

# Increase amount of brightness in comparison of brightness

Teluhiko Hilano (Kanagawa Institute of Technology)  
hilano@ic.kanagawa-it.ac.jp

## An Effect of Contrast

The appearance of a color depends on the colors near it. In two squares with center circles of the same color, the brightness of the circles will appear to differ depending on the brightness of their backgrounds.

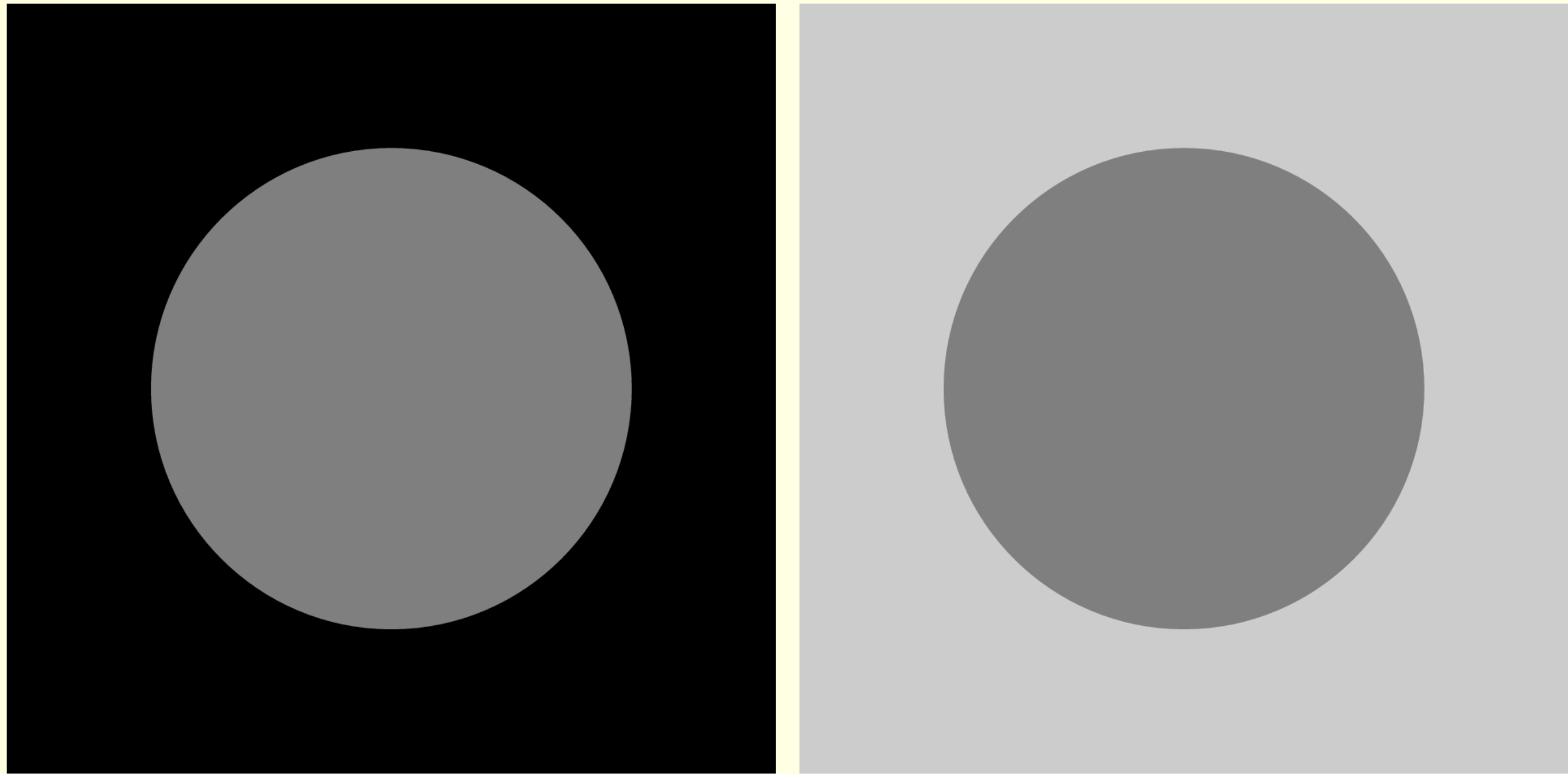


Figure 1: An effect of contrast

The brighter the background, the darker its circle appears. In this research, we want to quantify perception of the difference in the brightness of the circles.

