WCS project are shown in Figure 1b.

The WCS differed from B&K in the technique for eliciting naming responses. In the WCS procedure, no preliminary interview was administered to establish a set of basic color terms, and in the naming task the 330 individual color stimuli were shown to each cooperating speaker, one by one, according to a fixed random order, and a name elicited for each (in contrast with the B&K procedure of presenting the entire stimulus array at once to elicit naming responses). Fieldworkers were instructed to urge observers to respond with short names (although, depending on the morphology of the language, particular field circumstances, and local culture, there was considerable variation in the degree to which the field investigators were able to satisfy these desiderata). Identification of basic color terms, therefore, was done by the fieldworker as a result of the naming task itself, rather than through prior elicitation. The best example (focus) responses were elicited in the same way in both studies: once a set of basic color terms was isolated, the native observer was presented with the full palette (in WCS, a physically improved version of the original Munsell chip board, devised by Collier et al. 1976) and asked to indicate the chip (or chips) that represented the best example of each term, one by one.

3. Data processing and analysis

Once data gathering was completed (*Ca.* 1980), data processing, quality control, and analysis were undertaken at University of California, Berkeley, and at SIL in Dallas.

Computer programs were developed for both data entry and data analysis. The original processing yielded, for each language, a preliminary data summary that included the following information:

- Language name and location.
- Name, age, sex, and other vital statistics of each speaker interviewed.

- List of terms used, each with a tentative gloss and a typographical symbol representing it in the naming and focus arrays. (See Figure 2a for an example. All the examples in Figure 2 are for the Niger-Congo language Wobé of Côte d'Ivoire. The information shown in Figure 2 is not that of the initial data entry and preliminary processing but of the final results of checking, following corrections to the original data entry and preliminary analyses, as described below.)
- Individual naming arrays, structured by the form of the full stimulus array shown in Figure 1 and presenting, for each speaker, the full picture of his or her use of color terms from the naming task (see Figure 2b for examples).
- Individual focus arrays, presenting, for each speaker, the full picture of his/her focal (best example) choices from the focus task. (see Figure 2c for examples).
- Aggregate naming arrays, also in the form of the stimulus array, presenting the aggregated results of the naming task across all speakers, at various levels of interspeaker agreement. For example, for a language with 25 native observers, the 40% naming aggregate shows for each stimulus chip *c* (1) the symbol for the most popular name given to c, if at least 10 speakers gave *c* that name or (2) a blank if no single name was given to c by 10 or more speakers. (see Figure 2d for examples).

Symbol	Term	Gloss
o	*kpe'*	black/green/blue
+	*"pluu-*	white
#	*-sain'*	red/yellow

(a) (Diacritics stand for tones: " = very high; ' = high; - = low.)

```
        ***  Speaker  15     ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B +++++++++#++#++++++++++++++++++++++++++++ B
C +#############++oo+++++++++++++++++++#### C
D +############ooooo+ooo+o+o++oooo+++###### D
E +###########*#ooooooooooooooooooooo###### E
F o###########ooooooooooooooooooooooo###### F
G o#########ooooooooooooooooooooooooo###### G
H o######o#oooooooooooooooooooooooooo###### H
I o####o#oooooooooooooooooooooooooooooo#### I
J ooooooooooooooooooooooooooooooooooooooooo J
```

```
        ***  Speaker  17     ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B +++#++#++###+##++++++++++++++++++++++++++ B
C +#################oooo+o+o++o+o++++###### C
D +###############ooooooooooo+ooooo#+###### D
E o##############oooooooooooooooooo######## E
F o#############oooooooooooooooooooo####### F
G o##########oo##o#ooooooooooooooooo####### G
H o########oooooooooooooooooooooooooo###### H
I o######oooooooooooooooooooooooo+o#o###### I
J ooooooooooooooooooooooooooooooooooooooooo J
```

```
        ***  Speaker  22     ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B +++++++++++++++++++++++++++++++++++++++++ B
C +##############oooooooo+++++++++++++##### C
D +##############oooooooooo#ooooo+o++###### D
E +#############ooooooooooooooooooo######## E
F o############oooooooooooooooooooooo###### F
G o############oooooooooooooooooooo######## G
H o###o######ooooooooooooooooooooooo####### H
I o######ooooooooooooooooooooooooooo####### I
J ooooooooooooooooooooooooooooooooooooooooo J
```

```
        ***  Speaker  23     ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B ++++++++++++++++++++++++++++++++++++#++++ B
C +#############ooooo+++++o++++++++++++#### C
D +####+#########ooooooooooooo+ooo++++##### D
E +#############oooooooooooooooooooooo##### E
F o#############oooooooo#ooooooooooo+###### F
G o######## #oooooooooooooooooooooooo###### G
H o#######o#*#oooooooooooooooooooooooo##### H
I o####ooooooooooooooooooooooooooooo#oo#### I
J ooooooooooooooooooooooooooooooooooooooooo J
```

(b)

Fig. 2 (a) Wobé basic color terms, with glosses and key symbols. (b). Naming responses for four Wobé speakers (see previous figure for terms denoted by typographical symbols).

```
          *** Speaker 15 ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B                                           B
C                                           C
D                                           D
E                                           E
F                                           F
G #                                       # G
H                                           H
I                                           I
J ooooooooooooooooooooooooooooooooooooooooo J
```

```
          *** Speaker 17 ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B                                           B
C                                           C
D                                           D
E                                           E
F                                         # F
G #                                         G
H                                           H
I                                           I
J ooooooooooooooooooooooooooooooooooooooooo J
```

```
          *** Speaker 22 ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B                                           B
C                                           C
D                                           D
E                                           E
F                                           F
G #                                       # G
H                                           H
I                                           I
J ooooooooooooooooooooooooooooooooooooooooo J
```

```
          *** Speaker 23 ***
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B                                           B
C                                           C
D                                           D
E                                           E
F                                         # F
G #                                         G
H                                           H
I                                           I
J ooooooooooooooooooooooooooooooooooooooooo J
```

