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Research report

Color classification by chimpanzees (*Pan troglodytes*) in a matching-to-sample task

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Abstract

We investigated chimpanzees' color classification using a matching-to-sample procedure. One of the two subjects had learned symbolic color names through long-term training, while the other had received less training and had a limited understanding of color names. The results showed similar distributions of classified colors in a color space, irrespective of the subjects' differential color-naming experience. However, the chimpanzee with little color-naming experience showed less stable classifications. These results suggest common features of color classification in chimpanzees, as well as the influence of color experience and/or the learning of color names on the stability of classification of colors.

Keywords: Color classification; Matching-to-sample task; Color name; Chimpanzee

1. Introduction

It is thought that chimpanzees (*Pan troglodytes*), our closest evolutionary relatives, have much in common with humans in terms of color perception [8–10], based on the shared biological foundations [5,6]. Behavioral studies of color classification by chimpanzees, however, have not been conducted so much. A few studies demonstrated that chimpanzees could classify colors in a manner similar to humans [7,12], suggesting their ability to perceive colors categorically as humans do. In those studies, chimpanzees who showed "categorical" color perception had been trained from an early stage of life on a number of tasks involving language-like skills with geometric figures as symbols representing, among other things, color names.

In the present study, we investigated color classification of two chimpanzees, one of whom had acquired symbolic color names while the other had not, under identical experimental conditions. We adopted the color matching method to carry out a direct comparison of color classification by two chimpanzees without the influence of task performance. Through such a "non-linguistic" test, we attempt to expand further our understanding of the nature of chimpanzee color perception, and to discuss the influence of the experience and/or the learning of color names on the performance of color classification. We also discuss the possibility that extensive experience with colors can refine "categorical" color perception in chimpanzees.

2. Materials and methods

2.1. Subjects

Two 23-year-old female chimpanzees, named Ai and Pendesa, participated in the experiment. Ai's training in the use of symbols (e.g. color and object names) and of a computer-controlled apparatus began at the age of 2 years [1,12]. At the time of the present study, Ai had already learned two kinds of symbolic color name: complex geometric figures called "lexigrams", and Chinese characters (Kanji characters). She had received extensive training and maintained her performance in symbolic matching-to-sample tasks (color-to-symbol and symbol-to-color) at over 95% correctness [11,15]. She had also shown that her color classification was similar to humans' in a color-naming test

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using lexigrams and Munsell color chips [12]. In contrast, Pendesa's training in a symbolic matching-to-sample task using color symbols began at 21 years of age. Previously, she had already learned a matching-to-sample task on the basis of identity of form and color in which she performed as well as Ai, however, her performance in the symbolic task was not as accurate as Ai's [14]. Moreover, her training in the symbolic matching-to-sample task was limited to the combinations of only three colors. In fact, a sample of red color was tested exclusively with red, green, and yellow symbols as alternatives, and never any of the other color symbols. The training of the blue–brown–pink and gray–orange–purple combinations was conducted in the same way. In addition, she had no experience of using color symbols in situations other than the matching-to-sample task with two alternatives, while Ai used color symbols in other contexts, such as the naming of the colors of real-life objects and the symbolic matching-to-sample of symbols (i.e. matching Chinese characters to lexigrams and vice versa) [11].

The subjects lived with 12 other chimpanzees in an outdoor compound and attached indoor residences. They were not deprived of food at any time during the present study. Care and use of the chimpanzees adhered to *The Guide for the Care and Use of Laboratory Primate* (1986) of the Primate Research Institute, Kyoto University.

2.2. Apparatus

Subjects were tested in an experimental booth (approximately 1.8 m × 1.8 m × 2.0 m) with acrylic panels as walls on all four sides. A 21-in. color CRT monitor (NEC PC-KH2021), equipped with a touch-sensitive panel (Microtouch SMT2), was embedded in one wall of the booth. This monitor system served not only as the output device for stimulus presentations, but also as the input device for the subjects' response with accurate information on touch locations. A universal feeder (Biomedica, BUF-310) delivered small pieces of food reward (apples or raisins) into a food tray below the monitor. A computer (NEC PC-9821Xn) served to control the stimulus color generation varying the output level of green, red, and blue phosphors on the CRT monitor in 16 gradations each. Experimental events, including the recording of response time, were also controlled by this computer.

