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Color Assimilation and Contrast near Absolute Threshold

John J. McCann
McCann Imaging, Belmont, MA 02478 USA

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John McCann
McCann Imaging, 161 Claflin St., Belmont MA, 02474, USA

ABSTRACT

Simultaneous Contrast and *Assimilation* test targets are almost always viewed at high light levels. We measured the appearances of *Simultaneous Contrast*, *Assimilation* and other spatial surrounds near absolute rod threshold. Given the very different spatial organizations of receptive fields in rod and cone vision at detection threshold, it is not obvious that these familiar cone-vision spatial effects would be observed at rod light levels. Nevertheless, the spatial experiments showed that these targets have the same changes in appearance as those observed in bright light. Our experiments used very dim candle light that was above threshold for rods and L cones, and below threshold for M and S cones. Although detection threshold experiments show very different spatial organizations for rod and cone vision, we found that spatial contrast experiments gave the same changes of appearance. Neural contrast mechanisms at the lowest end of our visual HDR range are very similar to those at the top of the range in sunlight. This is true for both chromatic and achromatic targets.

Keywords: HDR vision, scotopic vision, rod/cone color, spatial interactions, contrast, assimilation.

1. INTRODUCTION

Human Vision has very High-Dynamic Range (HDR). The more than 10 log unit range of responses uses two types of light receptors in the retina. The rods respond to very low light levels; they are 1000 times more sensitive to light than the cones. The cones respond to the highest light levels. Selig Hecht and his colleagues measured the rod and cone responses to light using detection threshold and other psychophysical techniques. In detection threshold experiments, the dark-adapted observer reports when he can see a flash of light. The collection of these experiments show a complex spatial pattern of response to light. Threshold sensitivities vary considerably with stimulus size and retinal position, as well as with its spectra.[1] Rods use pools of receptors to gain sensitivity. Cones make high-resolution foveal vision at higher light levels.

The spatial portrait of rods and cones from detection threshold experiments is that they have markedly different spatial receptive fields.

1.1 Two identical Test Patches (A&B)

Above cone threshold, there are a wide variety of spatial experiments that follow the same null experiment format. These experiments incorporate two identical *Test Patches (A&B)* in a surround area. The common idea is that these identical *A & B* patches look different when viewed in a spatially modified surround. The control experiment always shows that *A & B* look the same when placed in a uniform surround (Figure 1, top). The common result is that the spatial content of the experimental surround can change the *Test Patch* appearances [2-4] These experiments provide a large body of research demonstrating that pixel-based mechanisms, such as rod and cone receptor adaptation cannot account for visual appearance. *Neural Contrast*, namely the spatial interaction of neurons responding to all parts of the image on the retina are needed to predict visual appearance. [5]

Simultaneous Contrast is one of these null experiments. It works well with relatively large Target Patches. If the *A* surround is white, the gray square looks darker; and if the *B* surround is black, the gray square looks lighter. If the surround is blue, the colored square looks slightly more yellow; and if the *B* surround is yellow the colored square looks more blue (Figure 1, bottom).

Assimilation is another set of null experiments with the opposite results. It works best with small Target Patches in a more complex surround. If the *A* adjacent stripes are white, the gray stripes look lighter; and if the *B* adjacent stripes are black, the gray stripes look darker. If the *A* adjacent stripes are blue, the colored stripes look more blue; and if the *B* adjacent stripes are yellow the colored stripes look more yellow (Figure 1, middle).

