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DIFFERENTIAL COLOR PERCEPTION THEORY

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ABSTRACT

Trichromatic and Opponent-process color theories has introduced some complicated systems for color mixing and color perception.
Bothe theories has assumed three color receptors as principle color sensors for generating any colored scene; one receptor for shortwave called S-cone and another for medium wavelength called M-cone and another one for long wave length called L-cone.
Our approach to this inspiring phenomena has different simple assumption and distinct proposal for color mixing and perceiving.
Human color sight vision can be distinguished only by two color receptors, *Long* and *Medium*.
Each receptor gain signal has its own value and polarity with respect to each incident electromagnetic wavelength through the whole visible spectrum.
Blue color is only a color summation of (negative Red) and (negative Green), or it is just as -(Red+Green).
S-cones with rods surrounding the fovea of our retina work together for night vision and dim light perceiving.
color sense is now analogous to the other four known human senses since it has only two inversely related variables, i. e Positive (Red+Green) and negative (Red+Green).
After-image phenomena and simultaneous contrast explain the color polarity for the same receptor as well.
Cones topography on our retina coincide with our principle assumption, since the S-cones is approximately absent from the fovea spot (the most color sensitive part of our retina) and they spread with relatively very small population around the fovea in between rods (Williams et al., 1981) .

INTRODUCTION

Our four sensing systems, smell, touch, taste and hearing systems working with the same differential principal , depending on the rule of opponency, as easy as we consider that bitter is only the lack of sweat, cold is the lack of heat, darkness is the lack of light and blue is only the lack of yellow. It is going exactly with the law of conservation of energy, you can't get something from nothing.

In general, negative values is only the lack of the positive ones. It goes as Psychophysical process throughout our sensing systems as well.

Although Trichromatic and opponent process theories have solved some puzzles of the color phenomena but they still have some complicated three dimensional explanations to our fifth beautiful sense of vision and color perception.
Accordingly it seems wise enough to have some other theory for better understanding and simpler manipulation analogues to the other four senses in due.
"Differential Color Perception Theory" has been considered as a new color theory very analogues to the four human senses in the way mentioned above.
It is simple as "blue is only the lack of yellow".
This will go correct for all the components of yellow perception relative to the components of blue..

1. Biological differential colour perception amplifier

Figure 1 illustrates a synaptic network analogous to the conventional electronic differential amplifier (Delton T. Hom,1994).

The red triangular block shown on figure 1 stands for the whole synaptic network including L-cone receptor at the input gate followed by bipolar cell ended with ganglion cell at the output. Horizontal cells and Imecrene cells are included inside the symbolic triangle to perform positive and negative feedback effects for colour adaptation and hysteresis (Ido Perlman, 2012).

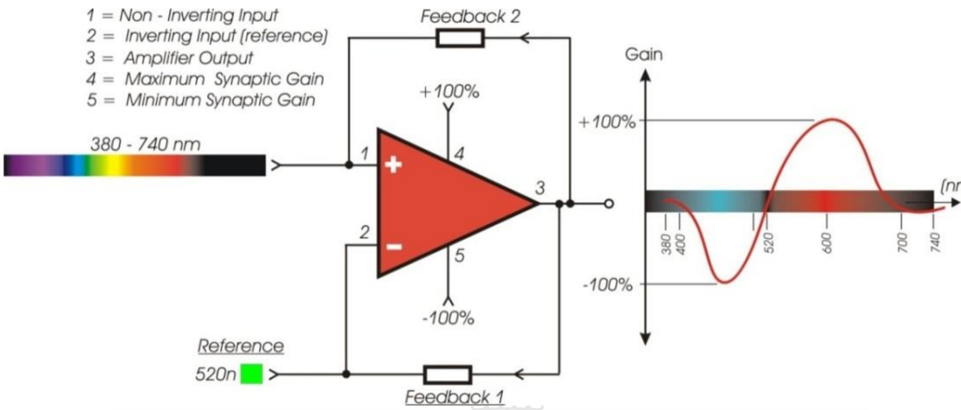

Figure 1. Red biological differential amplifier (RBDA).