2.3. Stimuli

Total of 134 distinct colors were used in the present study. All the stimuli were presented as colored squares (5.2 cm × 5.2 cm) against a black background (approximately 0 cd/m^2) of the CRT monitor. Ten colors (Table 1) were selected as "standard colors", which were used as representatives of each color group, much like color terms in color-naming tasks (e.g. refs. [4,12]). The standard colors were generated using the same output level as the colors which were stably matched to symbols corresponding to red, orange, yellow, green, blue, purple, pink, brown, white, and gray in the symbolic matching-to-sample tasks continuously given to both subjects prior to this study (cf. [14]). The remaining 124 colors (hereafter referred to as "test colors") were selected from throughout the available range of CRT colors (Fig. 1, see also Table A.1 in Appendix A). CIE 1931 *xy*-chromaticity coordinates and luminances of the stimuli were measured by a colorimeter (Minolta, CS-100).

Table 1
The CIE 1931 *xy*-chromaticity coordinates and luminances (Y) of the standard colors with corresponding color names

Color name	x	y	Y (cd/m^2)
Red	0.529	0.392	24.9
Orange	0.483	0.437	34.3
Yellow	0.395	0.524	65.9
Green	0.305	0.581	58.4
Blue	0.188	0.171	17.4
Purple	0.215	0.177	20.0
Pink	0.355	0.328	43.4
Brown	0.412	0.427	13.8
White	0.307	0.373	78.2
Gray	0.314	0.384	31.2

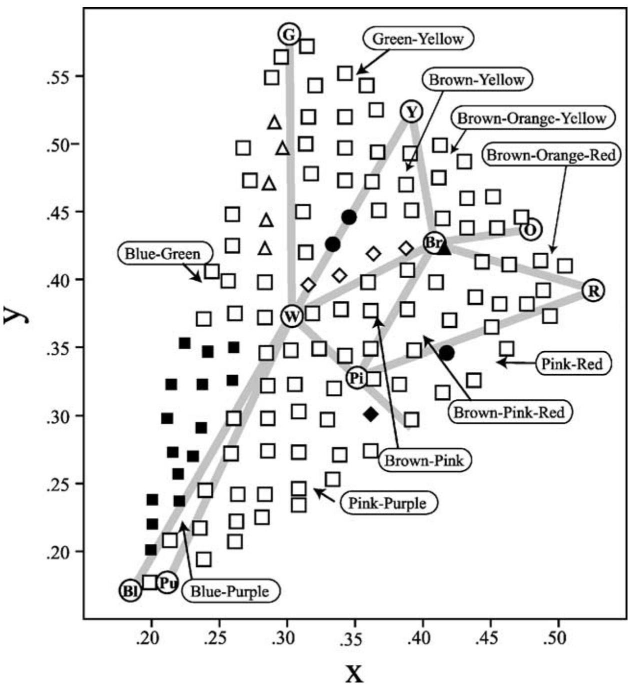

Fig. 1. CIE 1931 *xy*-chromaticity coordinates of stimuli, divided according to the pairs or triplets of comparisons (standard colors) tested. Open circles show the standard colors; Bl: blue, Br: brown, G: green, O: orange, Pi: pink, Pu: purple, R: red, Y: yellow. The test colors shown by open squares were tested against the standard colors indicated by confines with arrows and hyphenated color names. The test colors shown by other symbols additionally included the following standard colors as candidates for comparison; brown (filled circle), orange (filled triangle), pink (open lozenges), purple (filled squares), red (filled lozenge), yellow (open triangles).