## The experimental way

We prepared many printed samples with center circles of varying brightness. The size of the sample is 8 cm and the diameter of the circle is 5 cm. The background colors are black and light gray(80% brightness) and the brightness of the center circles are from 40% to 60% in every 2% by HSL color value[2]. These samples are printed by Epson PX5002 inkjet printer on the paper Epson Crispia.

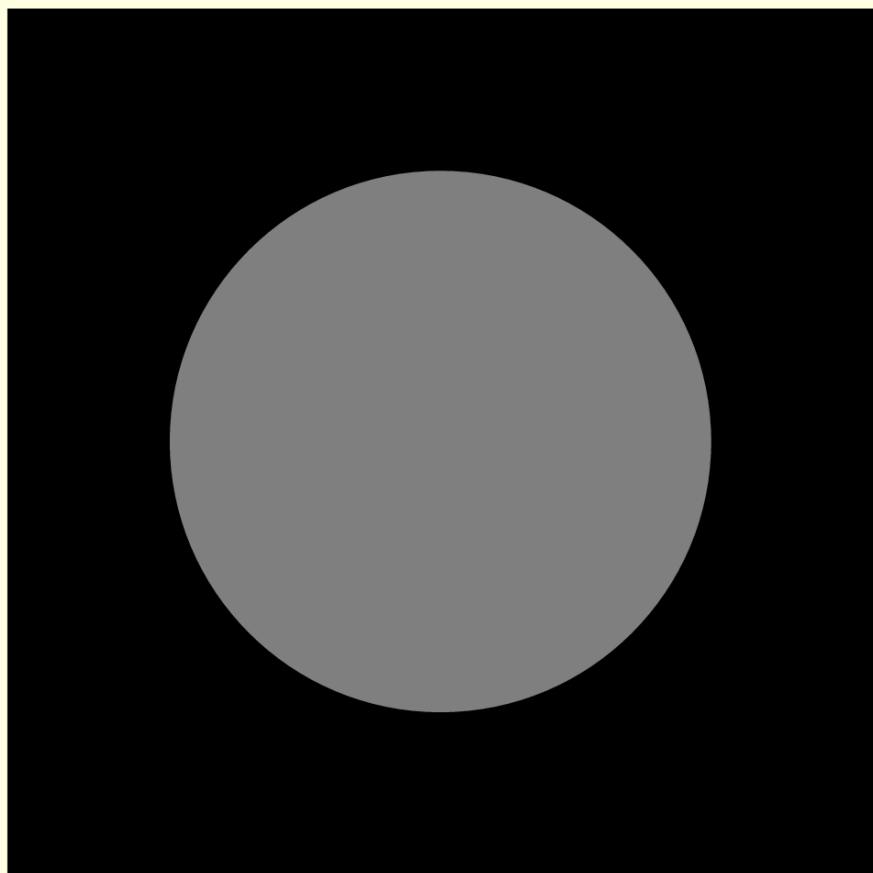


Figure 2: The reference Figure

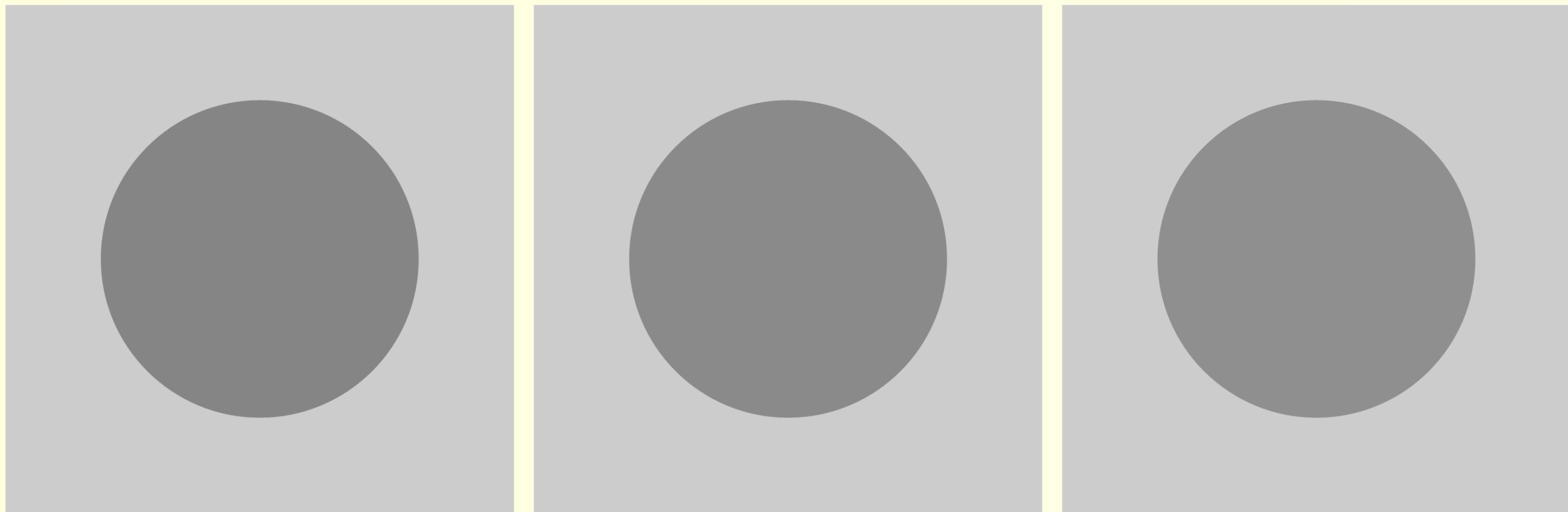


Figure 3: Example of Samples(gray of brightness 52%, 54% and 56%)

The brightness of the backgrounds in Figures2 and 3 are 0% and 90%, respectively. We showed these samples to subjects and asked them to select a sample whose center circle has the same center brightness as the reference image.

