

# Edge-Aware Color Appearance

## Supplemental Material

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### 1 Color Appearance Data

This document provides the psychophysical experimental data used to develop our model. Two different types of color experiments were conducted, each involving edge width variation of their main stimuli: (1) a magnitude estimation experiment (phases: 1–12) to quantify perceived color appearance attribute and (2) a hue cancellation experiment (phases: 13–16) to quantify perceived hue induction on a given colored background.

**Magnitude Estimation** The magnitude estimation experimental data consists of the following main parts: (1) physical measurements of color stimuli in CIEXYZ coordinates (Y value corresponds to absolute luminance in [cd/m<sup>2</sup>]), measured by a GretagMecbeth EyeOne spectrometer, and (2) perceptual attribute estimates (averaged over six participants) of the stimuli in lightness  $J$ , colorfulness  $M$ , and hue quadrature  $H$ . In each phase, 20 main color patches were observed on an LCD display (Apple 23-inch Cinema HD Display) with a variation of edge gradient (0.08°, 0.50°, 0.92°, and 1.33°). Table 1 summarizes the viewing conditions of the magnitude experiment. Six participants that passed the Ishihara and City University vision tests for normal color vision participated in the experiments. Each participant completed a total of 720 estimations (12 phases with 20 patches and 3 estimates each) in about three hours, excluding break times. The coefficient of variation (CV) of inter-observer variance was 13.18% for lightness, 25.91% for colorfulness, and 6.56% for hue. The CV

Phase Number	Color Temp.	Edge Width	Reference White (Abs.)			Background (Abs.)			
			X	Y[cd/m <sup>2</sup> ]	Z	%	X	Y[cd/m <sup>2</sup> ]	Z
1	6533K	0.08°	179.08	188.89	205.96	0%	0.29	0.32	0.42
2	6533K	0.50°	179.08	188.89	205.96	0%	0.29	0.32	0.42
3	6533K	0.92°	179.08	188.89	205.96	0%	0.29	0.32	0.42
4	6533K	1.33°	179.08	188.89	205.96	0%	0.29	0.32	0.42
5	6557K	0.08°	173.25	182.52	200.07	12%	21.25	22.23	24.48
6	6557K	0.50°	173.25	182.52	200.07	12%	21.25	22.23	24.48
7	6557K	0.92°	173.25	182.52	200.07	12%	21.25	22.23	24.48
8	6557K	1.33°	173.25	182.52	200.07	12%	21.25	22.23	24.48
9	6523K	0.08°	178.45	188.27	204.90	100%	179.40	188.72	207.21
10	6523K	0.50°	178.45	188.27	204.90	100%	179.40	188.72	207.21
11	6523K	0.92°	178.45	188.27	204.90	100%	179.40	188.72	207.21
12	6523K	1.33°	178.45	188.27	204.90	100%	179.40	188.72	207.21

**Table 1:** Summary of viewing conditions for all 12 phases. Ambient luminance of all phases was set to dark.

error for repeatability was 11.74% for lightness, 22.74% for colorfulness, and 4.43% for hue. Note that our experimental results are compatible with the LUTCHI data [Luo et al., 1991] and Kim et al. [2009]. The scale of the lightness attribute (relative to the brightness of reference white) varies between 0 and 100. The colorfulness attribute is quantified in an absolute scale of 0 to unlimited. The hue attribute has a circulating scale from 0 to 400: redness (0) – yellowness (100) – greenness (200) – blueness (300) – redness (400); in addition, if the observed path was too dark, too bright, or neutral, participants were allowed to denote its hue attribute as not available ('N/A').