2.4. Procedure

In the first training phase, a delayed matching-to-sample task with two alternatives was given to the subjects. In this task, the sample and comparison stimuli were selected from among the 10 standard colors. Each trial was initiated by the subjects' touch to a warning stimulus (an empty white circle of 15 mm in diameter) located at the bottom of the screen, followed by the presentation of a sample color stimulus in one of three positions along the bottom of the screen. The subjects were required to touch the stimulus three times. After each touch, the stimulus was relocated to one of the other two positions along the bottom of the screen. Once three touches to the sample had been recorded, the display was cleared and two alternatives appeared (0-s delay) near the center of the screen. The position of the third sample relocation was controlled so as to equalize the distance to the two alternatives. Alternatives were separated from each other by approximately 12 cm (center-to-center). When subjects touched the correct comparison (the same color as the sample), a chime sounded and a food reward was delivered. The choice of the incorrect comparison was followed by a buzzer sound and a 5-s time-out. The time interval between the last touch to the sample and the touch to the comparison was recorded as the response time. The position of the correct comparison was counterbalanced. A session consisted of 90 trials and all possible combinations of correct and incorrect comparisons among the 10 standard colors were tested in the session. Ai participated in 14 sessions of training phase, and Pendesa in 34 sessions. The difference in the number of training sessions was not due to the chimpanzees' performance, but the schedule of other experiments in which the subjects were participating.

In the test phase, a session consisted of 90 baseline trials, which were the same as those in the training phase, and 12 probe trials in which the responses were never reinforced. Two of the probe trials were baseline probe trials, in which color stimuli from baseline trials (standard colors) were presented without any feedback (i.e. no chime or reinforcement). These baseline probe trials served to prevent the subjects' developing an expectation that only probe trials were associated with a lack of food reward. In the other 10 test probe trials, the sample was selected from among the 124 test colors and the subjects were required to match either of two comparisons of standard colors to the test color. Eight of the standard colors all except the achromatic gray and white were used as comparisons for test probe trials. Fig. 1 shows the pairs of sample and comparison colors (see also Table A.1 in Appendix A). In the present experiment, we only tested pairs of test and standard colors adjacent on the CIE 1931 *xy*-coordinate plane. For example, test colors between the standard yellow and orange on the plane were paired with any two comparisons of the standard yellow, orange, and brown. Each pair was tested twice, counterbalanced across the left–right position. These probe trials were randomly intermixed with 90 baseline trials. Both subjects were given 41 sessions in the test phase.

2.5. Data analysis

Boynton and Olson [4] used the following three measures to confirm the salience of basic color terms in humans: consistency, consensus, and response time. In their study, high consistency, high consensus, and shorter response times characterized the use of basic color terms. We applied the same measures to analyze the results of the test probe trials. In the present study, consistent response to a test color was defined as matches to a certain standard color rather than any of the other comparisons at every encounter. Consensus refers to between-subject agreement in the consistent match of a standard color, expressed as the numbers of test colors to which both subjects consistently responded with the same standard color. Response times of consistent and inconsistent responses were compared to examine the stability of color classification in each subject.

3. Results

From the beginning of the training, both subjects showed very accurate performances (mean correct = Ai: 96.9%, Pendesa: 98.6%). Their performances in baseline trials in the test phase were also highly accurate (97.9% for Ai and 99.5% for Pendesa).

3.1. Consistency

Fig. 2 shows response consistency for each subject. In the figures, coordinates of test colors with consistent responses are plotted using the initial letters of the standard color to which they were matched, while the remaining test colors are represented by plus signs. The distributions of the consistently matched colors on the chromaticity diagrams are similar between the two subjects, showing some spatial clusters around the standard colors. On the other hand, some distinct differences are also evident in the two subjects' classifications. For example, Ai made consistent matches using every standard color, while Pendesa scarcely showed consistent responses with standard blue and brown. Overall consistency was significantly higher in Ai, who showed consistent responses to 81 colors (65% of the test colors), while Pendesa responded consistently to only 56 test colors (45%) ($\chi^2(1, N = 248) = 9.39$, $P < 0.01$).