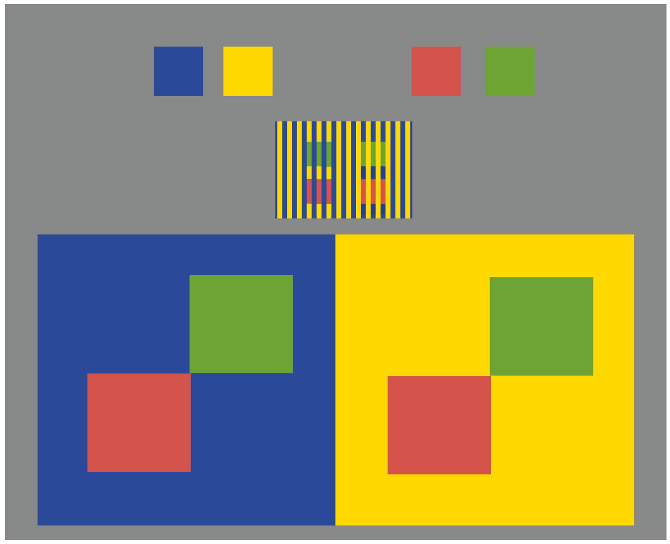


Figure 1 (top) four color samples in the same gray surround;
(middle) the same four samples in an *Assimilation* surround (green and red test stripes on the right - yellower);
(bottom) the same four samples in a *Simultaneous Contrast* surround (green and red on the left - yellower).

In sunlight the Assimilation surround (Figure 1, middle) the green bars on the left have blue bars on each side, and these green bars have a bluer appearance. The green bars on the right have yellow bars on each side, and these green bars have a yellower appearance. The same is true for the red bars below the green ones. They look bluer adjacent-to-blue; and yellower adjacent-to-yellow. *Assimilation* colors correlate with cone crosstalk across edges. [6]

In sunlight the *Simultaneous Contrast* surround (Figure 1, bottom) the green square on the left has blue on each side, and this green square has a yellower appearance. The green square on the right has yellow on each side, and it has a bluer appearance. The same is true for the red squares below the green ones. They look yellower adjacent-to-blue; and bluer adjacent-to-yellow.

Assimilation produces large color changes towards the color of the adjacent stripes. *Simultaneous Contrast* produces small changes in the opposite direction from the color of the surround.

We measured the appearances of *Simultaneous Contrast, Assimilation* and other spatial surrounds near absolute rod threshold. The hypothesis was that given the very different spatial organizations of rod and cone vision, it is not obvious that these familiar cone-vision spatial effects would be observed using rod vision.

2. SPATIAL PROPERTIES OF RODS

At rod absolute threshold we can detect a flash of 4 to 6 photons. [7] We cannot see any objects; all we can do is detect the presence of light. Increasing the illumination does two things: it allows us to see ill-defined forms, or colorless shapes, and it causes rod vision to light adapt, thus raising detection threshold. Unlike film with fixed sensitivity to light, vision both *dark adapts* to gain sensitivity, and *light adapts* to lose it. [8] Further increases in illumination make shapes clearer, and then sharper, and then colorful, and then bright, and then dazzling. The other end of human dynamic range is snow on top of a mountain.

Light adaptation, caused by bleached photopigment, sends a signal out of the retina until the rods and cones have regenerated all the bleached photopigment.[9, 10] Exposure to light creates a light-adapted floor that determines the minimum detectable stimulus at that moment.

Mountaintop snow bleaches so much photopigment that it takes more than 30 minutes in total darkness to approach absolute threshold again. Just because the eye can detect light over this 10 log unit range, does not mean that we can see details in a particular scene over that range. *Dark Adaptation* is a slow chemical process that follows the regeneration of rhodopsin in the pigment epithelium and re-migration back into the rod outer segments.[8] *Light Adaptation* is a fast neural process that is a different mechanism. Light and dark adaptation have very different rates of losing and regaining sensitivity. It is not a simple reciprocal mechanism. As well, pupil size has an asymmetric response to light and dark, with fast and slow responses. The complex balance of pupil size, light-, and dark-adaptation is scene dependent, and sets the floor of the range limits of what we see at a given moment.

This paper studies what we see near absolute threshold, rod vision and the low radiance end of human HDR vision. In particular, it looks for changes in the way we process spatial information. Such changes are possible because of the many differences in anatomy and physiology of rods and cones. These differences can be measured in the comparisons of resolution limits and spatial frequency responses for rods and cones. [11]

2.1 Dark Adaptation Curves

Hecht and colleagues measured the recovery of sensitivity in the dark following light adaptation.

