Measuring the visible range of high-dynamic-range images

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We made pairs of identical film transparencies. We viewed one (single-contrast), then two super-imposed in registration (double-contrast). Single-contrast images have 2.7 log10 dynamic range; double-contrast ones 5.4 log10 range. Observers estimated the appearance of 40 gray areas surrounded with white and black blocks of different sizes. First, the surround had equal white and black areas (average single-contrast luminance = 50.01% max; double-contrast = 50.00% max). Doubling the contrast had minimal effect on retinal glare. Magnitude estimates show nearly the same plot (appearance vs log luminance) for both contrasts in the range of 0.0 to 2.3, and no discrimination at higher optical densities. Second, with a 8% white - 92% black surround appearances ranged from 0.0 to 2.9. Increasing the stimulus range had little effect on appearance. Decreasing the white area of the surround decreased veiling glare and increased the range of usable densities. These, and other experiments, measure how veiling glare controls the range of appearance in high-dynamic-range images.

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Outline

1. High-Dynamic-Range(HDR) displays superimpose an illumination image on an LCD display (range ~ 100,000 : 1). How wide a range of luminance is usable by humans?
2. Appearance is controlled by both optical glare and physiological simultaneous contrast [Figure 1].
3. We measured the range appearances in constant spatial targets with variable dynamic ranges.
4. The superposition of identical transparencies doubles the densities (squares the transmissions) [Figure 2].
5. Observers made magnitude estimates of appearances between white (100) and black (1).
6. Increasing the range 500x caused minimal change in appearance.
7. Varying the amount of white in the surround changes the luminance range between white and black.

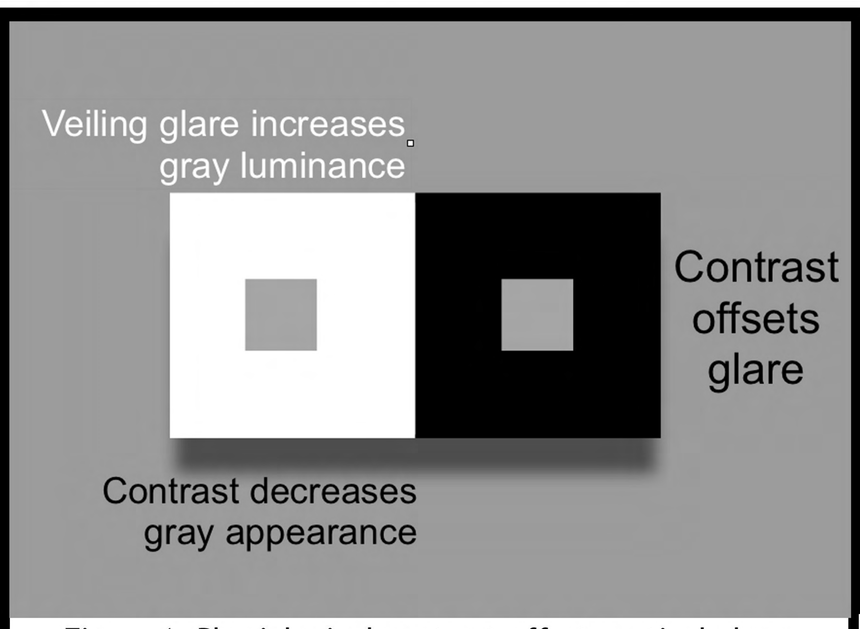


Figure 1. Physiological contrast offsets optical glare.