3.2. Consensus

Consensus between subjects is shown in Table 2. This table also contains the number of sample colors tested, the numbers of test colors matched consistently to a standard color by each subject, and the expected values of consensus.

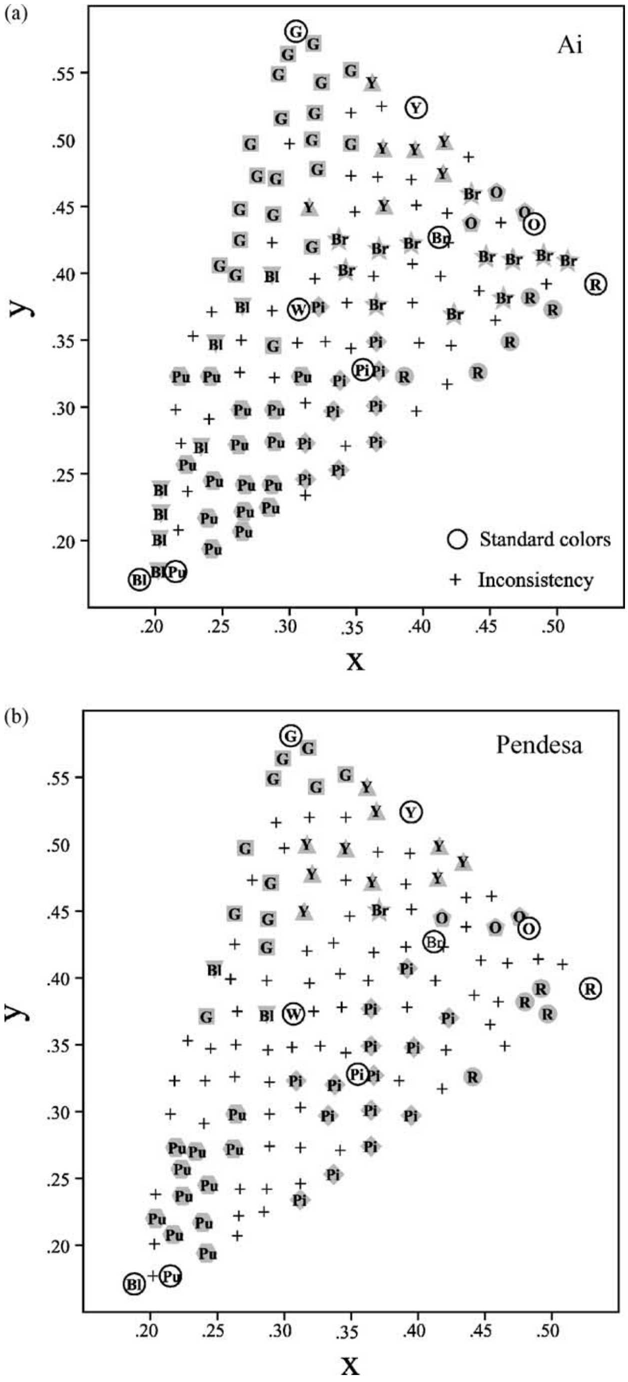

Fig. 2. The test colors plotted on *xy*-chromaticity diagrams, showing the consistently chosen standard colors, and centroids of the test colors consistently responded to. Bl: blue, Br: brown, G: green, O: orange, Pi: pink, Pu: purple, R: red, Y: yellow. (a) Test colors consistently and inconsistently responded to by subject Ai. (b) Test colors consistently and inconsistently responded to by subject Pendesa.

The subjects showed relatively high consensus in their consistent responses to standard green, pink, red, and yellow. In contrast, the consistent responses to standard blue and brown were not shared. This dissensus on blue and brown was mainly derived from low consistency in Pendesa.