Figure 2 shows the network effect of green biological differential amplifier**.**
The green triangular block contains M-cone receptor at the input followed by bipolar cell and ganglion cell at the output, horizontal cells function for negative and positive feedbacks to perform gain control and hysteresis.

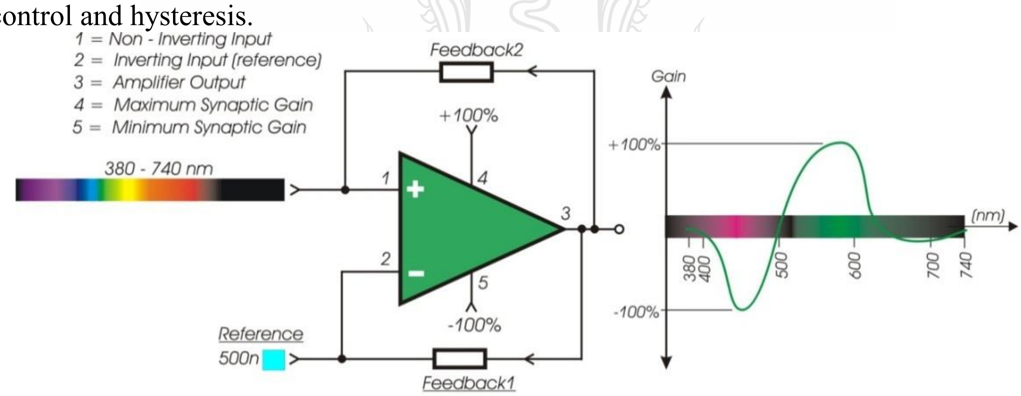

Figure 2. Green biological differential amplifier (GBDA).

2. L and M- receptors characteristic curves

Imposing outputs of RBDA and GBDA together will introduce L and M-receptors characteristic curves as shown on figure 3

3. Assumptions Analysis

Referring to figure 1. or figure 2. it can be expressing the illustration mathematically as shown on equation (1)

$$(V_1 - V_2)G = V_o \qquad (1)$$

Where: $V_1 = input\ \ 1\ to\ the\ differentiator$
$V_2 = input\ 2\ to\ the\ differentiator$
$V_o = output$
$G = Gain$

Considering the transfer function (1) it is possible to estimate three possible output states :

1. V_o will be positive if $V_1 > V_2$
2. V_o will be negative if $V_1 < V_2$
3. V_o will be zero if $V_1 = V_2$

According to the analogues electronic differential amplifier principal the red biological differential amplifier shown on figure 1 will flip its output to negative response for all the incident colour radiations less than a reference wave length of 520nm, our mind will perceive it as cyan with peak value at 480nm.

For all the incident colour radiations more than *520nm* it will flip the output to positive response and our mind will perceive red color with a peak value at around *600nm*.

If the incident colour is around *520nm* the output will be zero and our brain will perceive black.

For figure 2 the green biological amplifier will flip to negative response as far as the input incident spectrum is less than 500nm, this will lead to magenta perception with a peak value at 460nm.

For all the incident wavelengths more than a reference wavelength of 500nm the green biological differential amplifier will flip to green with its peak value at 570nm.

If the incident color is *500nm* the output will be zero and black will be perceived as default.

Our brain will receive two outputs one from the red differential amplifier and another from green differential amplifier, this will lead to full visible spectrum perception as shown on figure 3.