**Hue Cancellation** Viewing patterns, which contain only a random color on a colored background, were adjusted by the same participants on the same display. The white point of the display was calibrated to  $X=172.9$ ,  $Y=182.25$  [ $\text{cd}/\text{m}^2$ ], and  $Z=200.43$ , the correlated color temperature (CCT) of which was 6587K. For a given colored background, participants were asked to adjust a patch with an initial random color such that it appeared as neutral gray. The edge width of the random main color was varied in  $0.08^\circ$ ,  $0.50^\circ$ ,  $0.92^\circ$ , and  $1.33^\circ$ . The initial path color was varied to have five different luminance levels (24/42/62/82/100 in CIE  $L^*$ ). The participants were able to control hue and chroma but not luminance to yield neutral gray. The background was varied to have eight different hues (3/45/84/133/178/239/266/313 in CIE  $H^*$ ) with a fixed chroma  $\sim 37.40$  in CIE  $C^*$  and a fixed lightness  $\sim 40.79$  in CIE  $L^*$ . Tables 8 and 9 provide the radiometric measurements of the neutralized main patch and its surrounding background color.

## References

- KIM, M. H., WEYRICH, T., AND KAUTZ, J. 2009. Modeling human color perception under extended luminance levels. *ACM Trans. Graph. (Proc. SIGGRAPH 2009)* 28, 3, 27:1–9.
- LUO, M. R., CLARKE, A. A., RHODES, P. A., SCHAPPO, A., SCRIVENER, S. A. R., AND TAIT, C. J. 1991. Quantifying colour appearance. Part I. LUTCHI colour appearance data. *Color Res. Appl.* 16, 3, 166–180.

Color	Phase 1						Phase 2					
	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H
1	19.96	27.84	9.68	53.33	41.55	179.17	19.96	27.84	9.68	53.50	45.62	178.33
2	81.55	63.12	136.61	65.00	41.97	347.00	81.55	63.12	136.61	68.50	39.26	337.33
3	22.41	44.26	12.02	59.17	53.14	194.50	22.41	44.26	12.02	65.83	59.06	190.00
4	108.80	74.68	74.80	81.67	47.50	382.50	108.80	74.68	74.80	73.83	47.49	375.83
5	36.81	26.60	11.64	56.67	44.08	38.33	36.81	26.60	11.64	53.67	46.15	32.50
6	79.68	89.41	163.94	69.17	27.57	298.50	79.68	89.41	163.94	70.67	28.42	296.67
7	19.71	20.97	23.70	41.17	10.46	250.00	19.71	20.97	23.70	39.50	1.46	250.00
8	78.94	109.01	203.26	82.17	50.27	289.67	78.94	109.01	203.26	74.17	50.11	283.17
9	10.70	16.70	20.48	44.50	41.05	234.50	10.70	16.70	20.48	38.83	48.74	221.33
10	43.11	42.47	23.27	61.67	29.10	93.83	43.11	42.47	23.27	58.00	28.98	110.00
11	84.18	93.18	200.13	78.83	38.71	300.33	84.18	93.18	200.13	71.17	37.56	301.33
12	30.85	48.90	33.78	60.83	40.45	193.33	30.85	48.90	33.78	63.50	40.33	191.67
13	87.42	50.97	2.94	81.67	71.19	41.67	87.42	50.97	2.94	75.83	71.86	38.33
14	121.99	95.76	100.98	79.17	41.85	384.17	121.99	95.76	100.98	76.50	38.48	382.83
15	43.65	36.21	193.65	58.83	59.22	304.33	43.65	36.21	193.65	62.83	58.50	303.83
16	65.26	80.92	199.49	81.17	55.12	293.33	65.26	80.92	199.49	72.50	45.83	295.83
17	14.22	12.92	4.41	44.33	39.95	89.67	14.22	12.92	4.41	36.33	45.40	76.33
18	77.71	105.48	139.34	77.50	39.64	263.83	77.71	105.48	139.34	65.50	35.90	263.33
19	8.05	7.08	3.74	34.17	39.49	70.33	8.05	7.08	3.74	31.00	46.83	75.00
20	12.84	8.17	3.08	35.33	53.67	82.67	12.84	8.17	3.08	36.33	50.57	16.00