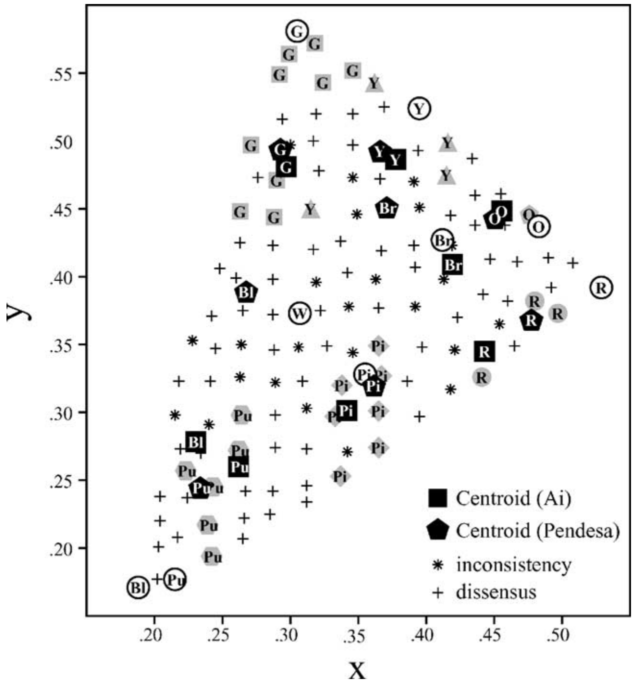

Fig. 3. Consensus between subjects and centroids (white letters). Black letters show the test colors to which both subjects consistently responded with the same standard color. Asterisk means inconsistent responses by both subjects. Plus signs indicate other patterns of responses.

The locations of centroids for each color are also shown in the CIE 1931 *xy*-coordinate diagram (Fig. 3). The centroid for a standard color was calculated by averaging the coordinates of all the test colors to which each subject responded consistently with the standard color. Corresponding centroids were adjacent to each other, except for blue and brown, which had no consensus between subjects. This suggests that the color classifications of the two subjects were similar to each other in the terms of color selection despite differences in overall consistency and the relatively low consensus on consistent responses.

3.3. Response time

Response time has been used as an indicator of the categorical change of the perceived color in some color classification tasks in humans (e.g. ref. [4]) and a chimpanzee [12]. This measure would be expected to vary depending on how easily subjects can classify the color, in other words, it would reflect how confident subjects are of their own classifications. The response times of consistent responses (average ± S.D.: 583 ± 118 ms) were significantly shorter than those of inconsistent responses (682 ± 181 ms) in subject Ai (Mann–Whitney *U*-test; $N = 124$ ($n_1 = 81$, $n_2 = 43$), $z = 3.34$, $P < 0.01$). In contrast, such a tendency did not appear in Pendesa (consistent 544 ± 69 ms, inconsistent 573 ± 164 ms, Mann–Whitney *U*-test; $N = 124$ ($n_1 = 56$, $n_2 = 68$), $z = 0.37$, $P > 0.10$).

Table 2
Numbers of test colors used as samples against each of the standard colors (comparisons), numbers of test colors consistently responded to, and consensus between subjects for consistent responses

Standard color	Tested colors	Consistent responses		Obtained consensus	Expected consensus	*P*
		Ai	Pendesa			
Blue	38	8	2	0	0.4	1.00
Brown	41	12	1	0	0.3	1.00
Orange	13	3	3	1	0.7	0.58
Purple	45	16	11	6	3.9	0.13
Yellow	39	7	10	4	1.8	0.06
Red	23	5	4	3	0.9	0.02
Pink	52	10	14	7	2.7	0.00
Green	50	20	11	9	4.4	0.00
Total		81	56	30		

Consensus means the number of test colors to which both chimpanzees responded consistently. Expected consensus was calculated from the values for tested colors (T) and consistent responses (Ai (A) and Pendesa (Pe)): T(A/T)(Pe/T). The *P* value refers to the probability of observing a consensus larger than or equal to the obtained value with random color combinations of consistent responses by Ai and Pendesa.

4. Discussion

The present study manifested the similarity and dissimilarity of the color classification between two chimpanzees. One chimpanzee (Ai) had been trained on language-like skills, including the use of symbols corresponding to colors for many years since the age of 2, while the other chimpanzee (Pendesa) was trained to use the same symbols in the same manner at the age of 21 years, although she did not achieve as accurate a performance as Ai.