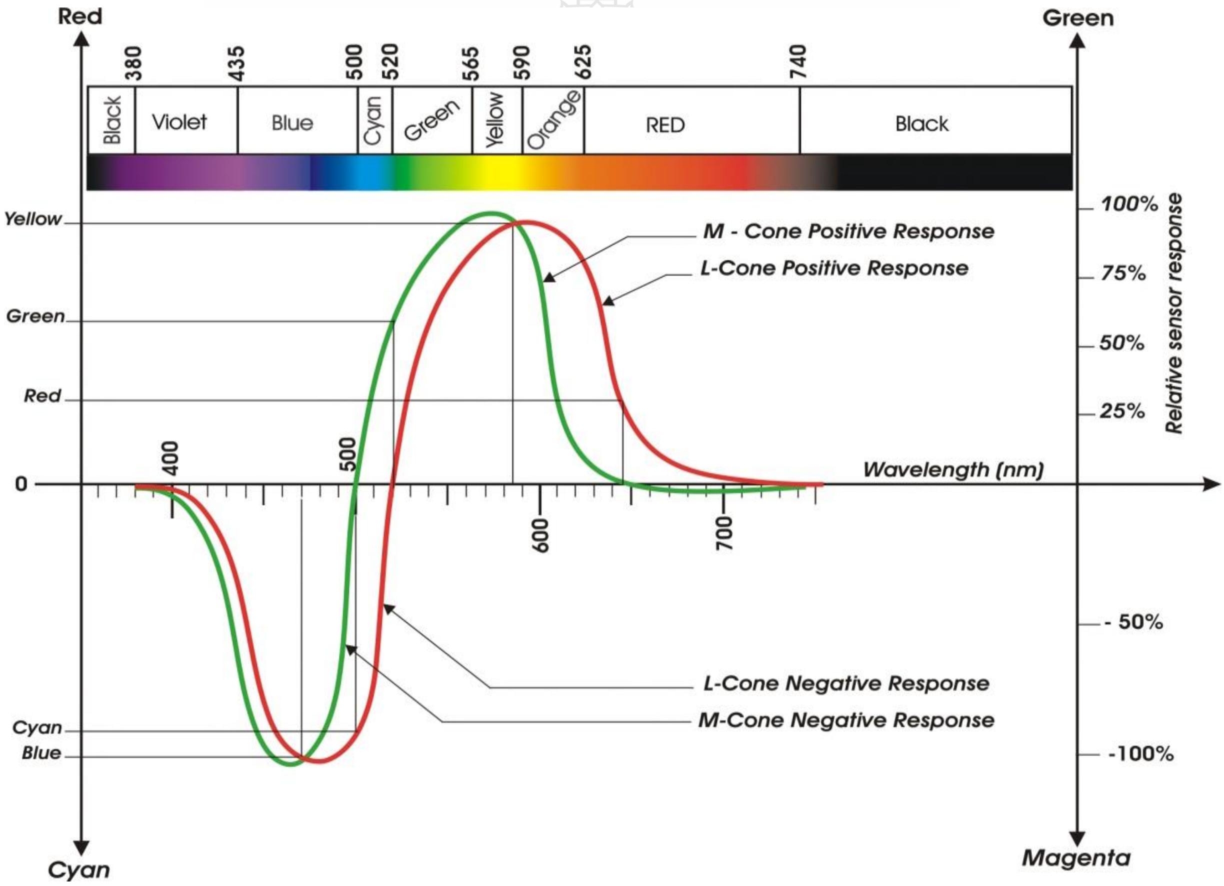

Figure 3. M and L- receptors characteristic curves

4. Colour space of Differential Colour Perception theory

Only two axis in the Cartesian space is enough to represent any color of our visible spectrum (figure 5)

Any point on the colour space of figure 5 expressing a specific colour with two components of Red and Green, P_1 is a point on the R-axis with 100% Red and 0% Green, it can be written as P_1(100,0) which is 100%Red, Blue can be located at P_6 (-100,-100).

