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CATEGORICAL COLOR PERCEPTION OF JAPANESE OBSERVERS: COMPARISON WITH THAT OF AMERICANS

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Abstract—Ten native Japanese observers named 424 colors of the OSA Uniform Color Scales set using monolexemic color terms of their choice. The results are compared with those from seven American subjects previously studied by Boynton and Olson. It is concluded, in full agreement with the original thesis of Berlin and Kay, that there are eleven basic color terms in each language, each of which describes a fundamental color sensation dependent upon an underlying physiology that does not differ between the two groups.

Color vision Color naming Basic color terms Categorical perception

INTRODUCTION

Using a color-naming method, Boynton and Olson (1987) confirmed the idea of eleven basic color terms, which had been originally proposed by Berlin and Kay (1969) to identify categorically-distinct color sensations. Three separate response measures were used by Boynton and Olson: *consistency* of naming within subjects, *consensus* between subjects, and *response time*. In addition to the eleven Berlin and Kay color terms, 22 other terms were employed by all subjects, whose responses were limited to single-words (monolexemic color naming). The results were clear-cut. Except for black, which is poorly represented among the OSA samples, all basic color terms showed greater consistency of use than any nonbasic ones. Full consensus was achieved only for color samples named with basic color terms, and response times were significantly shortest for samples named with consistently-used basic terms.

Because that experiment utilized color terms drawn only from the English language, we thought it of interest and importance to study the use of color terms in another language, and we decided to use Japanese subjects in order to compare their use of basic color terms with that of American subjects. Japanese has been categorized as one of the fully developed languages in the Berlin and Key study, with the eleven basic terms given as *shiro* (white), *kuro* (black), *aka* (red), *midori* (green), *ao* (blue), *ki* (yellow), *cha* (brown), *murasaki* (purple), *momo* (pink), *daidai* (orange), and *hai* (gray).† The aims of the research reported below were (a) to study how these basic color terms in Japanese would be characterized by our method, (b) to compare the usage of color terms between Japanese and Americans, and (c) to test the extent to which color perception, as identified by these basic color terms, is universal between subjects who use languages having very different origins.

METHODS

Procedure

The apparatus and experimental design used in this study were fully described by Boynton and Olson (1987). Here native Japanese subjects who were unaware of the purpose of the experiment responded with monolexemic color terms when presented with 424 samples of the OSA Uniform Color Scales set. The color samples, which subtended about 4° of visual angle, were

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†In Japanese, the suffix *iro* is often added to a color term; it has no particular significance. For example, *momo* and *momoiro* mean exactly the same thing. In this paper, Japanese color terms will be italicized and English color terms will not.

presented in a random order (which differed between subjects) and then the reverse of that order was used until each sample had been seen and named twice. The samples were illuminated indirectly by a photoflood lamp with a rated color temperature of 3200 K, and were seen against a gray background (OSA $L = -2$). Response times were measured, but speed of response was not stressed. All instructions were given in Japanese.

Subjects

Ten native Japanese subjects were employed in this study. All were fluent speakers of Japanese with limited knowledge of English. All had color vision falling within the normal range on the Farnsworth–Munsell 100-hue test. Table 1 shows the sex, age, and the Japanese prefecture of origin of these subjects. The youngest and oldest of the subjects are related to the first author. One of these (S.U.) is his 4-yr-old daughter; another (K.U.) is his father, age 68. All subjects, including these two, were naive as to the purpose of the experiment and were tested in La Jolla.

RESULTS AND DISCUSSION

The 10 subjects used 66 different color terms and the number used by individual subjects ranged from 12 to 50 (also shown in Table 1). In addition to the 11 basic colors terms, those used by more than 4 subjects are: *mizu* (water), *Kusa* (grass green), *hada* (skin color), *uquisu* (color of the Japanese bush warbler), *shu* (cinnebar), *oudo* (yellow soil), *azuki* (red bean), *sora* (sky), *yamabuki* (globeflower), *ai* (indigo), *kon* (dark blue), and two terms borrowed from English, *cream* and *beige*.

Table 1. Sex, age, Japanese prefecture of origin, and number of color terms used by the 10 subjects of the study

Subject	Sex	Age	N	Prefecture of origin
K.M.	F	39	50	Fukuoka
H.Y.	M	40	32	Shizuoka
T.I.	M	37	32	Tokyo
N.K.	M	31	30	Yamaguchi
K.H.	F	34	30	Iwate
Y.K.	F	31	24	Kanagawa
S.S.	M	28	22	Nagano
M.I.	M	39	16	Tokushima
K.U.	M	68	15	Gunma
S.U.	F	4	12	Kanagawa
Total			66	

N = number of different color terms used in this study.