The distribution of classified colors and centroids obtained in the CIE 1931 *xy*-chromaticity diagram (Figs. 2 and 3) suggests that the subjects perceive and group colors in a similar way. On the other hand, the stability of such color grouping, or color "categorization", differed between the two subjects. In contrast to Ai, Pendesa showed low consistency and indistinctive response times for consistent and inconsistent responses, despite high level of accuracy in the performance of color matching at baseline trials in common with Ai. Distinctive consistent and inconsistent response times in Ai suggest that she perceived colors with a clearer distinction of being inside or outside of a color group and hesitated in the responses to colors located on the borders of color groups. Pendesa may not have had such clear distinctions resulting in no hesitation to respond to these colors.

Disagreement of consistent responses, caused mainly by low consistency in Pendesa (Table 2), suggests that some of the arbitrarily selected standard colors did not represent well the perceived groups of colors. This is reminiscent of the fact that people of certain cultures use less than 10 basic color terms [2]. For example, standard blue and purple would be included in one group in the perception of Pendesa. A further analogy with the human study is that human subjects rarely used the color term "brown" to label colors in color-naming tests when the stimuli were presented as aperture-colors by light sources (e.g. colors with a black background on CRT monitors), which suggests that the perceptual brown category disappeared in this condition [16]. As is the case with humans, Pendesa would classify the colors to which Ai matched the standard brown comparison as border colors of the adjacent red, orange, or yellow color categories. In other words, these findings suggest the possibility that Ai generalizes the symbolic brown representation to "no-brown" colors as a result of intensive symbolic color training using a CRT monitor. Given the enormous difference of the subjects' experiences in life, we can infer that these results derive from differential amounts of discriminative learning of colors and/or experiences during acquisition training of color names. This also implies the possibility of refinement of color perception or distortion of the perceived color "categories" depending on the color experiences of the chimpanzees. Studies on human color categories have revealed that prior to language acquisition infants categorically perceive hues in much the same way as adults do [3], and that boundaries of basic color categories are not stable in young children compared with adults [13]. Similar developmental and/or learning processes may be reflected in the similarities and differences of the "categorical" color perception of the two subjects in the present experiment.

In sum, these results suggest that chimpanzees skilled and unskilled in the use of color names perceive similar color groupings despite differences in the stability of their color classification. In turn, this implies that experiences of color discrimination and/or color-naming training have an influence on "categorical" color perception in chimpanzees. Furthermore, such perception of color "category" and its development may be shared by humans and chimpanzees.

In the future, with this type of non-linguistic color classification task, we would be able to conduct comparative studies on color classification not only by chimpanzees, but also humans of different cultures and languages, immature infants, or non-hominoid animals, such as monkeys, under exactly identical conditions. Through such comparative studies, we would be able to further explore categorical color perception and its phylogeny.

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Appendix A

Table A.1
CIE 1931 *xy*-chromaticity coordinates and luminances (Y) of the test colors, standard colors used as comparisons, and consistently chosen colors