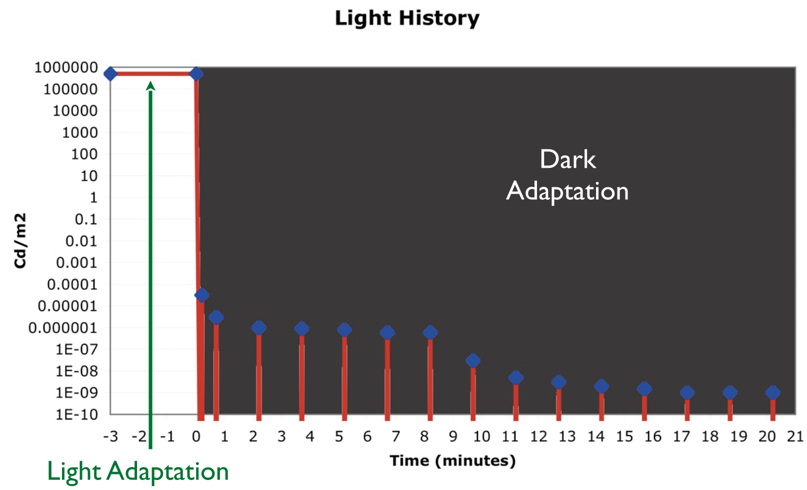


Figure 2. Light history of Hecht's experiment measuring dark adaptation. Following three minutes of light adaptation to 500,000 cd/m2, they measured the amount of blue light at detection threshold. The upper branch showed dark adaptation of the cones, white the lower branch showed that of the rods. Rods continue to gain sensitivity for 30 minutes. [12]

2.2 Size and Position

Hecht and colleagues[1] (see Pirenne, 1962 for review) measured rod absolute threshold using a wide variety of test spots, varying in size and retinal position. After 30 minutes of dark adaptation they found:

- increasing the size of the centrally fixated target from 2° to 20° increased the sensitivity to light by a factor of 300.
- moving a 2° spot from central fixation to 10° eccentricity increased the sensitivity to light by a factor of 200.
- with central fixation, a 20° annulus has the same very low threshold as a 20° filled circle.

Absolute threshold is the result of pools of receptors that vary in size with retinal eccentricity.

2.3 Binocular Matching

Craik (1940)[13] and Wright (1946)[14] used binocular matching experiments to compare subjective brightnesses under different states of adaptation. Observer stated whether the right-eye test field looks the same as left-eye test field when the state of adaptation of the two eyes were different. The results showed that adjusting stimuli luminances can compensate for adaptation. Pirenne summarized the results as follows:

> "These experiments have an obvious bearing on the common observation that the eye is very poor at determining absolute levels of luminance, whereas ... it can be very efficient at detecting differences in luminance. They established the curious fact that a 1 sec luminance flash of 10 cd/m^2 presented to the dark-adapted eye appears subjectively brighter than a steady field of 50,000 cd/m^2 to which the eye has become fully adapted."[1] (page 200)

3. ROD / LCONE COLOR

We studied chromatic targets near the absolute sensitivity threshold. We used illumination that was so dim that it stimulated only the rods just above their absolute threshold.

In order to make a colored image we have a minimum set of requirements:

- two independent sets of information;
- two different bands of wavelengths for that information;
- two independent retinal receptors, with different spectral sensitivities (such as: rods, L, M, S cones).

The information can be from colored papers in daylight illumination, or color separation information sent to independent color channels of printers or displays.

Working backwards from retina to the illumination, we need two different retinal receptors with different spectral sensitivities. The rods have the highest sensitivity. To see colors with the least amount of light, at the lowest end of the human HDR range, we should use the rods as one of the two receptors. Historically rod vision has been studied using daylight spectra, or other very broad band light. As well, rod vision has been studied using very narrow band light. Under these conditions rod vision appears achromatic.

Stabell and Stabell[15, 16] found colors from the interactions of rods with cones. McCann and Benton [17] used low-voltage tungsten light that emitted much more long-wave, than short-wave light. They observed the wide range of colors expected for two-color vision. They verified that these colors were the result of rod/L-cone interaction with experiments using rod vs. cone physiological properties. McCann, et al.[18] reviewed these experiments that included:

- dark adaptation curves
- measured action spectra- photopic/scotopic
- Stiles-Crawford Effect
- flicker fusion frequency
- apparent sharpness

Colors generated by the least amount of light will use the rods to detect the shorter-wave light, and L-cones to detect long-wave light.