Figure 1 shows the centroids of these color terms in the OSA color space, based on the means of the L, g and j values of color samples named with each term, weighted according to whether the name was used once or twice.

Bilingual problems

Subjects were not specifically instructed to use Japanese color terms—only monolexemic ones. Because the Japanese language is no longer free of influence from the English language, all subjects used some English color terms, especially pink, orange, and gray, which are now in common use in Japan. Original Japanese color terms that correspond to English ones, such as *momo* for pink, *daidai* for orange, and *hai* for gray, were also used, but not by all subjects. For example, to name samples in the orange region, three subjects used only *daidai*, two used only *orange*, and five used both terms indiscriminately, showing that there is a bilingual problem with the Japanese subjects, of a kind that does not occur for Americans, which complicates the definition of a basic color term. The question here is whether *daidai* and *orange*, for example, represent a single color or two different colors within and/or across subjects. If they mean the same thing, then it is reasonable to combine them into a single category.

An answer may be found by looking at the distribution of centroids in the OSA space of samples that are named with *daidai* and *orange*. If these distributions are not significantly different, then it is reasonable to conclude that the two terms represent a single color, and that, for further analysis, they should be combined into a single category. Using the mean data of the ten subjects, we chose two criteria for this assessment: (a) the distance between the two centroids, and (b) the number of samples that were named with both color terms. Table 2 shows the centroid locations of *daidai* and *orange*, *momo* and *pink*, and *hai* and *gray*, and the distances between them. All of these distances are very small, and obviously negligible compared to the standard deviations of the measurements. Table 3 shows the numbers of samples named with each of these color terms, and (within each category) the number of these that were also named with the other color term. For example, 90% of samples named *orange* were also called *daidai* and 68% of samples named *daidai* were also identified as *orange*. Samples called *momo* and *gray* are completely included within those named *pink* and *hai*

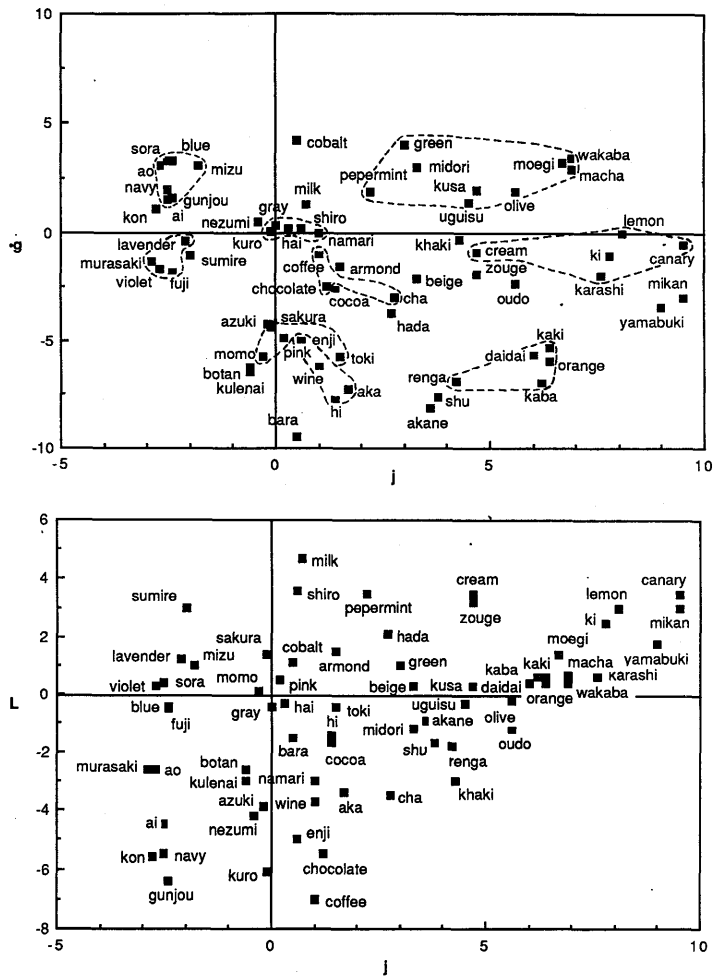

Fig. 1. *Top*: Centroid locations, with all subjects combined, of all colors named with the terms shown, calculated according to the mean of the j and g coordinates of all OSA sample colors named by a term, weighted according to the number of times the term was used. Dashed lines include color terms grouped according to the criteria of Table 6, except for the achromatic colors near the origin which have been included here as a single group. *Bottom*: The third dimension of centroid locations, showing the lightness dimension, L, plotted as a function of j. Dashed lines are not included here because of the confusion that would be caused by the extensive overlap between the locations of categories whose members have nearly equal j values.