(c)

```
   40% Agreement Level, 10 of 25 speakers
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B +++++++++++++++++++++++++++++++++++++++++ B
C +##############oooo++++++++++++++++++#### C
D +##############oooooooooooo+ooo++++###### D
E +#############ooooooooooooooooooo######## E
F o#############ooooooooooooooooooooo###### F
G o##########oooooooooooooooooooooo######## G
H o########oooooooooooooooooooooooooo###### H
I o####ooooooooooooooooooooooooooooo####### I
J ooooooooooooooooooooooooooooooooooooooooo J
      Coverage is 100% (330 of 330 chips)
```

```
   100% Agreement Level, 25 of 25 speakers
            1         2         3         4
  01234567890123456789012345678901234567890
A +++++++++++++++++++++++++++++++++++++++++ A
B ++  ++ ++      +++++++++++ +++++ +++ ++   B
C + #     ###                    + +      # C
D +# ## #####                         ##### D
E  ########                           ##### E
F  ###### #                          ###### F
G o#####                    o        ###### G
H  ###          o                      #### H
I o         o   o      o     o              I
J                                           J
      Coverage is 31% (102 of 330 chips)
```

(d)

Fig. 2 (c) Focus (best example) responses for four Wobé speakers. (d) Aggregate naming arrays for 25 Wobé speakers. (Note that at the 40% level of agreement all 330 chips were named. That is, at least 10 speakers gave the modal response for each of the 330 chips. Wobé was a high-consensus language.)

Subsequently, an additional kind of array was produced, called a *term map*. A term map for a given term furnishes a visual picture of the relative frequency of that term's usage over the stimulus space in the form of a kind of contour map. A term map is thus a display of the denotation of a color term. Conceptually, one can imagine a 3D histogram for a term t in which the stimulus surface constitutes the floor plane and the height of the column over each stimulus chip c represents the proportion of speakers using t to name any chip who used t to name c. We represent two dimensionally a contour map of such a 3D histogram, viewed from above: this is what we call a term map. Specifically, a term map for a term t is a display of the stimulus surface where the symbol appearing on chip c is

- #, if 81% or more speakers who used t named c with t,
- +, if 61 – 80% of the speakers who used t named c with t,

- –, if 41 – 60% of the speakers who used *t* named *c* with *t*,
- ·, if 21 – 40% of the speakers who used *t* named *c* with *t*,
- nothing (blank), if 20% or fewer of the speakers who used *t* named *c* with *t*,
- @, if the percentage of *t*-users who used *t* to name *c* equaled or exceeded the percentage of *t*-use by *t*-users for any other chip. The numerical value of @, the consensus level for *t*, is given at the bottom of each term map, as well as the number of collaborating speakers of the language and the number using the term mapped.

The density of the symbols as visual objects increases as the proportion of respondents they represent increases; thus, a term map gives a somewhat iconic representation of a term as a gradient category, where proportion of speakers using *t* to name *c* is taken as a proxy for the degree of membership of color *c* in the gradient category named by term *t*[8].

Figure 3 shows the term maps for Wobé.

```
o: kpe' 'black/green/blue'

            1         2         3         4
  01234567890123456789012345678901234567890
A                                           A
B                                           B
C                ---+......                 C
D               .++####++#-+-.-++           D
E              .+###########+####-+.        E
F -           ..-##################--       F
G @         .-+++###########@######..       G
H #       ..-+###@##################+-.     H
I @     -+###@###@######@#####@#####+---    I
J ######################################### J

  25 of 25 speakers searched; 25 used term
 Consensus level is 100% (25 of 25 speakers)
```

```
+: "pluu- 'white'

            1         2         3         4
  01234567890123456789012345678901234567890
A @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@ A
B @@##@@#@@++-++#@@@@@@@@@@@#@@@@@#@@@#@@## B
C @   .       . ...-.+-+++++####+@#@#++     C
D @                    .  ...--..+##+       D
E +                              ..         E
F .                                         F
G                                           G
H                                           H
I                                           I
J                                           J

  25 of 25 speakers searched; 25 used term
 Consensus level is 100% (25 of 25 speakers)
```

```
#: -sain' 'red/yellow'

            1         2         3         4
  01234567890123456789012345678901234567890
A                                           A
B           .-..                            B
C  #@#+###@@@#+#.                    ..###@ C
D  @#@@#@@@@@##+-                    +@@@@@ D
E  @@@@@@@@###++.                  -+#@@@@@ E
F  @@@@@@#@#++++.                  -.@@@@@@ F
G  @@@@@##++-..                    -+@@@@@@ G
H  @@@###+-.                       .-+#@@@@ H
I  ####-.                          .---+### I
J                                           J

  25 of 25 speakers searched; 25 used term
 Consensus level is 100% (25 of 25 speakers)
```

Fig. 3. Term maps for the three terms in Wobé. (# INDICATES 81–100% agreement. + INDICATES 61–80% agreement. – INDICATES 41–60% agreement. • INDICATES 21–40% agreement. [BLANK] 0–20% agreement. @ INDICATES maximum agreement. The large number of chips receiving perfect consensus for the white/light and red/yellow/warm terms, indicated by @, is unusual.)