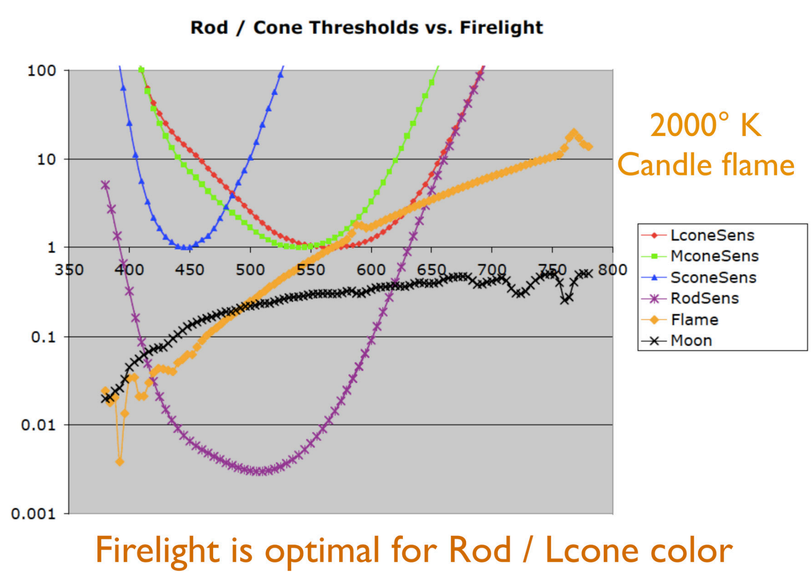


Figure 3 plots the threshold spectral sensitivity of rods and L, M, S cones (amount of light vs. wavelength). As well, it plots the measured spectra for flame and moonlight. Low intensities of moonlight stimulates only the rods. Increased amounts of moonlight stimulates L and M cones. Firelight (2000° K) is rich enough in long-wave light to stimulate the rods and the long-wave cones. Rods and long-wave cones generate color appearances near absolute threshold.

Colors are best with the right balance of long-wave to short-wave light.[19] In order to balance the much greater rod sensitivity, we need minimal short-wave light (Figure 3). As well, we need much more long-wave light to balance the L-cones insensitivity. Firelight, a 2,000°K blackbody radiator, has the desired balance of spectral light. [20]

4. EXPERIMENTAL PROCEDURE

We studied the appearance of the test target in Figure 1 at low levels of illumination at a distance from a single candle.

4.1 Methods

All experiments were conducted in the middle of the night in a room without illumination, and with shaded windows. Four observers were dark adapted a minimum of 1 hour before making observations. The light source was a single wax candle flame at a distance of 20 feet. Observers had their backs to the light and held a printed test target paper (at 16 inches) so that nearly uniform light passed over their shoulder onto the paper target. Each observer repeated the task four times in different trials.

4.2 Control experiment for rod/ L-cone color vision

We used prints of Figure 4 (left) for identifying rod/L-cone vision. The left side shows the color test target with green and blue letters.