Table 2. Centroid locations for three pairs of color terms, and the distances between members of each pair, which provide a basis for combining data within pairs. Data of all subjects are combined

	Centroids			Standard deviation		
Color term	L	j	g	L	j	g
daidai	0.4	6	−5.7	1.8	2	1.8
orange	0.4	6.4	−6	1.7	1.8	1.7
Component distances:	0	0.4	0.3	Total distance:	0.50	
momo	0.1	−0.3	−5.8	2	1.4	1.5
pink	0.5	0.2	−4.9	2.1	1.6	2.1
Component distances:	0.4	0.5	0.9	Total distance:	1.18	
hai	−0.3	0.3	0.2	2.3	1.4	0.8
gray	−0.4	0	0.4	2.1	1	0.6
Component distances:	0.1	0.3	0.2	Total distance:	0.39	

Table 3. For the same three pairs of color terms shown in Table 2, this table shows the total number of samples named with each term, the number of samples also named with the other color term, and the percentage of such overlapping samples. Data of all subjects are combined

Color term	N	N'	Percent overlap (%)
daidai	79	54	68
orange	60	54	90
momo	24	24	100
pink	92	24	26
hai	51	16	31
gray	16	16	100

N: number of samples named with a color term.
N': number of samples named with both color terms.
Percent overlap: $N'/N \times 100$.

respectively. It seems reasonable therefore to combine *daidai* with *orange*, *momo* with *pink*, and *hai* with *gray*, treating them as equivalent. We will use *DAIDAI*, *MOMO*, and *HAI* to represent these combined categories.

Consensus, consistency, and response time

Except for *mizu*, the only color terms used by all subjects were ten of the basic eleven of Berlin and Kay. *Kuro* (black), which is not well represented in the OSA set, was not used by one of the subjects.

In Table 4, percent consensus refers to the agreement achieved, with the data of all subjects combined, for the sample yielding the highest consensus of any of the subset of 424 samples that were called by that name. For example the value of 90 for *kuro* means that, of the 20 trials on which such an optimal sample was presented (2 for each subject), it was called *kuro* 18 times. (There could be one or more other samples named with equal consensus; the table does not reveal this information.) Five basic color terms, *shiro*, *midori*, *cha*, *murasaki*, and *HAI*, were used with 100% consensus, *MOMO* with 95%, *kuro*, *aka*, and *DAIDAI* with 90%, and *ki* and *ao*, 85%. Except for *mizu* and *hada*, no color sample was named with more than 60% consensus using a nonbasic color term. We have chosen to draw a line at 75% to separate and define consensus and nonconsensus groups. All eleven basic color terms are in the consensus group.

Percentage of response consistency is calculated by dividing the number of instances where a sample is named consistently by a subject (same name used on both occasions) by the total number of responses using a given color name. There is some overlap between this consistency measure for basic vs nonbasic color terms: *hada*, *mizu*, *beige*, and *ai* were used more consistently than some of the basic color terms.

All eleven basic color terms except *HAI* were used more quickly, on the average, than any of the nonbasic ones, although five nonbasic terms (*mizu*, *hada*, *kusa*, *cream*, and *shu*) were used almost as quickly as *MOMO*.

Table 5, which lists mean response times, shows that basic terms are used more quickly than nonbasic ones, and that the identification of color samples that are consistently named occurs more quickly than for those that are not. This pattern is very similar to that found for American subjects by Boynton and Olson, whose data are included in the table for comparison.