[8] The conventions for representing the various displays in Figures 2 and 3 were developed in an age of typewriter technology.

4. Cleaning the data

Before the initial data entry had been checked, a set of microfiche summaries containing preliminary versions of the data arrays described above was accidentally made available to the public in 1991. This release of unchecked data was unfortunate because we subsequently discovered that these summaries contained many errors, especially in the assigning of similar spellings to same or different terms. Coders had frequently made snap judgments about probable morphological variations in unfamiliar languages. Such errors of primary interpretation, along with simple input errors – using the same abbreviation for two different terms, using two different abbreviations for a single term, and the like, introduced significant inaccuracy into the data in the 1991 microfiche summaries. The current archived data are based on a number of data-cleaning procedures subsequently adopted: (1) checking the electronic record against the original paper coding booklets, (2) carefully surveying fieldworkers' notes regarding spelling variations and morphological structure, (3) rerunning various summary programs to see if, for example, two distinct "terms" with similar spellings had virtually identical term maps (indicating mere spelling variation), (5) corresponding with the original investigators in some cases and with other specialists in the same or related languages in other cases regarding morphological analysis of the recorded color terms, and (6) in general checking all possible information from whatever source to make as certain as possible that what our data listed as the roster of color terms of a language was an accurate rendition of the color terms of that language as recorded by the field investigators.

5. Original format of the data and creation of the WCS Online Data Archive

The early work of converting the handwritten coding sheets (prepared in the field) to electronic format was split between a team of researchers at SIL in Dallas, Texas, and a team at UC Berkeley. The two halves were eventually joined together when the SIL data came to Berkeley in the mid-1980s. At that point, the WCS data were not stored in a single database but rather in 110 separate directories, one for each language. Within a language directory, the data were stored in four main files (with some subsidiary files): (1) an Informants file, containing the name and vital statistics of each native collaborator for that language, along with an identification number and some ancillary information regarding other languages spoken, etc.; (2) a Dictionary file, containing the color terms of the language and one or more abbreviations with which they could be referred to in other files; (3) a Naming data file, containing the naming data for each collaborating speaker; and (4) a Focus file, containing the best example(s) of data for each speaker. The WCS data remained in these 110 separate and unlinked directories until December 2000.

The primary copies of the World Color Survey electronic computer files, described above, were housed at UC Berkeley on an aging hard disk connected to an old computer, with accompanying fragile removable media backup disks. In December 2000, those files were all compressed into a single archive, copied to a campus server, and then burned to CD-ROM. In early 2002, work began to extract the data from that archive, to create an operating system-independent, public, online archive. We describe the archive creation process here, so that users of the archive may have a clear picture of the nature of the data and their origin.

Initial study of the electronic source files revealed that a number of components in different formats would have to be processed separately for integration into a coherent whole. A major reason for this was that the SIL and Berkeley teams had applied different conventions to the digitization of their respective data.

The results of the naming task (presented in the current online archive in the file "term.txt") constituted by far the bulk of the data, totaling nearly 1 million lines of text. These naming data, in 110 separate files, had received the greatest attention of all the existing files, and by the year 2000 had attained a fairly stable state. Other components of the data included focus data (from the best-example task), speaker data (personal information on the native observers), language data (geographical information on the languages), dictionary data, and analyses of the color terms present for each language. Compared to the naming data, each of these latter components had received considerably less attention over the years. Unlike the naming data, the separate Berkeley and Dallas focus data had never been consolidated into a coherent whole. Instead, portions of each had been partially processed, and in 2002 we began to reassemble the pieces and complete the processing.

The source files fell into two major groups, labeled "new" and "old." The "new" files represented the effort to combine the Berkeley and Dallas data. The old files themselves were still split into "Berkeley" and "Dallas" groups. There were omissions in the "new" files of focus data only available in the "old" files, and there was a certain amount of overlap and variability in formatting among all three. The task then became one of identifying omissions in the "new" focus data, filling in these gaps, and verifying the new focus data where they were present. Gaps in the new data were filled in from the primary electronic source of the missing data (Berkeley or Dallas). In the event that no electronic data were available, it was necessary to revert the coding sheets and input the data afresh, interpreting the fieldworkers' conventions as best these could be determined. Fortunately, recourse to the original coding sheets was necessary only for a relatively small number of languages.

The data from the coding sheets had originally been entered into the computer systems via a process that involved creating an electronic "dictionary," that is, an inventory of the terms attested on all coding sheets for all speakers of the language. A unique abbreviation (WCS code) was then assigned to each of the terms, often bearing an obvious relation to those used by the original fieldworker. Different fieldworkers had used different transcriptional and notational conventions. Thus, the electronic Dictionary data contained both an ASCII (or other encoded) interpretation of the fieldworker's transcription of the native color term, and a one- or two-letter abbreviation to be used in the input of both naming and focus data. These three repositories of term abbreviations had to ultimately agree among themselves, and also to be transparently related to the rendering of the terms on the coding sheets. Where there was disagreement, a correction had to be applied, based on assessment of all of the available documentation.