Number	x	y	Y (cd/m^2)	Comparison	Consistency	
					Ai	Pendesa
1	0.202	0.177	19.6	Bl, Pu	Bl	–
2	0.203	0.201	16.5	Bl, G, Pu	Bl	–
3	0.204	0.220	13.4	Bl, G, Pu	Bl	Pu
4	0.204	0.238	29.1	Bl, G, Pu	Bl	–
5	0.215	0.298	29.8	Bl, G, Pu	–	–
6	0.217	0.208	16.6	Bl, Pu	–	Pu
7	0.218	0.323	50.4	Bl, G, Pu	Pu	–
8	0.219	0.273	26.9	Bl, G, Pu	–	Pu
9	0.223	0.257	18.6	Bl, G, Pu	Pu	Pu
10	0.224	0.237	20.3	Bl, G, Pu	–	Pu
11	0.228	0.353	52.5	Bl, G, Pu	–	–
12	0.234	0.270	18.2	Bl, G, Pu	Bl	Pu
13	0.239	0.217	18.2	Pi, Pu	Pu	Pu
14	0.240	0.291	17.4	Bl, G, Pu	–	–
15	0.241	0.323	25.5	Bl, G, Pu	Pu	–
16	0.242	0.194	19.2	Pi, Pu	Pu	Pu
17	0.242	0.371	27.7	Bl, G	–	G
18	0.243	0.245	21.9	Bl, Pu	Pu	Pu
19	0.245	0.347	28.5	Bl, G, Pu	Bl	–
20	0.248	0.406	35.8	Bl, G	G	Bl
21	0.260	0.399	45.3	Bl, G	G	–
22	0.262	0.272	20.9	Bl, Pu	Pu	Pu
23	0.263	0.326	16.4	Bl, G, Pu	–	–
24	0.263	0.425	53.8	Bl, G	G	–
25	0.263	0.448	35.1	Bl, G	G	G
26	0.264	0.298	25.9	Bl, Pu	Pu	Pu
27	0.264	0.350	43.2	Bl, G, Pu	–	–
28	0.265	0.207	21.5	Pi, Pu	Pu	–
29	0.265	0.375	37.5	Bl, G	Bl	–
30	0.266	0.222	23.2	Pi, Pu	Pu	–
31	0.267	0.242	27.0	Pi, Pu	Pu	–
32	0.271	0.497	53.7	Bl, G	G	G
33	0.276	0.473	44.1	Bl, G	G	–
34	0.285	0.225	20.6	Pi, Pu	Pu	–
35	0.287	0.242	22.1	Pi, Pu	Pu	–
36	0.287	0.372	40.7	Bl, G	–	Bl
37	0.287	0.398	47.9	Bl, G	Bl	–
38	0.287	0.423	55.5	Bl, G, Y	–	G
39	0.288	0.346	52.3	Bl, G	G	–
40	0.288	0.444	35.8	Bl, G, Y	G	G
41	0.289	0.274	33.9	Pi, Pu	Pu	–

Table A.1 (*Continued*)

Number	x	y	Y (cd/m^2)	Comparison	Consistency	
					Ai	Pendesa
42	0.289	0.298	38.5	Pi, Pu	Pu	–
43	0.289	0.322	44.7	Pi, Pu	–	–
44	0.290	0.471	48.7	Bl, G, Y	G	G
45	0.292	0.549	42.4	Bl, G	G	G
46	0.294	0.516	57.3	Bl, G, Y	G	–
47	0.299	0.564	56.9	Bl, G	G	G
48	0.300	0.497	63.5	Bl, G, Y	–	–
49	0.306	0.348	44.0	Pi, Pu	–	–
50	0.309	0.323	57.4	Pi, Pu	Pu	Pi
51	0.312	0.234	26.3	Pi, Pu	–	Pi
52	0.312	0.246	28.0	Pi, Pu	Pi	–
53	0.312	0.273	42.2	Pi, Pu	Pi	–
54	0.312	0.303	15.0	Pi, Pu	–	–
55	0.315	0.450	57.0	G, Y	Y	Y
56	0.317	0.420	58.5	G, Y	G	–
57	0.317	0.500	44.7	G, Y	G	Y
58	0.318	0.572	51.1	G, Y	G	G
59	0.319	0.396	58.8	G, Pi, Y	–	–
60	0.319	0.520	38.2	G, Y	G	–
61	0.321	0.478	36.8	G, Y	G	Y
62	0.322	0.375	51.7	Br, Pi	Pi	–
63	0.324	0.543	52.3	G, Y	G	G
64	0.327	0.349	37.3	Pi, Pu	–	–
65	0.333	0.297	28.2	Pi, Pu	Pi	Pi
66	0.337	0.253	25.0	Pi, Pu	Pi	Pi
67	0.337	0.426	50.3	Br, G, Y	Br	–
68	0.338	0.320	33.7	Pi, Pu	Pi	Pi
69	0.342	0.271	17.9	Pi, Pu	–	–
70	0.342	0.403	43.4	Br, Pi, Y	Br	–
71	0.343	0.378	45.0	Br, Pi	–	–
72	0.346	0.344	14.2	Br, Pi	–	–
73	0.346	0.473	57.7	G, Y	–	–
74	0.346	0.497	67.3	G, Y	G	Y
75	0.346	0.520	46.0	G, Y	–	–
76	0.346	0.552	54.0	G, Y	G	G
77	0.349	0.446	31.6	Br, G, Y	–	–
78	0.362	0.543	55.2	G, Y	Y	Y
79	0.363	0.398	40.7	Br, Pi	–	–
80	0.365	0.274	24.6	Pi, Pu	Pi	Pi
81	0.365	0.301	23.5	Pi, Pu, R	Pi	Pi
82	0.365	0.349	23.1	Br, Pi	Pi	Pi
83	0.365	0.377	45.1	Br, Pi	Br	Pi
84	0.366	0.472	39.1	Br, Y	–	Y
85	0.367	0.327	39.7	Pi, R	Pi	Pi
86	0.367	0.419	41.6	Br, Pi, Y	Br	–
87	0.369	0.525	36.9	G, Y	–	Y
88	0.370	0.494	65.7	G, Y	Y	–
89	0.371	0.451	51.4	Br, Y	Y	Br
90	0.386	0.323	13.8	Pi, R	R	–
91	0.391	0.423	40.3	Br, Pi, Y	Br	–
92	0.391	0.470	32.6	Br, Y	–	–