Table 4. For each of the basic and nonbasic color terms listed, with the data of all subjects combined, the first column shows the percentage agreement achieved for the sample yielding the greatest agreement for the use of that term. The next column shows the percentage of times that, when a name is used, the same name is used to name a sample on the other occasion that it was presented. The last column shows mean response time

Color terms	Consensus (%)	Consistency (%)	*RT* (sec)
Basic			
shiro (white)	100	65	1.90
kuro (black)	90	67	2.25
aka (red)	90	65	2.14
midori (green)	100	80	2.01
ki (yellow)	85	61	2.19
ao (blue)	85	62	2.18
cha (brown)	100	74	2.21
murasaki (purple)	100	81	2.00
MOMO (pink)	95	71	2.31
DAIDAI (orange)	90	68	2.26
HAI (gray)	100	73	2.51
Nonbasic			
mizu (water)	90	64	2.36
hada (skin)	80	67	2.35
kusa (grass green)	45	59	2.35
uguisu (Japanese bush warbler)	35	53	2.50
shu (cinnaber)	35	60	2.36
oudo (yellow soil)	60	54	2.54
azuki (red bean)	40	46	2.93
sora (sky)	40	44	2.44
yamabuki (globeflower)	45	49	2.52
ai (indigo)	45	62	2.64
kon (dark blue)	20	38	2.80
cream (cream)	45	58	2.33
beige (beige)	30	62	2.48

RT = mean response time.

Table 5. Mean response time data, with all subjects combined, divided according to consistency and consensus of use

Conditions	This study		Boynton and Olson	
	N	*RT* (sec)	*N*	*RT* (sec)
(1) Basic terms: consistent, consensus	120	1.68	1972	1.46
(2) Basic terms: consistent, no consensus	3684	2.02	2578	1.74
(3) Basic terms: inconsistent	1462	2.52	965	2.18
(4) Nonbasic terms: consistent, consensus	0		0	
(5) Nonbasic terms: consistent, no consensus	1800	2.34	276	2.19
(6) Nonbasic terms: inconsistent	1414	2.65	325	2.55

N = number of judgements.
RT = mean response time.

Is "mizu" *a basic color term?*

According to the results shown so far, *mizu* satisfies all criteria required for its categorization as a basic color term. As shown in Fig. 1, *mizu* represents light blue and *ao*, dark blue. *Mizu* was used by the ten subjects with 90% consensus at 64% consistency (both greater than for *ki* and *ao*) and with a shorter response time than *HAI*. However, of the 79 samples named *mizu*, 61 (77%) are also named *ao*. Among the eleven basic color terms, those most strongly linked in this way are *aka* and *MOMO*, where 60% of samples named *aka* were also named *MOMO*. Thus *mizu* is not used quite as independently as the basic color terms.

In English, blue covers a huge region in color space; perhaps not surprisingly, some languages develop another color term to describe just part of the blue region. Berlin and Kay (1969) reported that the Russian language has two basic color terms in the blue region: *goluboy* (light blue) and *siniy* (dark blue), but *siniy*, depending on context, had two meanings—either blue or dark blue. This usage is remarkably similar to the use of blues by Japanese, because, *ao* may be used also as a generic blue, whereas *mizu* is limited to light blue. Thus it is likely that *mizu* is a secondary term. In fact, as we will see, our Japanese subjects used six other color terms for blue.

Comparison between Japanese and American data

The Japanese results are not as clear-cut as the American. In the Boynton and Olson study, 100% consensus was reached for all 11 basic color terms and no others. Here, there are only five color terms that qualify as basic using the 100% consensus criterion, but if this is dropped to 75%, 13 color terms can be so classified. The criteria of consistency and response time also fail to separate basic and nonbasic color terms completely.

The Japanese subjects used 66 different monolexemic color terms, which is twice as many as were used by the American subjects. Therefore, it may be reasonable to suppose that the Japanese, or at least some of them, subdivide some large regions of color space that are named by the Americans with a single term, which would reduce consistency scores. The fact that the 4-yr-old subject used only one nonbasic term (*mizu*) suggests that whereas basic color terms are learned early, and are used by everyone, nonbasic terms are learned later.