The original fieldworkers themselves had employed various collection and organizational techniques, all of which contributed another level of variability to the data. In examination of the coding sheets, it became apparent that some fieldworkers were fastidious workers who had clearly put great effort into selecting their native collaborators, collecting the responses, and copying out the final coding sheets in pen or with a typewriter, using IPA for their transcriptions. At the other extreme, data on the coding sheets were sometimes barely legible and sometimes internally inconsistent, as when the same abbreviation was used for evidently different terms or two different abbreviations were used for the same term. Once the relations among the various data formats became clear, we compiled the data together into a single data archive composed of four files in tab-delimited plain text format: one containing the naming data ("term.txt"), one containing best-example data ("foci.txt"), one describing the languages ("lang.txt"), and one describing the individual speakers of the languages ("spkr.txt"). The various "dictionary" files have also been combined into a single file compatible with the other four, and integrated into the relational database system. This dictionary data appears in the online archives in UTF-8 format under the name "dict.txt." Online documentation concerning the formats of these files is included with the archive. The work to prepare the data consumed all of 2002, and it was not until January 2003 that the first portion of the online data was released to the public

6. Uses of the WCS archive

The WCS data archive has been used in investigating two broad questions, one concerning *universals* and the other concerning *variation* in color naming.

6.1. Universals of color naming

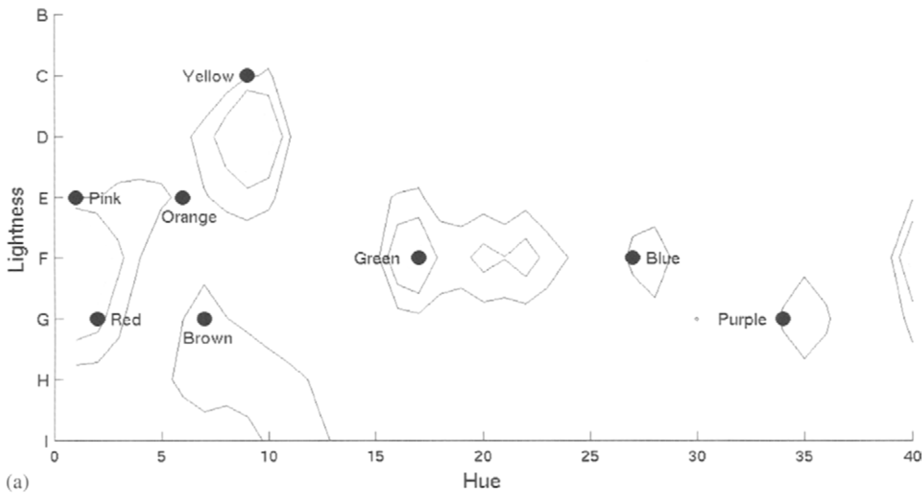
Since B&K found evidence for universals in color naming across languages, the existence of such constraints has generally been accepted in the scientific community. However, there have always been dissenters from this consensus [e.g., Durbin (1972), Hickerson (1971)], and this dissenting view has recently gained some prominence [e.g., Davidoff, Davies, and Roberson (1999) Lucy (1992, 1996, 1997), Roberson, Davies, and Davidoff (2000), Saunders and van Brakel (1997)]. Criticisms of the universalist position have come in two major varieties. The first points out that B&K's findings were never objectively tested, as they relied on visual inspection of color naming data. Lucy (1997) challenges such a methodology as hopelessly subjective:

> [Work in the B&K tradition] not only seeks universals, but sets up a procedure which guarantees both their discovery and their form. ... when a category is identified ... it is really the investigator who decides which "color" it will count as ... What appears to be objective – in this case, a statement of statistical odds – is [not]. (p. 334)

In this view, B&K's subjective methodology allowed them to impose their own universalist assumptions on their data – so the universals are actually in the minds of the investigators, not in the languages of the world. The second strand of criticism points out that B&K's data were drawn primarily from written languages, and thus may not be representative. This point is coupled with analyses of particular unwritten languages, which are claimed to counterexemplify universal constraints [e.g., Berinmo: Davidoff et al. (1999), Roberson et al. (2000), Hanunóo and Zuni: Lucy (1997)]. Kay (1999) has responded to this with counter-analyses of these languages, arguing that each fits neatly into the universal pattern. Disputes of this sort over conflicting interpretations of individual color naming systems could continue indefinitely without resolving the main issue of whether universal, cross-language constraints on color naming systems actually exist. We wished to resolve this issue in a manner that would respond to both varieties of criticism.

To that end, Kay and Regier (2003) used the WCS database and the B&K data to objectively test the hypothesis that color terms across languages cluster together more tightly in color space than would be expected by chance. This was done as follows. First, for each term in each WCS language, the centroid (i.e., center of mass) of each speaker's naming distribution was calculated, after translation of Munsell coordinates into CIE L*a*b* coordinates [Wyszecki and Stiles (1967)][9]. We refer to the resulting point as the "speaker centroid" for that speaker and that term. For each term, we then calculated the "term centroid": the centroid of the speaker centroids for that term. This produced a point representation of the term in CIE L*a*b* space. Each centroid was coerced to the nearest point in the stimulus array, so that our point representation of the term resided within the set of points out of which it was constructed. The speaker centroids were plotted over the stimulus space, yielding the picture shown in Figure 4a, Figure 4a is Plate 9.4a in the Separate Color Plate section. Intuitively, the speaker centroids are not distributed randomly or evenly over the stimulus space. Figure 4a shows sharp peaks and broad valleys in the distribution of speaker centroids. We showed this clustering of speaker centroids to be statistically significant by the results of a Monte Carlo simulation on the *term* centroids, depicted in Figure 4b – this time demonstrating universality across color terms without regard to their frequency of use, since each term is now represented by one centroid, whatever its frequency. In that simulation, a measure of dispersion (the opposite of clustering) of term centroids was defined as the sum, across languages, of the distances between each term (centroid) in that language and the closest term (centroid) in another language. This measure was calculated in the WCS data and in 1000 hypothetical randomized datasets, each created by rotating the actual WCS naming centroid distribution a random degree of hue angle in CIE L*a*b* space (to maintain the shape of the distribution while randomizing its location in perceptual space). In Figure 4b, Figure 4b is Plate 9.4b in the Separate Color Plate section it can be seen that the dispersion measure for the actual WCS dataset falls well below the lower bound of the distribution of 1,000 hypothetical WCS

[9] CIE L*a*b* is a three-dimensional color space; its creators made a systematic effort to assure that local Euclidean distance corresponds to perceptual dissimilarity.