## Evaluation of Colors

Since the printed color depends on the equipment, we have evaluated colors of the samples by a colorimeter TCD100[3]. The color differences are calculated by Excel datasheet given by [1].

Table 1: Color Values of the circles in Figure 3

$H$	$S$	$L$	$L^*$	$a^*$	$b^*$	$dE$
0	0	50	55.9	-1.2	-0.8	0
0	0	52	57.1	-1.1	-1.0	1.1367
0	0	54	59.3	-1.4	-1.0	3.1133
0	0	56	61.6	-1.1	-0.9	5.1065

## Chromatic Case

In the previous experiment, the colors of the circles are achromatic. Now we choose typical chromatic colors for the colors of circles:

Table 2: Color Values of the circles in Figure 4

HSL color value			$L^*a^*b^*$			LCH value	
$H$	$S$	$L$	$L^*$	$a^*$	$b^*$	Chroma	Hue
0	90	50	43.1	76.3	30.9	82.3	22.0
60	90	50	83.4	-3.7	142.4	140.6	91.4
120	90	50	46.1	-57.7	14.6	58.1	166.1
180	90	50	66.8	-35.2	-46.6	58.4	233.4
240	90	50	30.3	11.5	-59.5	59.4	280.9
300	90	50	62.7	68.0	-26.7	72.5	339.3

In these cases, we choose 90 as saturation, because we perceive the color of the circle with dark background vividly.