Table A.1 (*Continued*)

Number	x	y	Y (cd/m^2)	Comparison	Consistency	
					Ai	Pendesa
93	0.392	0.378	13.9	Br, Pi, R	–	–
94	0.392	0.407	38.4	Br, Pi	–	Pi
95	0.394	0.493	26.9	Br, Y	Y	–
96	0.395	0.297	23.8	Pi, R	–	Pi
97	0.395	0.451	56.5	Br, Y	–	–
98	0.397	0.348	26.8	Br, Pi, R	–	Pi
99	0.413	0.398	27.6	Br, Pi, R	–	–
100	0.415	0.475	43.5	Br, O, Y	Y	Y
101	0.416	0.499	45.4	Br, O, Y	Y	Y
102	0.418	0.317	21.7	Pi, R	–	–
103	0.418	0.445	32.0	Br, O, Y	–	O
104	0.419	0.423	30.8	Br, O, Pi, R	–	–
105	0.421	0.346	15.8	Pi, O, R	–	–
106	0.423	0.370	35.6	Br, Pi, R,	Br	Pi
107	0.434	0.487	52.6	Br, O, Y	–	Y
108	0.436	0.438	16.9	Br, O, Y	O	–
109	0.436	0.460	27.6	Br, O, Y	Br	–
110	0.441	0.326	26.5	Pu, R	R	R
111	0.442	0.387	28.0	Br, Pi, R	–	–
112	0.447	0.413	24.9	Br, Pi, R	Br	–
113	0.454	0.365	24.5	Br, Pi, R	–	–
114	0.455	0.461	33.1	Br, O, Y	O	–
115	0.458	0.438	23.0	Br, O, Y	–	O
116	0.460	0.382	21.0	Br, Pi, R	Br	–
117	0.465	0.349	22.3	Pi, R	R	–
118	0.467	0.411	27.0	Br, O, R	Br	–
119	0.476	0.446	33.8	Br, O, Y	O	O
120	0.480	0.382	28.9	Br, Pi, R	R	R
121	0.490	0.414	19.9	Br, O, R	Br	–
122	0.492	0.392	28.9	Br, Pi, R	–	R
123	0.497	0.373	21.7	Pi, R	R	R
124	0.508	0.410	22.8	Br, O, R	Br	–

Standard color names: Bl, blue; Br, brown; G, green; O, orange; Pi, pink; Pu, purple; R, red; Y, yellow.

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