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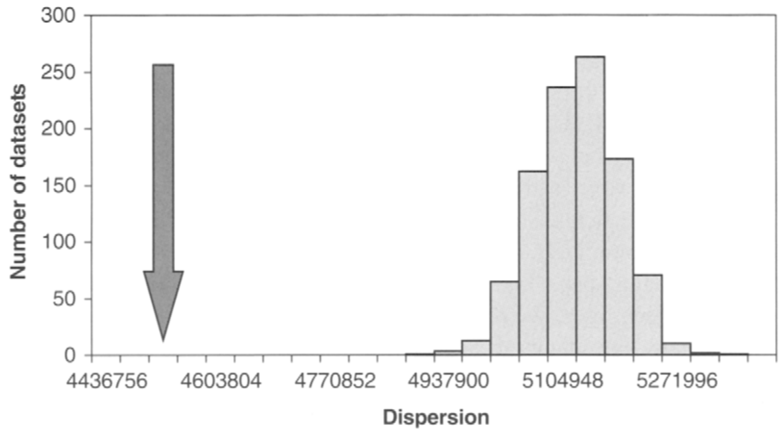

(b)

Fig. 4 (a) Contour plot of WCS speakers' naming centroids, compared with English naming centroids (black dots). (Source for English naming centroids: Sturges and Whitfield 1995.) The outermost contour represents a height of 100 centroids, and each subsequent contour represents an increment in height of 100 centroids. Source: Kay and Regier (2003). (b) Monte Carlo test for clustering within the WCS data. The distribution of dispersion values shown in blue was obtained from 1000 randomized datasets. The red arrow indicates the dispersion value obtained from the WCS data. [Source: Kay and Regier (2003)].

datasets, indicating a probability less than 0·001 that the degree of clustering in the real WCS dataset is the result of chance. A similar Monte Carlo test also revealed that color terms in the unwritten languages of the WCS tend to cluster near the color terms of written languages (Berlin and Kay 1969). (For further explanation, see Kay and Regier 2003.)

The above results concern the naming data from the WCS. Statistical tests of the degree of clustering of WCS best-example (focus) choices remain to be performed, but a preliminary plot of the focus data suggests strongly that such tests will turn out to be statistically significant. (Black dots represent the naming centroids for the English terms indicated.)

In the WCS focus distribution, the chips receiving the highest numbers of focus choices were J0 (black) and A0 (white), not shown in Figure 5, Figure 5 is Plate 9.5 in the Separate Color Plate section. In Figure 5, restricted to the WCS chromatic chips, two of the four major focus peaks fall, one each, on the English yellow and English green naming centroids. A third WCS focus peak falls on a chip adjacent to the English red naming centroid and the fourth major peak in the WCS best-example distribution falls two chips away from the English blue naming centroid. These observations suggest strongly that objective tests will show a non-chance association between the highest peaks of the WCS focus distribution and points in color space favored by English color naming*.

6.2. *Variation in color naming*

The above results demonstrate universal constraints in color naming. Yet there is also considerable cross-language variation, and it is still an open question *why* languages vary as they do in the naming of colors.

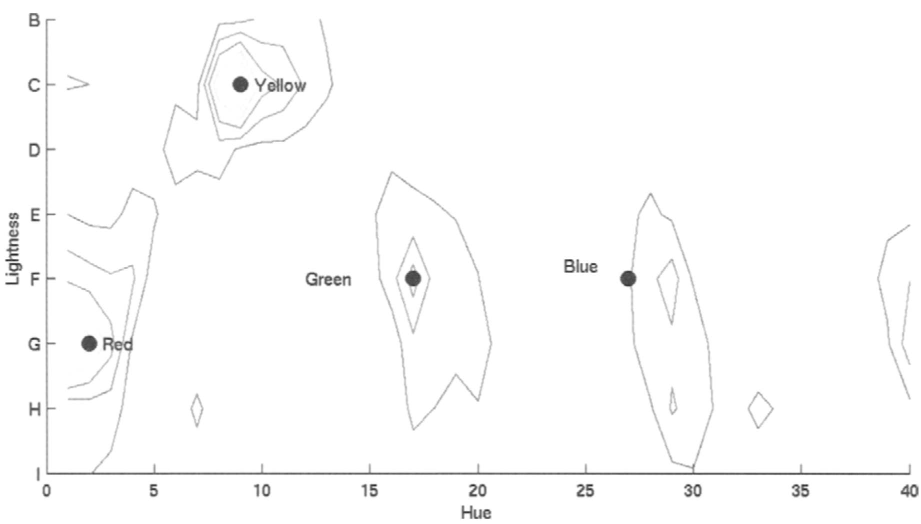

Fig. 5. Contour plot of WCS chromatic focus peaks compared with English naming centroids. [Source for English naming centroids: Sturges and Whitfield (1995)].