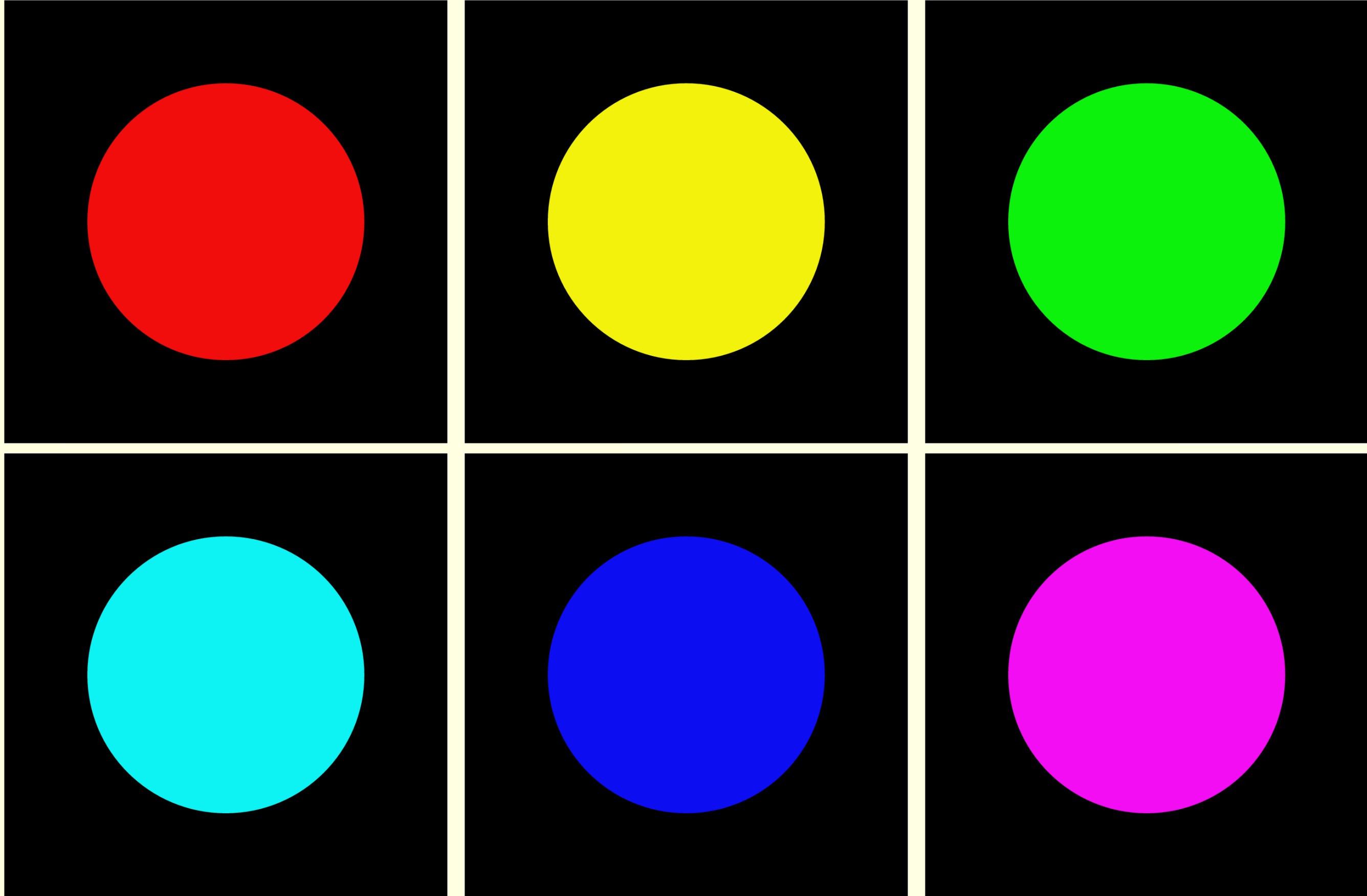


Figure 4: The reference Figures in color case

## Results

In the monochrome case, we perceive that the color of the circle of sample of gray 56% seems similar to the reference figure(Figure 2).

In the chromatic case, we prepare samples which saturations are 90%, 95% and 100%. The following table shows the chromatic cases:

Table 3: Results in the chromatic case in Figure 4

HSL color value			$L^*a^*b^*$			LCH value		$dE$
$H$	$S$	$L$	$L^*$	$a^*$	$b^*$	Chroma	Hue	
0	100	52	47.8	84.8	34.7	91.6	22.2	4.8676
60	100	52	89.6	-1.8	163.8	163.8	90.6	4.9344
120	100	52	50.9	-60.9	14.9	62.7	166.2	4.8462
180	100	54	70.3	-37.3	-45.0	58.4	230.3	2.9714
240	100	54	34.8	12.6	-64.4	65.6	281.0	3.7926
300	100	54	66.1	67.4	-25.1	71.9	339.5	2.8757

## Conclusion

In all cases, the colors of the circles in dark background are brighter than those in bright background. Their differences of the luminance are about 5. When the samples' brightness of the background color were 60, approximately 4 differences were obtained.

## References

- [1] G. Sharma, W. Wu, E. N. Dalal, The CIEDE2000 Color-Difference Formula: Implementation Notes, Supplementary Test Data, and Mathematical Observations, COLOR research and application, pp.21-30, Vol.30, 2005
- [2] W3C, CSS Color Module Level 3, <https://www.w3.org/TR/css-color-3/#hsl-color>
- [3] TCD100, <https://www.pce-instruments.com/f/english/media/colorimeter-catalog.pdf>
- [4] Jacques Ninio, *The Science of Illusions*, Cornell University Press, New York, 2001