Comparison of Japanese and American centroids

At the top of Fig. 1, in the upper-left region of the *g* vs *j* diagram, there is a cluster of symbols representing the centroids of color terms that might describe some kind of blue. At the bottom of the figure, it is seen that these colors vary much more along the lightness dimension than they do in their chromatic position. It seems likely to the first author that any Japanese native old enough to be familiar with these terms would agree that most of them belong to one generic category, the one called blue in English and for which *ao* is most suitable in Japanese. We sought an objective procedure according to which they could be classified. To do this, the use of secondary terms in relation to samples named with a basic term has been investigated by calculating the percentage of samples named with a given term that are also identified with the basic term on at least one occasion by one or more subjects ("percent overlap"). The overlap requirement selected was 75%. Another requirement for inclusion is that a term must reach the 75% criterion for only

Basic term	N_1	Nonbasic term	N_2	N_{12}	Percent overlap (%)
Included					
ao (blue)	87	*mizu*	79	61	77
		ai	38	32	84
		gunjou	5	5	100
		sora	49	39	80
		navy	2	2	100
		blue	25	23	92
midori (green)	132	*kusa*	109	99	91
		matcha	26	26	100
		uguisu	69	67	97
		moegi	23	23	100
		pepermint	12	11	92
		wakaba	8	8	100
		olive	13	13	100
		green	2	2	100
ki (yellow)	84	*lemon*	30	30	100
		karashi	13	12	92
		canary	2	2	100
		cream	43	37	86
DAIDAI (orange)	85	*kaki*	25	24	96
		kaba	5	5	100
		renga	37	31	84
aka (red)	50	*enji*	7	7	100
		hi	5	4	80
		ine	3	3	100
murasaki (purple)	77	*fuji*	68	60	88
		violet	18	16	89
		lavender	33	26	79
cha (brown)	67	*chocolate*	9	8	89
		coffee	1	1	100
MOMO (pink)	92	*toki*	24	24	100
		sakura	17	17	100
HAI (gray)	16	*namari*	2	2	100
kuro (black)	11	none			
shiro (white)	43	none			
Excluded					
ao (blue) *midori* (green)	87	*cobalt*	34	28	82
	132	*cobalt*	34	26	77
ki (yellow)	84	*yamabuki*	26	24	92
		mikan	7	7	100
DAIDAI (orange)	85	*yamabuki*	26	21	81
		mikan	7	6	86
DAIDAI (orange) *aka* (red)	85	*akane*	9	8	89
	50	*akane*	9	7	78
aka (red)	50	*kulenai*	16	14	88
		bara	2	2	100
		botan	5	4	80
MOMO (pink)	92	*kulenai*	16	12	75
		bara	2	2	100
		botan	5	5	100
MOMO (pink) *murasaki* (purple)	92	*sumire*	2	2	100
	77	*sumire*	2	2	100

Table 6. Grouping of nonbasic terms into categories headed by basic terms, according to a 75% overlap criterion. For example, 87 samples (N_1) were called *ao* at least once by at least one subject. Samples were called *mizu* at least once 79 (N_2) times, and on 61 of these occasions (N_{12}, 77%) it was used to identify a sample that was called *ao* on at least one other presentation. Sample that overlapped more than 75% with two basic color terms are excluded

one basic color category. Table 6 shows, at the top, six terms finally grouped with *ao*, as well as terms included in the other basic categories. At the bottom of Table 6, the eight terms excluded because they reached the 75% criterion for two categories are listed, together with supporting data. These are: (a) a blue-green, *cobalt*, excluded from *midori* and *ao*; (*b*) two orange-yellows (*yamabuki* and *mikan*), excluded from *ki* and *DAIDAI*; (c) an orange-red, *akana*, excluded from *DAIDAI* and *aka*; (d) three pink-reds (*kulenai*, *bara* and *botan*), excluded from *MOMO* and *aka*; (e) a pinkish-purple, *sumire*, excluded from *murasaki* and *MOMO*.

After the application of these criteria, there remain 9 greens, 7 blues, 5 yellows, 4 oranges, 4 reds, 4 purples, 3 pinks, 3 browns, 2 grays, 1 black, and 1 white.

Centroids were then recalculated after replacing all responses within each category, where one of the listed nonbasic terms was used, by the appropriate generic term. These centroids are plotted in Fig. 2, along with those for the American subjects of the Boynton and Olson study. The agreement is very good, better in fact (probably because of the larger N) than that among individual subjects within either language group.

In Table 7, the ratio of consistent to inconsistent responses for the Japanese subjects is shown for the basic term before and after combining it with other terms in each category. Also shown is the ratio for American subjects from Boynton and Olson. It will be seen that the combining procedure has brought the two sets of data much more nearly into agreement according to the consistency ratio criterion.