* Note added in proof: Recently, such objective tests have yielded confirmatory results (Regier, Kay and Cook 2005).

Lindsey and Brown (2002) provided a provocative answer for one aspect of this question, the investigation of which has employed the WCS online data archive. Some languages have separate terms for blue and green, while others have compound green-or-blue ("grue") terms; Lindsey and Brown asked why this should be. They suggested that grue terms may derive from a sunlight-induced yellowing of the ocular lens: with a yellowed lens, short wavelengths are disproportionately filtered and blue stimuli would appear green, and would be named by the word for green. In other words, grue terms in this view are really words for green, and they extend to what normal eyes see as blue only because the yellowed lens distorts the perception of color. In support of this hypothesis, Lindsey and Brown noted that the proportion of languages with grue terms (rather than separate green and blue terms) is well predicted by the amount of UVB radiation from sunlight that strikes the earth's surface where those languages are spoken – as would be predicted if grue is ultimately traceable to sunlight-induced lens yellowing. They also showed that speakers of English who were shown stimuli that artificially simulated sunlight-induced yellowing of the lens extended the English word *green* to include stimuli presenting a spectral distribution comparable to that of a blue stimulus viewed through a yellow filter.

Intriguingly, Lindsey and Brown note that their hypothesis has the potential to "explain away" some recent findings suggesting a Whorfian influence of language on color cognition. Davidoff et al. (1999) examined color naming and memory in speakers of Berinmo, a language that has an enlarged yellow term, extending into the region that would be named "green" in English; this enlarged yellow category shares a border with a grue category. Davidoff et al. examined how well Berinmo speakers remembered colors straddling the boundary between these two Berinmo categories, and found that their performance was better for these colors than it was for colors straddling the boundary between English *yellow* and *green*. English speakers showed the opposite pattern. These findings suggest that a language's color terms may influence color cognition for speakers of that language [see also Kay and Kempton (1984)]. However, Lindsey and Brown suggested a different interpretation of these data. They argued that since Berinmo has a grue term, its speakers may have yellowed lenses. This would explain why Berinmo's yellow term expands into green: because yellowish greens are seen as more yellow through this lens. And it would also explain why color memory covaries with color naming across English and Berinmo: because both memory and naming are shaped by color perception, and that perception may be distorted by a yellowed lens in Berinmo speakers, relative to English speakers.

Regier and Kay (2004) tested this lens-yellowing hypothesis further, by probing a prediction it makes concerning the *best examples* of grue categories. If grue is really a green category that extends into blue because of a distorted perceptual color space, then there should be a single peak in the best example choices for grue (since there is a single peak for green), and it should fall somewhere between focal green and focal blue. However, if grue is instead a genuine abstraction over green and blue in an undistorted perceptual color space, the best examples for grue should peak either at green, or at blue, or at both. This prediction was easily tested using the focus data from the WCS data archive. We found that best examples for grue terms peak at English *green* and very near English *blue* [Figure 6, Figure 6 is Plate 9.6 in the Separate Color Plate section; see also MacLaury (1997, pp. 234–235), compare also with Figure 5, which shows focal choices from all WCS languages combined, including those that distinguish between green and blue]. This suggests that the lens-yellowing hypothesis is incorrect. In doing so, it also indirectly supports the Whorfian hypothesis, by removing a competing explanation for the findings from Berinmo.

In response, Lindsey and Brown (2004) have presented further analyses of WCS focus data. Their findings confirm that grue best-example choices tend to peak at focal green and focal blue – which argues against their hypothesis. But at the same time, their findings also leave open the possibility that there may be a subset of speakers whose best-example choices fall between universal focal green and blue, and thus are consistent with their hypothesis. Further analysis will be needed to establish whether the observation of a small number focal choices between green and blue provides support for the Lindsey and Brown UVB hypothesis. In any case, the hypothesis seems imperiled on other grounds as well. A recent finding has shown that color naming in English by individuals with *naturally* yellowed ocular lenses does not differ from that by individuals with nonyellowed lenses [Hardy, Frederick, Kay, and Werner (2005)]. The probable reason for the difference observed between Lindsey and Brown's simulation of yellowed optical media and naturally yellowed optical media is that in the latter case long-term processes of adaptation have time to operate [Delahunt et al. (in press), Neitz et al. (2002), Schefrin and Werner (1990, 1993)], in order to perceptually compensate for the increased yellowing of the lens. This makes it quite unlikely that lens yellowing could account for grue terms in the world's languages.

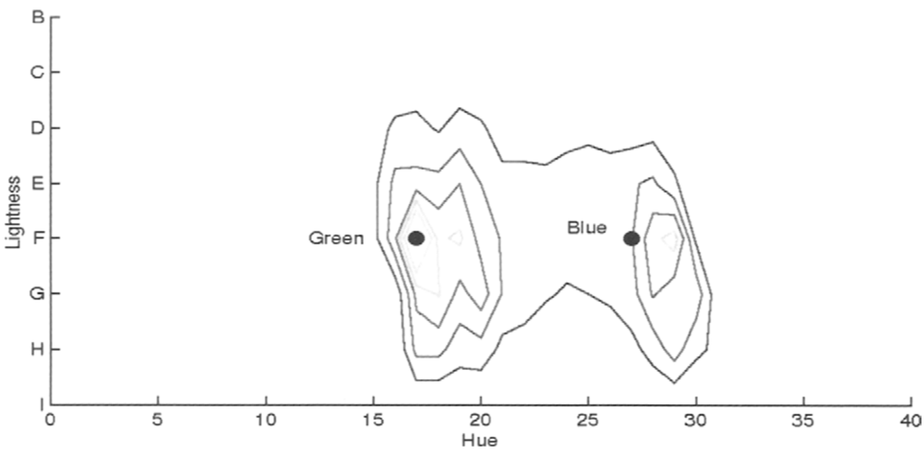

Fig. 6. Contour plot showing the distribution, over chromatic stimuli, of best examples of grue terms in the WCS. Outermost contour represents a height of 10 hits; each subsequent inner contour represents a height increment of 10 hits. [Source: Regier and Kay (2004)].