**Table 2:** Phase 1 & 2. Physical measurements vs. perceptual estimates (magnitude estimation).

Color	Phase 3						Phase 4					
	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H
1	19.96	27.84	9.68	43.33	46.07	198.17	19.96	27.84	9.68	45.67	47.30	173.33
2	81.55	63.12	136.61	59.17	40.05	350.83	81.55	63.12	136.61	64.00	39.44	348.00
3	22.41	44.26	12.02	61.83	61.15	191.67	22.41	44.26	12.02	59.17	65.15	194.50
4	108.80	74.68	74.80	73.33	49.42	360.00	108.80	74.68	74.80	65.83	43.81	380.83
5	36.81	26.60	11.64	51.67	49.34	30.83	36.81	26.60	11.64	50.00	39.98	46.67
6	79.68	89.41	163.94	67.00	26.55	300.00	79.68	89.41	163.94	70.00	21.47	298.33
7	19.71	20.97	23.70	45.00	1.46	250.00	19.71	20.97	23.70	36.33	1.46	250.00
8	78.94	109.01	203.26	75.83	47.57	292.50	78.94	109.01	203.26	71.67	45.31	279.17
9	10.70	16.70	20.48	37.50	42.37	230.67	10.70	16.70	20.48	34.17	45.05	224.83
10	43.11	42.47	23.27	49.17	30.02	80.00	43.11	42.47	23.27	63.33	28.77	81.67
11	84.18	93.18	200.13	71.67	33.74	296.67	84.18	93.18	200.13	66.67	29.66	296.67
12	30.85	48.90	33.78	55.83	41.60	191.67	30.85	48.90	33.78	60.83	40.30	192.00
13	87.42	50.97	2.94	74.67	72.40	37.50	87.42	50.97	2.94	74.83	72.99	32.50
14	121.99	95.76	100.98	74.17	45.54	378.33	121.99	95.76	100.98	69.83	36.00	318.33
15	43.65	36.21	193.65	59.17	61.62	299.50	43.65	36.21	193.65	56.33	63.54	304.17
16	65.26	80.92	199.49	75.00	42.32	296.67	65.26	80.92	199.49	70.83	47.08	296.00
17	14.22	12.92	4.41	37.83	47.26	71.67	14.22	12.92	4.41	38.33	48.03	63.33
18	77.71	105.48	139.34	68.33	28.76	262.67	77.71	105.48	139.34	67.50	32.80	245.00
19	8.05	7.08	3.74	29.00	47.60	62.50	8.05	7.08	3.74	27.67	45.08	58.50
20	12.84	8.17	3.08	36.67	46.62	15.17	12.84	8.17	3.08	34.17	50.77	11.00

**Table 3:** Phase 3 & 4. Physical measurements vs. perceptual estimates (magnitude estimation).

Color	Phase 5						Phase 6					
	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H
1	19.81	27.81	9.59	48.83	43.47	179.17	19.81	27.81	9.59	49.17	40.51	175.67
2	82.21	63.65	138.31	72.83	46.88	360.50	82.21	63.65	138.31	73.17	48.46	354.17
3	22.40	44.55	11.94	69.83	57.08	186.67	22.40	44.55	11.94	71.50	58.05	189.17
4	109.18	74.92	75.39	80.67	55.99	379.83	109.18	74.92	75.39	73.33	52.93	382.50
5	36.76	26.56	11.58	58.33	43.75	54.17	36.76	26.56	11.58	55.83	41.30	35.33
6	80.15	90.17	165.65	69.17	35.96	295.00	80.15	90.17	165.65	73.33	31.23	297.67
7	19.56	20.92	23.71	37.17	8.45	242.50	19.56	20.92	23.71	39.00	1.53	250.00
8	79.64	110.30	204.74	85.83	51.67	292.67	79.64	110.30	204.74	79.17	54.24	290.83
9	10.56	16.67	20.51	47.83	44.52	238.33	10.56	16.67	20.51	50.17	39.99	228.83
10	43.42	42.88	23.44	63.17	29.49	90.00	43.42	42.88	23.44	55.83	27.89	87.50
11	85.06	94.46	201.76	77.50	43.91	293.33	85.06	94.46	201.76	75.00	35.44	304.17
12	31.12	49.56	34.12	67.17	38.51	206.67	31.12	49.56	34.12	60.00	38.20	199.17
13	88.13	51.32	2.82	82.67	72.94	46.50	88.13	51.32	2.82	75.83	73.26	39.67
14	123.14	96.80	102.30	79.17	38.71	376.67	123.14	96.80	102.30	77.83	45.50	315.00
15	43.76	36.34	195.31	77.67	63.92	298.00	43.76	36.34	195.31	71.17	58.63	303.33
16	65.98	82.17	201.16	80.50	46.36	301.67	65.98	82.17	201.16	76.67	56.04	298.33
17	14.12	12.83	4.33	51.50	38.40	73.00	14.12	12.83	4.33	46.33	43.17	76.67
18	78.94	107.48	141.49	80.00	41.10	267.50	78.94	107.48	141.49	78.67	35.91	257.50
19	7.88	6.94	3.64	34.33	38.85	70.50	7.88	6.94	3.64	33.67	35.11	67.00
20	12.80	8.13	3.01	45.17	50.15	17.00	12.80	8.13	3.01	38.33	51.10	9.50