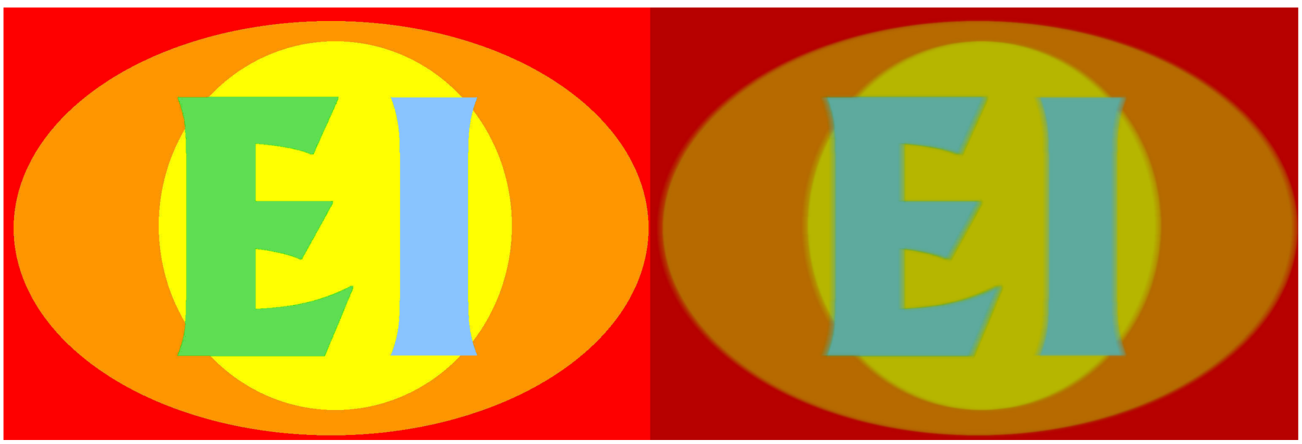


Figure 4 (left) the test target for rod / Lcone color when viewed in sunlight; (right) simulated appearance of this target in candle light. The green and blue color were chosen to have the same scotopic reflectances. Above M and S cone thresholds **E** is green and **I** is blue. Below M and S cone thresholds they have the same appearance. With rod and Lcone color vision **E** and **I** appear the same cyan.

These letters were selected to have the same average scotopic reflectance. When viewed in firelight all letters appear cyan when the target is at 20 feet from the candle flame (Figure 4 right). However, if it is held very close to the flame (1 foot), so that there is enough firelight to stimulate all the cones, the observers see distinct blue and green letters. We can use this control experiment to insure that we have viewing conditions that excite only rods and L-cones.[21]

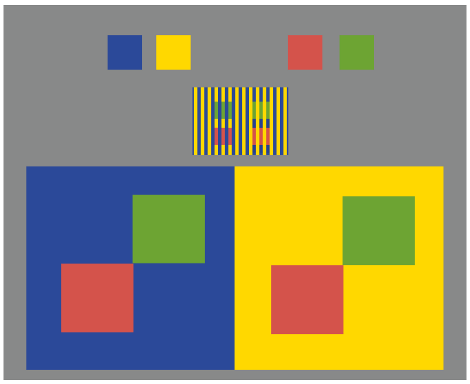
5. RESULTS

Table 1 shows the 4 colors used in these displays. Blue and yellow were background colors. Red and green were central test colors. *Color Simultaneous Contrast* works well with large angular subtends, while *Color Assimilation* works best with very small visual angles.

The *Color Assimilation* target in Table 1 divides the background and target into narrow blue and yellow stripes. The green test stripes are above the red test stripes. Observers report large changes in color. The top green stripes appear more blue on the left, and more yellow on the right. The lower red stripes are also more yellow on the right.

The *Color Simultaneous Contrast* target in Table 1 uses large solid background areas and test areas. The green squares are above the red squares. Observers report small changes in color. The top green square appears slightly more yellow on the left, and slightly more blue on the right. The red square is also slightly more yellow on the left.

Table 1. Examples of human color spatial image processing.

Target	Name	More Yellow on Rods/L-Cone	More Yellow on LMS Cones
	Colors Used		
	Assimilation	Right	Right
	Simultaneous Contrast	Left	Left
		Firelight	Daylight

The Assimilation Target causes a large changes towards more yellow on the right, while Simultaneous Contrast causes a small changes towards yellow on the left for both red and green test areas.

In Table 1 "More Yellow on Rods" column (Firelight) reports the position of appearances with more yellow in both the red and in the green test areas. For *Assimilation* with rod/L-cone color stripes were more yellow on the right for both red and green test colors. The same was true for L, M, S cone vision (Daylight).

For *Simultaneous Contrast* observers reported more yellow on the left with both rod/L-cone color and L, M, S cone color.

All observers, in all trials, reported that these A/B targets behaved: "almost the same" for both viewing conditions.
We found that color vision has consistent spatial behavior near absolute threshold and in bright sunlight. When we examined these targets using intermediate luminances we found considerable changes in apparent sharpness associated with retinal inhomogeneity. The green and blue hues change appearance by looking more cyan at low light levels.