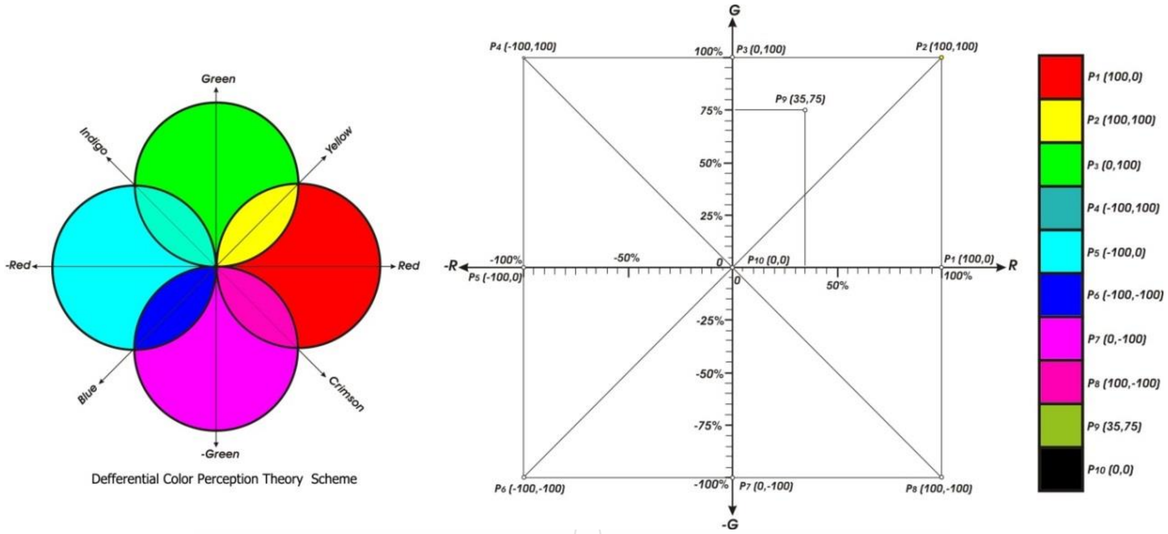

Figure 5: Colour scheme and color space of differential color perception theory

5. Perception Modes

In the night mode of our vision system we depend on rods and S-cones together for better sight details recognition.

Since night vision and dim light are genuine in the life of all mammals spices all the time the S-cone is genuine as well.

In the daylight mode one or more colour receptor/s could be far enough for better sight vision.

Due to the effect of those two different modes we could notice many differences in the genetic structure and locus of the S-cone visual pigment compared with the L- and M-cone pigments in out retina (Nathans et al., 1986), yet the S-cones are common to all vertebrate retinas and always form a consistent 8-10% of the cone photoreceptor population (Marc, 1982; Kolb and Lipetz, 1991).The S-cones are however, very few in the fovea center so causing a so-called S-cone blind spot (Williams et al., 1981) but they peak in number on the foveal slope at about 12% of the population.The pathways for transmitting information from S- cones to ganglion cells appears to be different from the midget pathways for the medium and long wavelength cones, the latter two chromatic pathways are via midget bipolar and midget ganglion cells connections related to a single spectral type of cone, either L- or M-cones

ACKNOWLEDGEMENTS

According to the characteristic curves of red and green biological differential amplifiers color mixing has to follow different color sets as ±(Red+Green), or simply as Red, cyan, Green and magenta. Or as an abriviation of (RcGm). *R* stands for Red, *c* stands for cyan, *G* stands for Green, *m* stands for majenta instead of RGB or CMYK systems.

REFERENCES

-Ido Perlman, Helga Kolb and Ralph Nelson, The Organization of the Retina and Visual System*, S-Potentials and Horizontal Cells* (1).

- Delton T. Horn, *Basic Electronics Theory*, 4th ed. McGraw-Hill Professional, 1994, p.342-343
- http://www.britannica.com/EBchecked/topic/1688997/*human-eye*/64937/Responses-of-uniform-population-of-receptors#toc64938
- Göran Darius Hildebrand and Alistair R. Fielder, *Anatomy and Physiology of the Retina, (39)*
- Hecht, Eugene, *Optics*, sec. (5.7), 2nd Ed, Addison Wesley, 1987
- Nathans J, Thomas D, Hogness DS. Molecular genetics of human color vision: the genes encoding the blue, green and red pigments. Science.1986;232:193–202. [PubMed]
  - Marc RE. Chromatic organization of the retina. In: LaVail M, Hollyfield J, editors. Cell biology of the eye. New York: Academic Press; 1982. p.435-473.
  - Williams DR, MacLeod DIA, Hayhoe M. Punctate sensitivity of the blue-sensitive mechanisms. Vision Res. 1981;21:1357–1375. [PubMed]