**Table 4:** Phase 5 & 6. Physical measurements vs. perceptual estimates (magnitude estimation).

Color	Phase 7						Phase 8					
	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H
1	19.81	27.81	9.59	54.17	38.42	177.50	19.81	27.81	9.59	50.00	36.13	180.00
2	82.21	63.65	138.31	68.33	46.83	358.33	82.21	63.65	138.31	71.67	43.56	358.33
3	22.40	44.55	11.94	71.83	61.77	192.50	22.40	44.55	11.94	72.50	59.02	188.83
4	109.18	74.92	75.39	73.33	57.52	380.00	109.18	74.92	75.39	72.50	52.49	378.33
5	36.76	26.56	11.58	57.00	46.04	35.00	36.76	26.56	11.58	62.17	43.26	98.33
6	80.15	90.17	165.65	71.33	29.28	298.33	80.15	90.17	165.65	65.50	24.62	296.67
7	19.56	20.92	23.71	45.50	4.63	250.00	19.56	20.92	23.71	45.00	1.53	250.00
8	79.64	110.30	204.74	77.33	54.20	302.50	79.64	110.30	204.74	75.83	51.08	282.50
9	10.56	16.67	20.51	48.00	44.85	232.50	10.56	16.67	20.51	45.00	41.23	237.67
10	43.42	42.88	23.44	57.17	24.26	80.50	43.42	42.88	23.44	60.83	27.59	81.67
11	85.06	94.46	201.76	73.33	44.32	295.33	85.06	94.46	201.76	72.00	28.28	300.33
12	31.12	49.56	34.12	59.67	39.18	197.50	31.12	49.56	34.12	68.00	31.97	210.00
13	88.13	51.32	2.82	82.00	72.25	38.67	88.13	51.32	2.82	80.00	67.00	38.33
14	123.14	96.80	102.30	80.67	54.11	376.67	123.14	96.80	102.30	76.67	34.44	370.00
15	43.76	36.34	195.31	70.83	59.09	305.00	43.76	36.34	195.31	68.33	57.59	303.33
16	65.98	82.17	201.16	73.50	54.48	297.50	65.98	82.17	201.16	75.00	50.65	313.33
17	14.12	12.83	4.33	43.00	43.84	70.50	14.12	12.83	4.33	44.67	38.22	74.17
18	78.94	107.48	141.49	76.33	40.22	252.50	78.94	107.48	141.49	76.33	35.56	263.83
19	7.88	6.94	3.64	35.83	45.44	59.17	7.88	6.94	3.64	35.83	36.45	65.83
20	12.80	8.13	3.01	45.00	49.18	10.50	12.80	8.13	3.01	41.17	48.29	10.50