7. Conclusion

The WCS data archives are a publicly accessible resource, available to all who wish to pursue questions related to color categorization across languages. We have provided this background to orient potential users of the archive – to give them a sense for where the data came from, how the data were compiled into an archive, and what sorts of questions the data can be used to investigate. We hope the archive proves to be a useful and flexible research tool for the scientific community as a whole.

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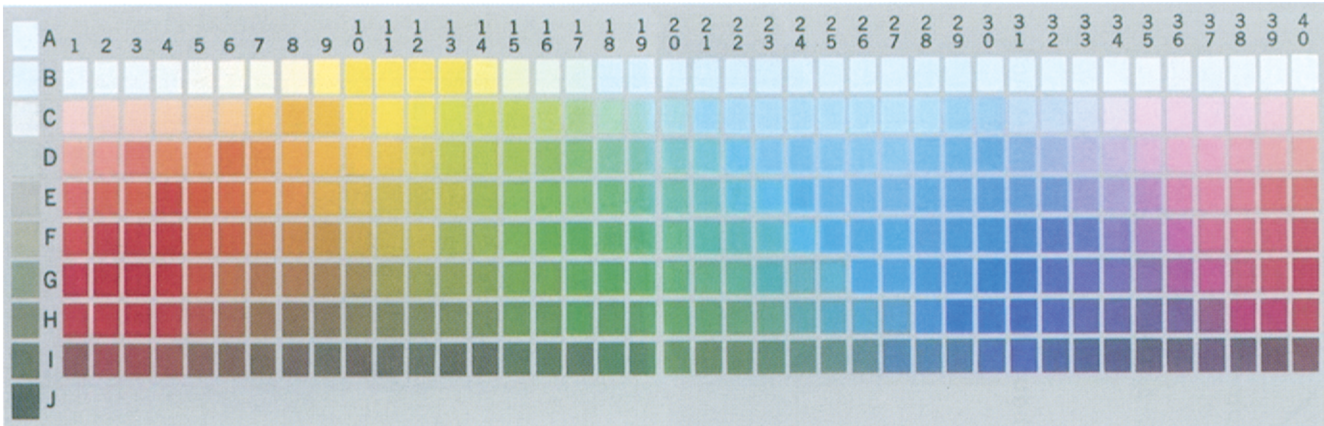

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C	0	6	6	6	6	6	6	8	14	16	14	12	12	12	10	10	8	8	6	6	6	6	4	4	4	4	4	4	4	6	6	4	4	4	4	6	6	6	6	6	6	8.0
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E	0	12	12	12	14	16	12	12	12	10	10	10	10	10	10	12	12	10	10	10	10	8	8	8	8	8	8	8	10	10	10	8	8	8	8	10	10	10	10	12	12	6.0
F	0	14	14	14	16	14	12	10	10	8	8	8	8	8	8	10	12	12	10	10	10	10	8	8	8	8	8	8	10	12	12	10	10	10	10	10	12	12	12	14	14	5.0
G	0	14	14	14	14	10	8	8	6	6	6	6	6	6	6	8	8	10	10	10	10	8	8	8	8	6	6	8	8	10	10	12	10	10	10	10	10	10	10	10	10	4.0
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I	0	8	8	8	6	4	4	4	2	2	2	2	2	2	2	4	4	4	6	6	6	4	4	4	4	4	4	6	6	6	8	10	8	8	8	6	6	8	8	8	8	2.0
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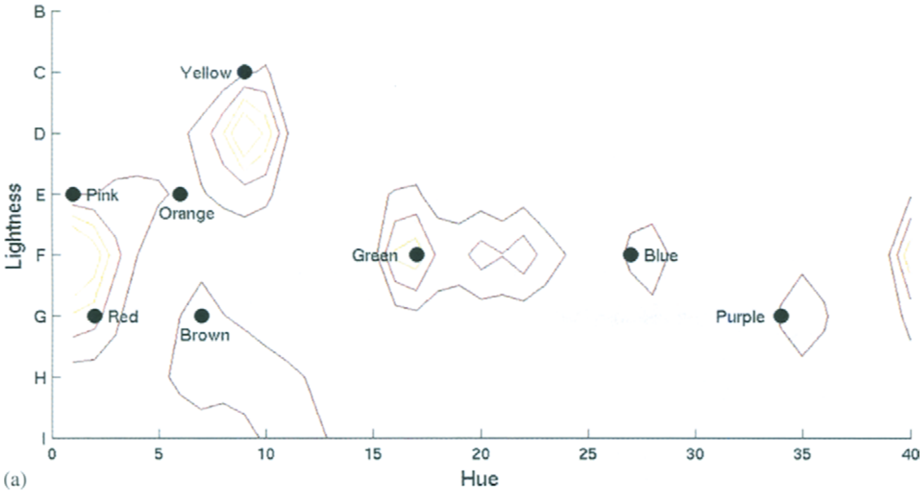
Plate 9.1 (a) The WCS stimulus array. (b) Munsell and WCS coordinates for stimulus palette. The leftmost column and the top row give the WCS coordinates for lightness and hue, respectively. The rightmost column and the bottom two rows give the Munsell coordinates for Value and Hue, respectively. Entries in the body of the table show the corresponding Munsell Chroma numbers. [With regard to the A and J rows, there are no Munsell hues at the extremes of Value (lightness): 9.5 (white) and 1.5 (black).]