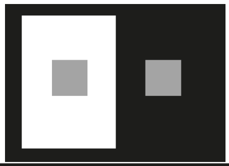
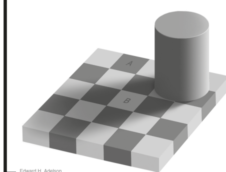
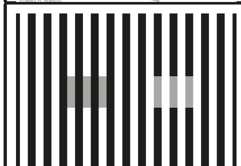
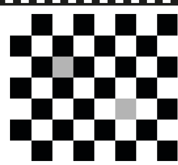
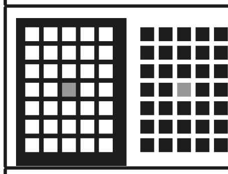
Color A/B appearances are controlled by scene dependent spatial mechanisms. The limits imposed by the human visual system cannot be analyzed by pixel-based techniques. These limits are controlled by the two opposing spatial mechanisms: glare and Neural Contrast.[5] The dynamic range of a real-life scene is limited by glare. The light on the retina is the sum of the image of the scene plus unwanted scene-dependent glare. However, we have scene-dependent *Neural Contrast* mechanisms that act to counteract glare. The scenes that generate the most veiling glare have the lowest retinal contrast, and the greatest apparent contrast.

Neural Contrast is a general name for all the spatial interactions found in Assimilation, Simultaneous Contrast and other spatial effects. These are not threshold phenomena. They are the result of supra-threshold interactions that are distinct from detection threshold mechanisms. The targets studied in this paper provide evidence that these Neural Contrast mechanisms have different properties from those measured by detection thresholds.

6. ACHROMATIC ROD RESPONSE TO TWO IDENTICAL TEST PATCHES (A&B)

McCann asked observers to report of the appearances of *A&B* test grays using the following spatial phenomena: Simultaneous Contrast, Adelson Tower, Whites Effect Assimilation, Devalois' Checkerboard, Dungeon Illusion, Benary Cross.[22] After fully dark adapting, observers viewed these printed targets just above absolute rod threshold. The amount of light was 100 times below L, M, S cone thresholds. Observers reported whether the left, or the right *Target Patch* appeared darker. The observations were made six times with variable orientation of the targets. When viewed with rods alone, near the absolute threshold of vision, do they behave: the same, almost the same, or differently? All reports, for all test targets were the same for rods as those measured above cone threshold. (Table 2)

Table 2 shows the variety of achromatic Assimilation and Simultaneous Contrast test targets viewed at light levels for rods only and for sunlight (above all cone thresholds).

	Name	Lighter on Rods	Lighter on Cones
	Simultaneous Contrast	Right	Right
	Adelson's Tower	Right	Right
	White's Effect	Right	Right
	Devalois Checkerboard	Right	Right
	Dungeon Illusion	Right	Right
	Benary's Cross	Right	Right

6.1 Relative Apparent Lightness - Rod Vision

McCann's experiments asked observers to identify the lighter of the two gray areas.[19] The experimenter gave the observer a stack of paper test targets to view at 18 inches. Each target was rotated 180°, half the time. The observers' task was to rotate the printed paper so that the lighter gray appearance was on the right. In any experiment, roughly half of the pages were rotated 180°. The observers went through the stack of six achromatic test targets. Later, the experimenter tabulated the results for rod vision. All observers, in all trials, reported the same result for rod only vision. In Table 2 the targets are arranged so that the right test gray is lighter than the one on the left (Lighter on Rods).

6.2 Relative Apparent Lightness - Cone Vision

The following day in daylight the observers performed the same task using cone vision. We used the same targets, this time in direct sunlight. The same procedure was repeated four times. The luminance of the white paper, measured by a Minolta CS-100 meter was 14,600 cd/m^2 (x=0.32, y=0.33). The result are tabulated in Table 2 (Lighter on Cones).

Above cone threshold, all observers reported the same result for these six test targets, for all trials. These targets do not show variable appearance with different observers, and different trials. All observers reported that the relative magnitude of the change in lightness was "about the same" in rod and in cone vision in sunlight.

7. LIMITS OF ROD VISION

The limits of the range of appearances observed near rod absolute threshold depends on the amount of light, the sizes of the stimulus areas, the position on the retina, and the spectra of the light. For rod-only vision the experience of absolute threshold is simply that one sees the presence of light. One cannot see shapes, or see any degree of contrast, just light. When looking at an array of papers with whites, blacks, grays and colors with luminances 10 times absolute threshold, one sees indistinct forms with low apparent contrast. Light areas and dark areas are visible, but it is hard to distinguish shapes. Squares and circles look almost the same. With luminances 100 times absolute threshold, one sees distinct forms with medium contrast. Image content is visible, with distinguishable shapes. The scene is achromatic as long as the light is below the absolute thresholds of all three cones.