**Table 5:** Phase 7 & 8. Physical measurements vs. perceptual estimates (magnitude estimation).

Color	Phase 9						Phase 10					
	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H
1	20.30	28.53	9.80	38.67	47.65	182.50	20.30	28.53	9.80	49.17	42.61	175.83
2	83.10	64.53	139.23	57.50	40.54	346.67	83.10	64.53	139.23	56.33	45.48	339.17
3	22.76	45.40	12.23	56.67	53.76	197.33	22.76	45.40	12.23	56.33	54.44	194.83
4	110.47	76.05	76.36	64.17	43.04	380.83	110.47	76.05	76.36	68.33	48.49	322.17
5	37.34	27.04	11.75	44.17	42.22	29.17	37.34	27.04	11.75	52.83	38.82	28.33
6	81.11	91.43	166.72	70.83	32.51	295.83	81.11	91.43	166.72	65.00	35.82	298.33
7	19.88	21.33	24.11	34.17	2.36	250.00	19.88	21.33	24.11	33.33	1.32	250.00
8	80.30	111.38	206.17	71.33	50.49	290.00	80.30	111.38	206.17	77.33	54.49	290.33
9	10.70	16.98	20.85	29.17	43.34	225.00	10.70	16.98	20.85	33.83	47.40	224.17
10	43.94	43.53	23.81	45.83	24.25	86.67	43.94	43.53	23.81	57.00	25.36	98.33
11	85.71	95.31	203.00	70.33	37.50	297.17	85.71	95.31	203.00	75.33	42.56	300.67
12	31.44	50.11	34.48	55.83	34.55	199.17	31.44	50.11	34.48	56.00	37.22	201.67
13	88.32	51.50	2.84	73.67	64.06	35.00	88.32	51.50	2.84	77.50	67.35	41.67
14	123.75	97.55	102.84	70.33	29.84	380.83	123.75	97.55	102.84	72.50	37.99	378.17
15	44.04	36.74	196.41	56.67	57.74	299.50	44.04	36.74	196.41	59.17	64.57	301.67
16	66.42	82.87	202.25	65.33	48.51	297.33	66.42	82.87	202.25	70.33	57.15	296.67
17	14.25	13.04	4.39	30.00	44.57	86.67	14.25	13.04	4.39	32.50	38.64	74.17
18	79.43	108.22	141.98	73.00	33.72	257.50	79.43	108.22	141.98	64.50	30.07	244.17
19	7.99	7.04	3.71	14.67	30.03	61.67	7.99	7.04	3.71	17.83	29.38	56.67
20	12.91	8.17	3.04	27.67	45.02	21.00	12.91	8.17	3.04	28.33	46.55	14.50

**Table 6:** Phase 9 & 10. Physical measurements vs. perceptual estimates (magnitude estimation).

Color	Phase 11						Phase 12					
	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H	X	Y[cd/m <sup>2</sup> ]	Z	J	M	H
1	20.30	28.53	9.80	46.67	44.38	183.33	20.30	28.53	9.80	52.50	41.11	181.67
2	83.10	64.53	139.23	63.83	47.94	339.83	83.10	64.53	139.23	67.17	43.59	338.33
3	22.76	45.40	12.23	58.17	54.05	189.50	22.76	45.40	12.23	62.33	56.87	194.17
4	110.47	76.05	76.36	73.67	44.97	295.83	110.47	76.05	76.36	74.00	39.54	380.00
5	37.34	27.04	11.75	51.67	32.72	25.50	37.34	27.04	11.75	60.00	35.94	28.33
6	81.11	91.43	166.72	68.33	28.17	294.17	81.11	91.43	166.72	74.17	27.53	296.67
7	19.88	21.33	24.11	32.50	2.28	275.00	19.88	21.33	24.11	41.33	1.32	250.00
8	80.30	111.38	206.17	75.33	55.29	285.83	80.30	111.38	206.17	78.33	54.23	293.33
9	10.70	16.98	20.85	39.17	54.14	232.50	10.70	16.98	20.85	29.67	51.15	251.67
10	43.94	43.53	23.81	58.33	23.63	98.50	43.94	43.53	23.81	64.17	21.00	85.00
11	85.71	95.31	203.00	70.00	45.58	283.33	85.71	95.31	203.00	76.33	33.65	305.00
12	31.44	50.11	34.48	59.17	34.06	195.83	31.44	50.11	34.48	62.50	37.66	198.33
13	88.32	51.50	2.84	78.00	66.80	41.67	88.32	51.50	2.84	76.67	67.32	49.17
14	123.75	97.55	102.84	73.67	32.25	380.00	123.75	97.55	102.84	75.50	38.21	381.67
15	44.04	36.74	196.41	65.83	63.01	299.33	44.04	36.74	196.41	60.83	63.17	304.17
16	66.42	82.87	202.25	69.50	49.90	295.00	66.42	82.87	202.25	73.33	52.19	295.00
17	14.25	13.04	4.39	32.50	37.03	68.33	14.25	13.04	4.39	35.83	31.28	74.17
18	79.43	108.22	141.98	74.67	29.89	251.17	79.43	108.22	141.98	72.00	29.82	260.00
19	7.99	7.04	3.71	20.50	26.30	95.00	7.99	7.04	3.71	20.00	29.85	59.17
20	12.91	8.17	3.04	33.67	50.98	17.00	12.91	8.17	3.04	28.00	47.40	22.50