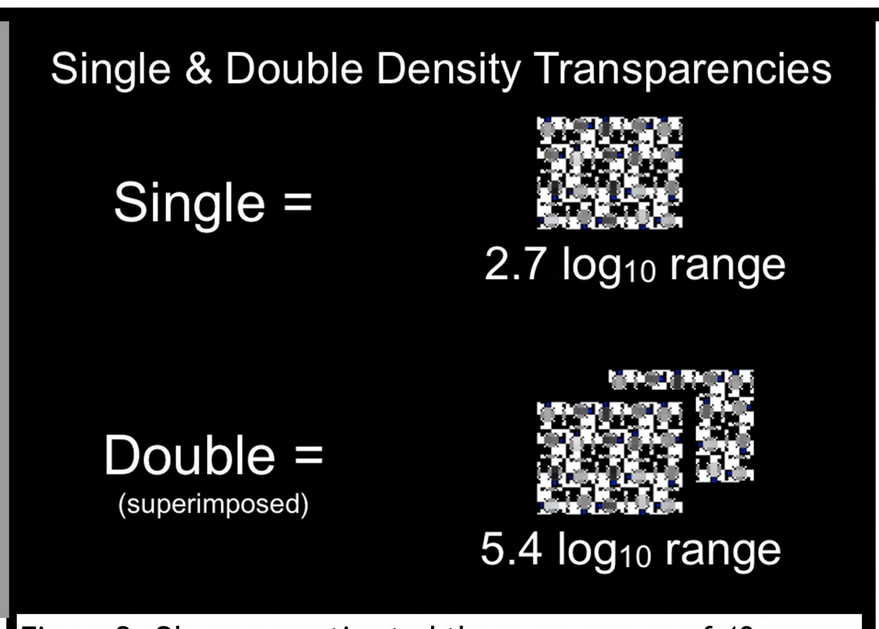


Figure 2. Observers estimated the appearances of 40 grays.

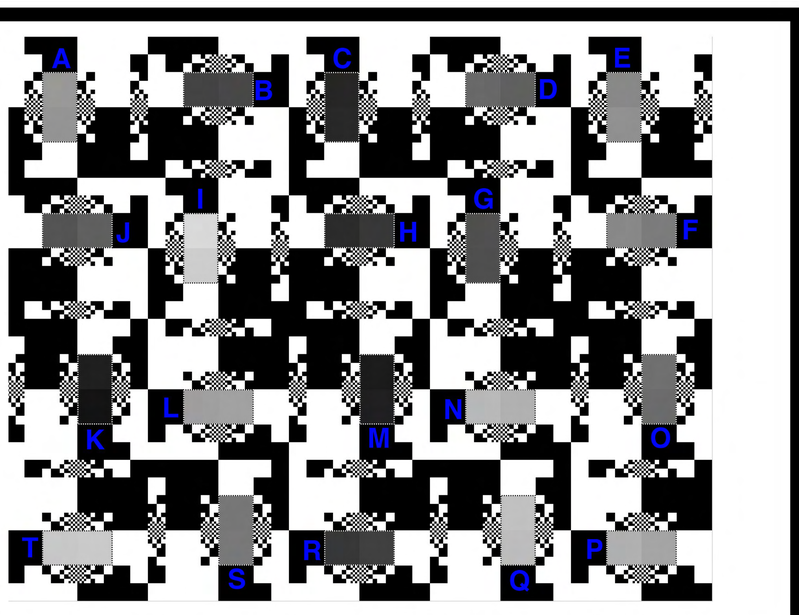


Figure 3. Surround for 40 gray squares is 50% white.

The target has 40 square gray patches are surrounded:
with 50% white squares (seven sizes)[12]
with 50% black squares (seven sizes).

Add the second transparency:
Doubles the density
Squares the dynamic range
Has constant simultaneous contrast
Has nearly constant average luminance
Has nearly constant veiling glare

Target	Max cd/m²	Min cd/m²	Range:1	%Average cd/m²	O.D. Min	O.D. Max	O.D. Range
Single Density	6,680	13.6	490	50.01%	0.20	2.89	2.69
Double Density	4,215	0.018	239,883	50.00%	0.40	5.78	5.38

Observers' instructions:
White = 100; Black =1
Find a gray area half-way [White-Black]
Call that 50
Find a gray area =75; a gray area =25
Using above estimates as reference
Estimate appearances of all 40 gray squares

Units	Estimates	Observers	Trials per Observer	Target Angle	Gray Square Angle
20	40	5	5	19.1° by 15.5°	0.8°