7.1 Achromatic limits of vision

The large rod receptive fields make small objects disappear. There are no rods in the fovea. Just above absolute rod threshold apparent contrast is limited. The whites are very dim.[5] The blacks are medium grays. The higher the luminance contrast of the test target, the greater the visibility with decreasing light levels. Take for example the Simultaneous Contrast target in Table 2. The A and B gray squares are surrounded by luminance extremes. The white/gray and black/gray luminance edges are large. As we walk away from the light sources described above, decreasing the target luminance, we observe the different appearances of the grays at very low light levels.

By comparison, if we repeat the experiment looking at the Tower experiment (Table 2), we get different results. The target is lower in contrast and is made of light gray/ dark gray luminance edges. With rod vision at higher light levels the A/B appearances are clearly different. With decreased illumination, observers have difficulty seeing the edges in the checkerboard. The image structure disappears and all the checkerboard edges are invisible. At this light level the A/B difference for the checkerboard is gone, while the A/B difference for *Simultaneous Contrast,* with larger edge ratios, is still clearly visible.

Size of gray test areas is also important. Figure 5 shows Pawan Sinha's Double gradient experiment [23] with variations of larger A/B gray areas.

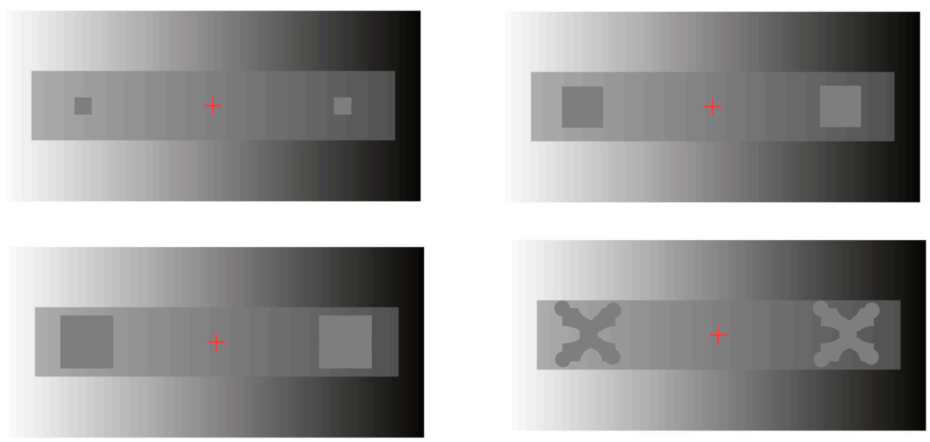


Figure 5 shows Pawan Sinha's Double Gradient experiment (top left). It has a red + as a central fixation point. On the left and right sides are identical luminance squares. These squares are surrounded by an apparently uniform gray surround that is actually a luminance gradient - greater on the left than the right. It appears uniform because of the second outside gradient - again with greater luminance on the left. The outer gradient makes the inner gradient look almost uniform. The edge ratios between the squares and inner gradient are different and responsible for the different A/B appearances. Variation 1 (top right) and Variation 2 (bottom left) have still larger gray squares; Variation 3 (bottom right) has a longer gray perimeter.

Observers viewed the four variations on an 8.5 by 11 inch print, at 16 inches viewing distance. First, they studied the print in sunlight. The magnitude of the A/B differences appeared about the same in all Variations. In the rod vision part of the experiment, observers compared the four variations of the Double Gradient experiment while walking away from the light source. On rod vision, with higher luminances, all four have the same differences in A/B appearances. At greater distances the smallest squares disappear, while the larger test areas are still visibly different. In all Variations the A/B differences are visible as long as the squares are visible. However, as the squares get dimmer, the squares disappear, and the A/B spatial effects disappear.

Although detection threshold experiments show very different spatial organizations for rod and cone vision, we found that supra-threshold spatial vision experiments gave the same changes of appearance for *A&B* test Patches. Spatial interactions at the lowest end of our visual HDR range are very similar to those at the top of the range in sunlight. This is true for both chromatic and achromatic targets. Other control experiments indicate consistent behavior over the entire range. All of the tested spatial demonstrations gave "almost the same" observer responses over the HDR range of illumination. There were considerable changes in apparent sharpness associated with retinal organization. There were changes in color hue due to changes in spectral sensitivity. However, the spatial comparison processes showed remarkably similar appearances, despite the well known changes in the anatomy physiology of rods and cones.