**Table 7:** Phase 11 & 12. Physical measurements vs. perceptual estimates (magnitude estimation).

Color	Phase 13						Phase 14					
	Neutral gray			Background			Neutral gray			Background		
	X	Y [cd/m <sup>2</sup> ]	Z	X	Y [cd/m <sup>2</sup> ]	Z	X	Y [cd/m <sup>2</sup> ]	Z	X	Y [cd/m <sup>2</sup> ]	Z
1	7.93	7.73	7.97	32.89	22.25	22.58	8.30	7.93	7.97	32.89	22.25	22.58
2	7.94	7.72	7.11	28.32	21.11	7.49	8.45	7.99	7.65	28.32	21.11	7.49
3	7.99	7.77	8.63	19.79	19.94	4.20	8.26	7.98	7.73	19.79	19.94	4.20
4	7.74	7.67	7.50	13.08	19.45	7.74	9.23	9.38	9.16	13.08	19.45	7.74
5	7.92	7.76	8.46	13.45	21.09	22.67	10.07	10.07	10.67	13.45	21.09	22.67
6	7.90	7.78	8.43	18.34	23.25	50.71	9.44	9.39	9.94	18.34	23.25	50.71
7	7.89	7.84	8.48	20.28	22.00	67.89	8.28	8.04	8.56	20.28	22.00	67.89
8	8.06	7.77	8.18	28.34	22.12	50.81	8.28	8.05	7.92	28.34	22.12	50.81
9	21.84	22.48	26.37	32.89	22.25	22.58	22.62	22.82	24.83	32.89	22.25	22.58
10	21.67	22.43	26.05	28.32	21.11	7.49	23.32	22.98	24.49	28.32	21.11	7.49
11	22.33	22.51	23.90	19.79	19.94	4.20	22.44	22.79	23.76	19.79	19.94	4.20
12	22.41	22.48	23.51	13.08	19.45	7.74	25.88	26.66	28.70	13.08	19.45	7.74
13	21.27	22.46	26.03	13.45	21.09	22.67	25.92	27.19	30.08	13.45	21.09	22.67
14	22.41	22.60	27.42	18.34	23.25	50.71	24.33	25.80	30.36	18.34	23.25	50.71
15	22.14	22.75	26.48	20.28	22.00	67.89	23.06	23.12	28.37	20.28	22.00	67.89
16	22.16	22.69	26.90	28.34	22.12	50.81	22.46	22.96	26.67	28.34	22.12	50.81
17	50.37	54.47	63.65	32.89	22.25	22.58	53.44	55.55	60.18	32.89	22.25	22.58
18	60.65	62.98	72.57	28.32	21.11	7.49	53.78	55.48	61.25	28.32	21.11	7.49
19	52.14	54.64	62.26	19.79	19.94	4.20	53.34	56.81	57.71	19.79	19.94	4.20
20	53.64	55.08	63.01	13.08	19.45	7.74	60.47	63.01	70.95	13.08	19.45	7.74
21	54.44	55.27	67.39	13.45	21.09	22.67	58.92	60.96	63.05	13.45	21.09	22.67
22	52.87	55.12	65.54	18.34	23.25	50.71	53.25	55.80	66.00	18.34	23.25	50.71
23	53.76	55.20	62.32	20.28	22.00	67.89	52.60	55.64	68.02	20.28	22.00	67.89
24	53.40	55.10	59.93	28.34	22.12	50.81	53.44	55.69	58.86	28.34	22.12	50.81
25	103.70	109.67	127.88	32.89	22.25	22.58	109.03	111.77	127.02	32.89	22.25	22.58
26	107.25	110.33	126.36	28.32	21.11	7.49	109.00	111.84	125.18	28.32	21.11	7.49
27	102.04	109.32	121.17	19.79	19.94	4.20	108.74	113.98	124.56	19.79	19.94	4.20
28	106.77	110.51	126.55	13.08	19.45	7.74	116.98	122.36	135.93	13.08	19.45	7.74
29	107.05	110.24	122.08	13.45	21.09	22.67	111.07	117.24	129.46	13.45	21.09	22.67
30	105.72	110.57	127.30	18.34	23.25	50.71	108.54	111.60	118.81	18.34	23.25	50.71
31	107.07	110.58	118.38	20.28	22.00	67.89	106.40	111.35	118.28	20.28	22.00	67.89
32	103.16	109.92	120.77	28.34	22.12	50.81	105.23	111.01	121.58	28.34	22.12	50.81
33	176.24	188.81	202.78	32.89	22.25	22.58	181.89	189.90	207.22	32.89	22.25	22.58
34	181.10	187.43	212.88	28.32	21.11	7.49	178.60	190.98	212.99	28.32	21.11	7.49
35	181.55	188.11	213.43	19.79	19.94	4.20	168.06	175.22	196.79	19.79	19.94	4.20
36	163.15	176.01	200.13	13.08	19.45	7.74	154.22	160.58	179.74	13.08	19.45	7.74
37	176.59	189.12	211.18	13.45	21.09	22.67	160.36	167.43	177.08	13.45	21.09	22.67
38	177.82	187.18	197.66	18.34	23.25	50.71	184.68	192.87	208.52	18.34	23.25	50.71
39	177.84	186.02	205.21	20.28	22.00	67.89	179.81	190.32	202.15	20.28	22.00	67.89
40	175.49	188.58	210.97	28.34	22.12	50.81	177.20	187.96	203.29	28.34	22.12	50.81