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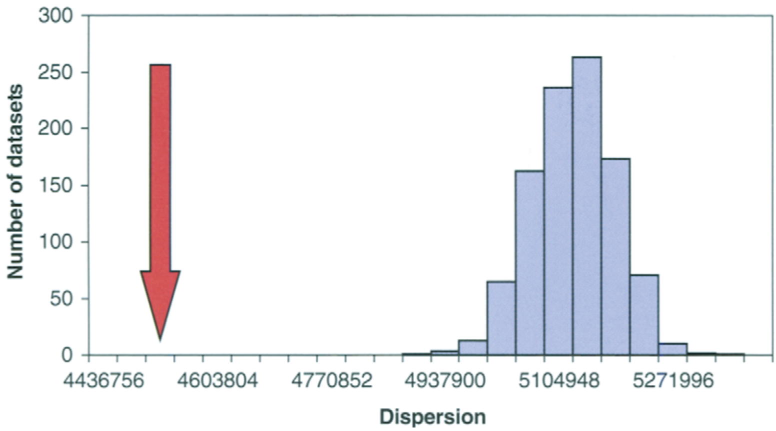

(b)

Plate 9.4 (a) Contour plot of WCS speakers' naming centroids, compared with English naming centroids (black dots). (Source for English naming centroids: Sturges and Whitfield 1995.) The outermost contour represents a height of 100 centroids, and each subsequent contour represents an increment in height of 100 centroids. Source: Kay and Regier (2003). (b) Monte Carlo test for clustering within the WCS data. The distribution of dispersion values shown in blue was obtained from 1000 randomized datasets. The red arrow indicates the dispersion value obtained from the WCS data. [Source: Kay and Regier (2003)].

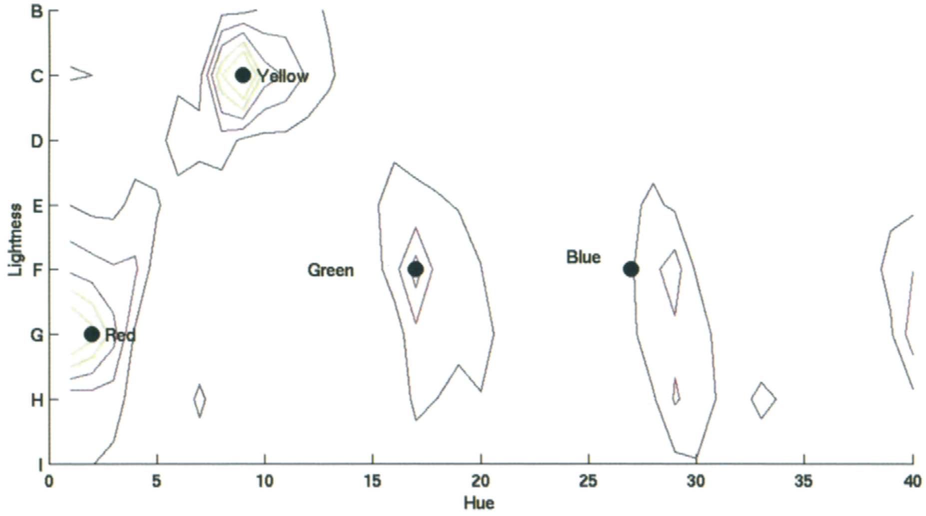

Plate 9.5. Contour plot of WCS chromatic focus peaks compared with English naming centroids. [Source for English naming centroids: Sturges and Whitfield (1995)].

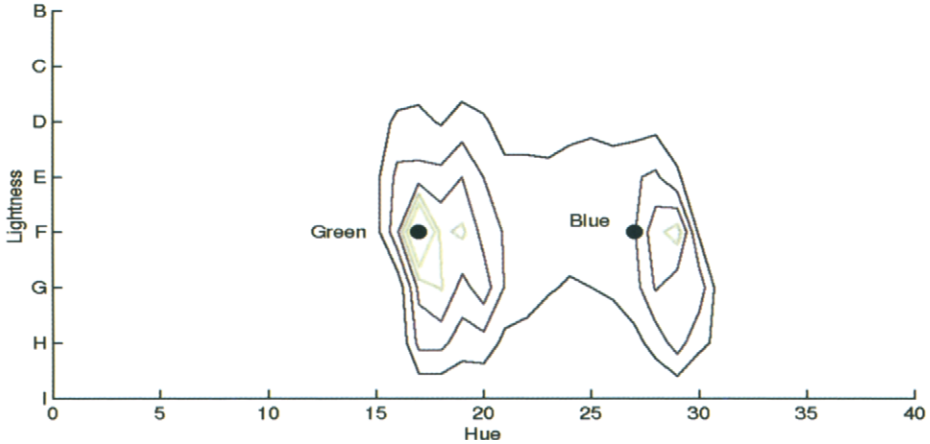

Plate 9.6. Contour plot showing the distribution, over chromatic stimuli, of best examples of grue terms in the WCS. Outermost contour represents a height of 10 hits; each subsequent inner contour represents a height increment of 10 hits. [Source: Regier and Kay (2004)].