Comparison of color-term usage between language groups

The OSA color space, which is designed to be isotropic with respect to color differences, divides very unevenly into the eleven categories of basic colors. Figure 3 shows a plot of the average number of times color terms were used consistently by American subjects, represented on the ordinate, vs the corresponding number

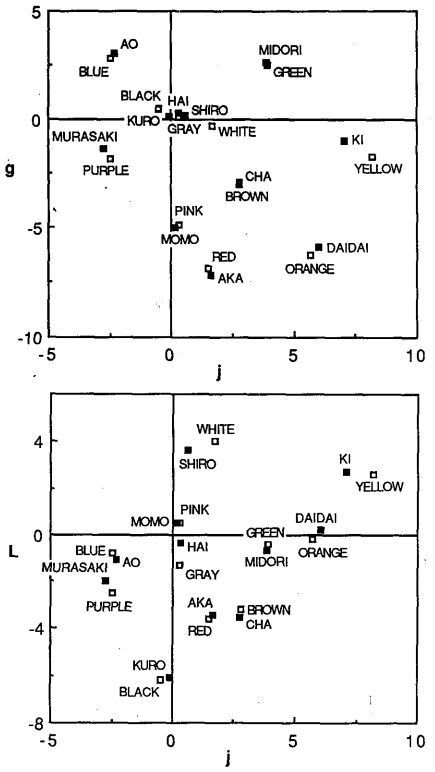

Fig. 2. Centroid location of basic colors after being grouped according to the criteria of Table 6, compared with those of basic colors from the study of English-spreaking subjects by Boynton and Olson. The top and bottom parts of the figure are as in Fig. 1.

for the Japanese subjects, represented on the abscissa. In this plot categories have been combined for the Japanese as just discussed, and the close agreement between the two groups serves further to validate the combining operation.

Table 7. Ratio of consistent to inconsistent response usage for each of the basic color terms. Data for the Japanese subjects of this study are shown at the left, both before and after nonbasic terms were combined into categories as shown in Table 6. The data at the right are from the study of Boynton and Olson using American, English-speaking subjects

Japanese term	Japanese ratio		English term	English ratio
	Uncombined	Combined		
midori	3.99	8.76	green	9.23
ao	1.60	7.27	blue	8.73
murasaki	4.20	5.27	purple	4.12
ki	1.58	2.42	yellow	3.58
DAIDAI	2.12	2.33	orange	3.55
cha	2.88	3.03	brown	2.98
MOMO	2.44	2.80	pink	2.75
aka	1.82	1.92	red	2.54
kuro	2.00	2.00	black	2.00
shiro	1.87	1.87	white	1.90
HAI	2.65	2.78	gray	1.88

Linking

Boynton and Olson defined "linking" to occur between two colors if there was any color sample in the set that was inconsistently labeled with the names of those colors by at least half the subjects. They found, with three exceptions, that colors separated by more than 7.5 OSA units were unlinked, whereas those separated by less than 7.5 OSA units were linked.

Table 8 shows the matrix of inconsistent pairing in the present experiment. It also gives the number of subjects who named each pair inconsistently (that is, with both terms), and the distance in OSA units between the centroid locations of the color pairs. For the Japanese subjects, with one exception, all colors more than 8 units apart are unlinked and, with two exceptions, all colors less than 6 units apart are linked. The "7.5-unit rule" applies in 84% of the cases, as follows:

With the rule:	>7.5, unlinked:	29
	<7.5, linked:	17
Against the rule:	>7.5, linked:	2
	<7.5, unlinked:	7

Boynton and Olson found only three, rather than nine, exceptions to the rule. All three of these exceptions are contained within the Japanese nine: Brown and yellow plot 9.9 units apart for the Americans; *cha* and *ki* are 10 units apart for the Japanese. In both cases these colors are nevertheless linked. The unlinked colors pink and gray plot 5.7 units apart for the Americans; *MOMO* and *HAI*, also unlinked, are 5.4 units apart for the Japanese. Green and brown are 6.8 units apart, *midori* and *cha*, 7.0

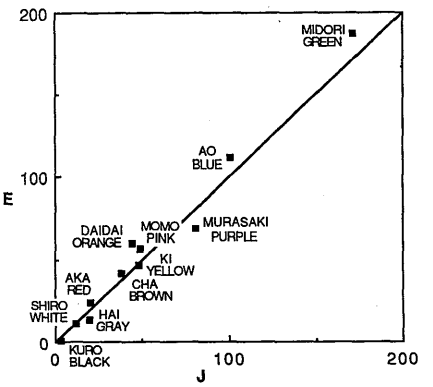

Fig. 3. Frequency of usage of color terms, after being grouped according to the criteria of Table 6, compared with the frequency of usage of color terms of English-speaking subjects by Boynton and Olson.