**Table 8:** Phase 13 & 14. Physical measurements of the chosen neutral gray and the background (hue cancellation).

Color	Phase 15						Phase 16					
	Neutral gray			Background			Neutral gray			Background		
	X	Y[cd/m <sup>2</sup> ]	Z	X	Y[cd/m <sup>2</sup> ]	Z	X	Y[cd/m <sup>2</sup> ]	Z	X	Y[cd/m <sup>2</sup> ]	Z
1	8.41	8.16	8.81	32.89	22.25	22.58	8.68	8.33	8.10	32.89	22.25	22.58
2	8.49	8.17	7.89	28.32	21.11	7.49	8.68	8.38	8.41	28.32	21.11	7.49
3	8.64	8.19	8.22	19.79	19.94	4.20	8.55	8.33	8.34	19.79	19.94	4.20
4	8.48	8.17	8.07	13.08	19.45	7.74	8.43	8.35	8.26	13.08	19.45	7.74
5	8.12	8.16	8.01	13.45	21.09	22.67	8.80	8.40	7.78	13.45	21.09	22.67
6	8.24	8.19	8.30	18.34	23.25	50.71	8.39	8.44	8.62	18.34	23.25	50.71
7	8.43	8.25	7.67	20.28	22.00	67.89	8.89	8.46	9.59	20.28	22.00	67.89
8	8.39	8.23	7.06	28.34	22.12	50.81	8.67	8.41	8.46	28.34	22.12	50.81
9	23.75	23.16	25.07	32.89	22.25	22.58	23.22	23.16	24.61	32.89	22.25	22.58
10	22.62	23.06	23.96	28.32	21.11	7.49	22.71	23.15	23.94	28.32	21.11	7.49
11	22.59	23.13	29.32	19.79	19.94	4.20	23.48	23.32	24.59	19.79	19.94	4.20
12	22.10	23.01	26.27	13.08	19.45	7.74	22.39	23.21	25.97	13.08	19.45	7.74
13	22.02	23.07	26.48	13.45	21.09	22.67	23.35	23.34	27.43	13.45	21.09	22.67
14	22.27	23.17	29.02	18.34	23.25	50.71	23.17	23.24	26.23	18.34	23.25	50.71
15	34.21	35.80	42.54	20.28	22.00	67.89	21.93	23.04	25.46	20.28	22.00	67.89
16	23.46	23.41	28.62	28.34	22.12	50.81	22.23	23.22	27.54	28.34	22.12	50.81
17	54.57	55.67	61.77	32.89	22.25	22.58	54.28	55.70	64.11	32.89	22.25	22.58
18	52.93	55.47	60.30	28.32	21.11	7.49	53.52	55.55	62.72	28.32	21.11	7.49
19	53.75	55.66	61.81	19.79	19.94	4.20	54.31	55.83	61.91	19.79	19.94	4.20
20	53.07	55.67	62.60	13.08	19.45	7.74	53.62	55.75	65.45	13.08	19.45	7.74