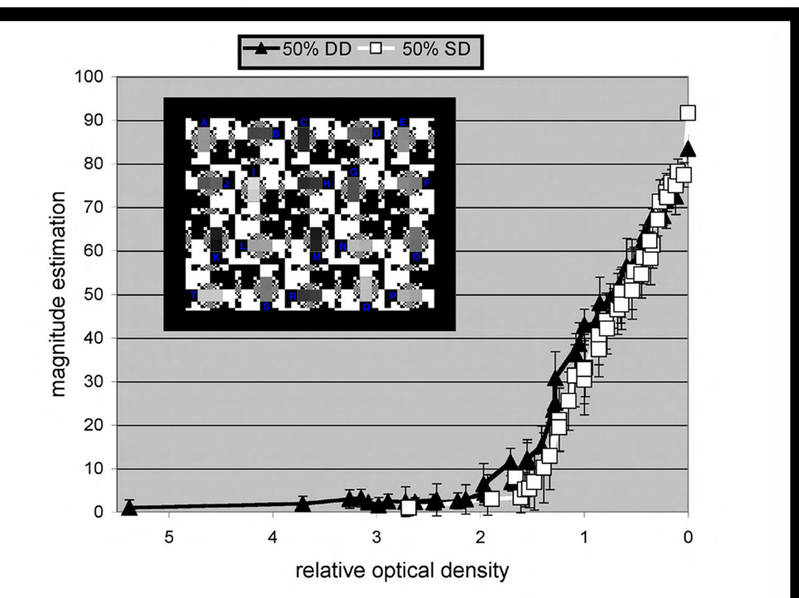


Figure 4. Usable luminance range is 2.3 log units.

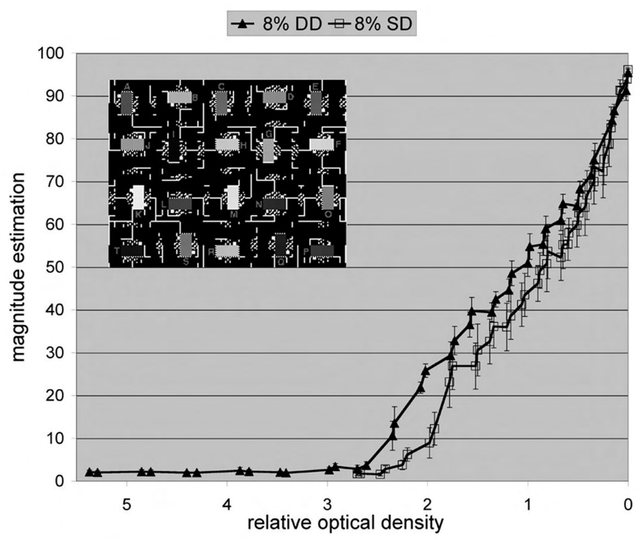


Figure 5. Usable luminance range is 2.9 log units.

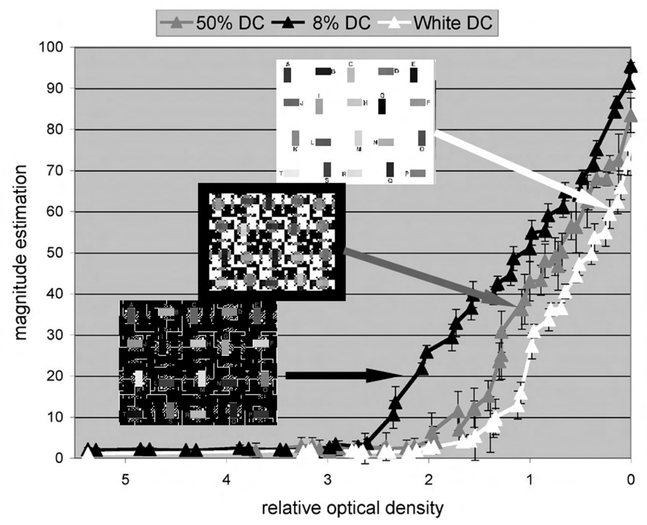


Figure 6. Usable range is surround dependent.

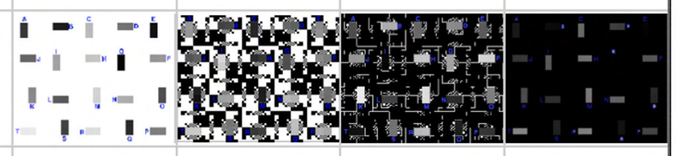
% White	100%	50%	8%	0%
				
Usable Range (log units)	2.0	2.3	2.9	5.0

Figure 7. Surround controls both optical veiling glare and physiological simultaneous contrast. They tend to cancel each other. Nevertheless, with highest glare the usable range is smallest. With minimal glare the range is largest.

Discussion

Veiling glare limits the range of luminances that can be accurately measured using in-camera multiple exposures [2-3, 6-11, 14].

Accurate scene luminances are not essential for accurate scene reproduction [4-7].

Human spatial processing requires details in bright and dark regions of a scene, not luminance fidelity. [1,4-8, 13] .

Conclusions

We made magnitude estimates of appearance of gray squares in HDR displays.

Usable dynamic range depends on glare and contrast.

Although HDR technolgy can gereate 5 log unit displays, humans sense only 3 log units in most uniform scenes.

References

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