Table 8. Pairing of basic color term usage, after the combining of nonbasic color terms as shown in Table 6. For inconsistent pairing, the number in parentheses shows the number of subjects who named at least one color sample using both terms. The number below shows the distance between the two color centroids in OSA units. For example, *aka* was used consistently 198 times, and was paired with *cha* 13 times, but only by 6 of 10 subjects. The OSA distance between *aka* and *cha* is 4.4 OSA units

	aka	*midori*	*ao*	*ki*	*shiro*	*kuro*	*murasaki*	*cha*	*MOMO*	*DAIDAI*	*HAI*
aka	198 0	0 (0) 10.8	0 (0) 11.5	1 (1) 12.0	0 (0) 12.4	0 (0) 8.4	8 (4) 7.5	13 (6) 4.4	28 (9) 6.1	16 (7) 6.9	0 (0) 8.8
midori		1708 0	58 (10) 6.2	77 (10) 6.8	6 (3) 7.3	5 (3) 9.0	3 (1) 8.0	4 (4) 7.0	0 (0) 8.7	0 (0) 8.9	16 (7) 4.3
ao			1010 0	0 (0) 11.5	11 (6) 7.8	4 (4) 8.0	25 (10) 4.6	0 (0) 8.6	0 (0) 8.7	0 (0) 12.4	12 (7) 3.9
ki				484 0	11 (5) 6.7	0 (0) 14.4	0 (0) 11.8	10 (5) 10.0	2 (2) 8.6	31 (7) 6.2	3 (1) 8.1
shiro					116 0	0 (0) 13.7	6 (4) 8.7	0 (0) 10.8	6 (5) 6.9	2 (1) 9.5	14 (9) 5.6
kuro						32 0	4 (3) 6.6	2 (2) 5.6	0 (0) 10.6	0 (0) 12.4	0 (0) 8.2
murasaki							812 0	4 (3) 6.2	45 (10) 5.8	1 (1) 10.4	9 (5) 4.2
cha								382 0	1 (1) 6.6	26 (10) 6.8	6 (5) 6.2
MOMO									492 0	20 (7) 5.9	1 (1) 5.4
DAIDAI										436 0	0 (0) 8.5
HAI											192 0

$N(n)$: N = number of inconsistent pairings, n = number of subjects who named each pair inconsistently; D = distance in OSA units.

units—unlinked in both cases. Table 8 shows that all of the unlinked color pairs less than 7.5 units apart were used inconsistently by at least one subject, and that four unlinked color pairs were linked by at least three subjects, just missing the criterion. Overall, then, the linkage relations between the two groups of subjects are quite similar.

SUMMARY

The Japanese and English languages have very different origins and of course they use very different sounds, as well as symbols of entirely different structures, to represent colors. It is not surprising, therefore, that two complications arose in the search for similarities between the data of ten Japanese subjects of this study, and those of seven American subjects previously studied by Boynton and Olson. One of these concerns the borrowing by the Japanese of three English terms (pink, orange, and gray) which are now often used instead of *momo*, *daidai*, and *hai*. A centroid analysis showed the borrowed terms to be almost exactly equivalent to their Japanese counterparts, and so the two categories were combined for further analysis. The second problem arose because the Japanese tend to use several terms to describe nuances of differences within a single category, particularly variations in lightness. Doing so reduces both the consistency of color-term usage within subjects and the consensus of color naming between them. Criteria were developed to provide an objective basis for combining data within each category. Doing so brought the Japanese data into line with those of the American subjects according to a variety of dependent measures. We interpret the results to imply a strong physiological basis for color sensation, one that is little influenced by genetic or cultural differences between Americans and Japanese. Using our methodology, the eleven categories elucidated by Berlin and Kay were clearly evident in the earlier study of American subjects, but because of cultural differences, as reflected in the language and cognitive style, a more detailed analysis was required to find them in the Japanese data. There was an exception to this, the 4-yr-old Japanese subject who used only one other word (*mizu*) besides the eleven generic basic color terms. Perhaps culture has not yet had an opportunity to complicate the linguistic expression of her eleven categorically-distinct color sensations.

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