21	54.26	55.80	60.44	13.45	21.09	22.67	54.34	55.74	64.79	13.45	21.09	22.67
22	54.58	56.00	61.03	18.34	23.25	50.71	53.00	55.51	63.75	18.34	23.25	50.71
23	53.05	55.68	71.20	20.28	22.00	67.89	53.36	55.78	65.16	20.28	22.00	67.89
24	53.43	55.51	61.70	28.34	22.12	50.81	53.05	55.38	59.70	28.34	22.12	50.81
25	105.86	111.13	128.11	32.89	22.25	22.58	104.16	110.88	121.68	32.89	22.25	22.58
26	106.80	111.18	126.02	28.32	21.11	7.49	108.23	111.80	131.24	28.32	21.11	7.49
27	107.37	111.38	126.79	19.79	19.94	4.20	106.27	111.05	129.89	19.79	19.94	4.20
28	105.47	111.13	123.38	13.08	19.45	7.74	105.12	110.97	128.79	13.08	19.45	7.74
29	108.96	111.50	129.44	13.45	21.09	22.67	106.36	110.76	119.31	13.45	21.09	22.67
30	104.08	110.58	116.19	18.34	23.25	50.71	104.33	110.64	120.39	18.34	23.25	50.71
31	106.19	111.17	129.86	20.28	22.00	67.89	105.85	110.82	117.68	20.28	22.00	67.89
32	106.22	111.01	123.81	28.34	22.12	50.81	105.01	110.13	118.93	28.34	22.12	50.81
33	177.49	188.53	204.27	32.89	22.25	22.58	178.39	190.41	214.24	32.89	22.25	22.58
34	178.51	188.17	197.76	28.32	21.11	7.49	178.02	190.08	205.95	28.32	21.11	7.49
35	181.93	191.22	203.52	19.79	19.94	4.20	178.75	188.13	209.00	19.79	19.94	4.20
36	174.72	184.65	207.59	13.08	19.45	7.74	177.49	188.47	205.13	13.08	19.45	7.74
37	182.28	191.95	207.06	13.45	21.09	22.67	177.93	189.24	212.40	13.45	21.09	22.67
38	180.92	188.08	209.95	18.34	23.25	50.71	180.33	190.82	214.02	18.34	23.25	50.71
39	180.82	190.16	201.79	20.28	22.00	67.89	179.18	188.11	209.14	20.28	22.00	67.89
40	179.67	189.54	199.10	28.34	22.12	50.81	181.46	190.27	203.56	28.34	22.12	50.81

**Table 9:** Phase 15 & 16. Physical measurements of the chosen neutral gray and the background (hue cancellation).