Neural Contrast at the lowest end of our visual HDR range are very similar to those at the top of the range in sunlight. This is true for both chromatic and achromatic targets.

7. SUMMARY

The Neural Contrast mechanisms that generate *Assimilation* and *Simultaneous Contrast* and other spatial effects are very similar over the HDR range of human vision. Despite different spatial pooling of the rods and the cones as measured by detection threshold, supra-threshold spatial effects remain consistent. Observers report changes in sharpness and hues, but not in the spatial interactions found in *Assimilation* and *Simultaneous Contrast.*

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REFERENCES

[1] Pirrene, M. H.,"Part 1: Visual Functions in Man" in The Eye: 2 The Visual Process, Davson H. ed., Academic Press, New York, 3-218 (1962).
[2] Albers, J., [Interaction of Color], Yale University Press, New Haven (1963).
[3] Land, E. H., and McCann, J. J., "Lightness and Retinex Theory," J. Opt. Soc. Am. 61, 1-11 (1971).
[4] Gilchrist, A., [Seeing Black and White], Oxford University Press, Oxford, (2006).
[5] McCann J. J., and Rizzi, A., [The Art and Science of HDR Imaging], Wiley, Chichester (2012).
[6] McCann J. J., "When do We Assimilate in Color?," Proc. IS&T/SID Color Imaging Conference, Scottsdale 10, 10 - 16 (2002).
[7] Hecht, S., Shlaer S., and Pirenne M. H., "Energy, Quanta and Vision," J. Gen. Physiol., 25, 819 (1938).
[8] Dowling, J. E., [The Retina: An Approachable Part of the Brain], Belknap Press, Cambridge, (1987).
[9] Alpern, M. and Campbell, F. W., "The behaviour of the pupil during dark adaptation," J. Physiol. 165, 5-7 P (1963).
[10] McCann, J. Pupil Response to Light, Senior thesis, Harvard College, (1964).
[11] Savoy, R. L., "Low Spatial Frequencies and Low Number of Cycles at Low Luminances", J. Photogr. Sci, Eng., 22, 76-79 (1978).
[12] Hecht, S., and Shlaer S., "An adaptometer for measuring human dark adaptation," J. opt. Soc. Am. 28, 269-275 (1938).
[13] Craik, K. J. W., "The effect of adaptation on subjective brightness," Proc. roy. Soc. B. 128, 232-247(1940).
[14] Wright, W.D.,[Researches on normal and defective colour vision], Kimpton, London, (1946).
[15] Stabell B., "Color Threshold Measurements in Scotopic Vision", Scand. J. Psycho. I., 8, 132 (1967).
[16] Stabell U., and Stabell B., "Chromatic rod-cone interaction during dark adaptation," J. opt. Soc. Am. A 15, 2809-2815 (1998).
[17] McCann J. J., and Benton J. L., "Interactions of the Long-wave Cones and the Rods to Produce Color Sensations," J. Opt Soc Am 59, 103-06 (1969).
[18] McCann J. J., Benton J. L., and McKee S. P., "Red/White Projections and Rod-Lcone Color: An Annotated Bibliography", J. Electronic Imaging, 13, 8-14 (2004).
[19] McKee S. K., McCann J.J., and Benton J. L., "Color Vision from Rod and Long-Wave Cone Interactions: Conditions in which Rods contribute to Multicolored Images", Vis. Research 17, 175-85 (1977).
[20] McCann J. J., "Ideal Illuminants for Rod /L-Cone Color, Processing," Color Imaging XI: Processing, Hardcopy, and Applications, Proc. SPIE 6058, 605801-605808 (2006).
[21] http://web.me.com/mccanns/Color/Rod_Color_Demo.html
[22] McCann J. J., "Appearance at the low-radiance end of HDR vision," Proc. IS&T/SID Color Imaging Conference, San Jose 19, 186-190 (2011).
[23] Sinha, P., "Brightness induction from unseen cues," Perception (in press).