There is no color without light . . . but

there are colors . . .

. . . and colors

Summary

Years of research and teaching in Optics and Photonics, particularly on the perception, recording and reproduction of shapes, volumes (3D, stereoscopy, holography, . . .) and colours (radiometry, photocolorimetry, . . .) had led me to believe that I had got a « *full overview on the subject*. »

Yet . . . attending commented paintings exhibitions challenged me : *could the way of treating « color » by scientists and artists be different* ? [1]

It is important to remember that ***color is not a physical quantity***, it cannot be quantified by a number followed by a unit : ***it is a sensation created by our brain***. [2]
The difficulty in understanding it prevented for a long time from making it the basis of an art and drawing prevailed until *Isaac* ***Newton*** (1642-1727) established at the beginning of the 17th century that ***white light is not homogeneous but is a continuous set of visible colors (hues)****, those of the spectrum* (from violet to red via blue, green, yellow and orange). [3]

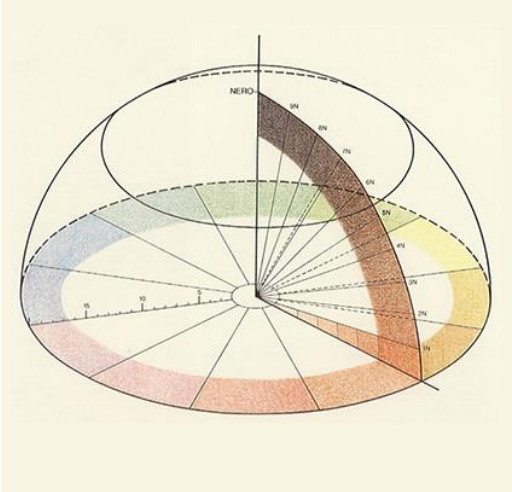
On an artistic perspective, the mid-19th century marked an essential turning point when *Michel-Eugène* ***Chevreul*** (1786-1889) established a general law which governs the perception of relationships between contiguous colors : ***the law of simultaneous contrast of colors*** (1839). [4] *The exploitation of Chevreul's ideas*, even if it was not theoretically obvious, *led to the abolition of gray tones, to an ever greater luminosity in paintings and to a pictorial expression based on colored contrasts*. A revaluation of color followed which exerted a considerable, although indirect, influence on several generations of painters, *Delacroix*, the Impressionists and post-impressionists (*Van Gogh, Gauguin, Cézanne, Seurat, Signac, . . .*), the symbolists, the futurists, etc.

On a scientific perspective, *Thomas* ***Young*** (1773-1829) was the one who allowed light to present itself in a continuous form of frequencies « all along » the spectrum. ***He revolutionized the understanding of light by establishing the theory of the three primary colors***. [5] The physical theory of color took off in the mid-19th century thanks to the exceptional work of *James C.* ***Maxwell*** (1831-1879) [6] on the

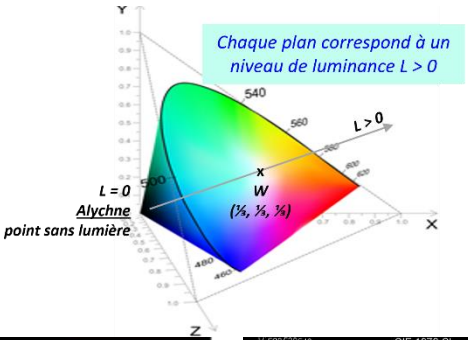
1. Bernard Sohet, lecturer – art historian, *L'impressionnisme, une nouvelle liberté artistique*, « *Paris 1874 : révolution dans l'art* », Musée Wallraf – Cologne, 23/03/2024 ; *Le musée Kröller – Müller : Vincent van Gogh, Claude Monet, Georges Seurat, Pablo Picasso, Paul Gauguin, Kandinsky et Piet Mondrian*, Utrecht, 18/05/2024
2. Yvon Renotte, *La couleur : perception et reproduction*, lecture given at U3A - Liège (Université du Troisième Âge) on May 3 2016, https://hdl.handle.net/2268/258726 ; *La couleur, une question simple ?*, lecture given on June 19 2015 at the University of Strasbourg (France) within « *2015 année internationale de la lumière et des techniques utilisant la lumière – UNESCO* » : ''*iCube en Lumière* '', Campus CNRS de Cronenbourg - iCube / CNRS, 89 slides
3. Isaac Newton, *Optick : a treatise of the reflections, refractions, inflections and colours of light*, four editions from 1704 to 1730, printed by S. Smith & B. Walford, printers of the Royal Society
4. Michel-Eugène Chevreul, *De la loi du contraste simultané des couleurs et de l'assortiment des objets colorés considérés d'après cette loi dans ses rapports avec la peinture, les tapisseries des Gobelins, les tapisseries de Beauvais pour meubles, les tapis, la mosaïque, les vitraux colorés, l'impression des étoffes, l'imprimerie, l'enluminure, la décoration des édifices, l'habillement et l'horticulture*, Paris, Pitois-Levrault (1839) ; reedited in 1889
5. Thomas Young, *The Bakerian lecture : On the theory of light and colours*. Philosophical Transactions of the Royal Society of London, 92 (1802), 12–48 ; *An account of some cases of the production of colours, not hitherto described*. Philosophical Transactions of the Royal Society of London, 92 (1802), 387–397 ; *Experiments and Calculations relative to Physical Optics*, Philosophical Transactions of the Royal Society of London, 94 (1804), 1–16
6. James Clerk Maxwell, *On the Theory of Colours in Relation to Colour Blindness*, Edinb. Transactions of the Royal Scottish Society of Arts, 4 (1856), 394-400 ; https://clerkmaxwellfoundation.org/PUBLISHED_SCIENTIFIC_PAPERS.pdf

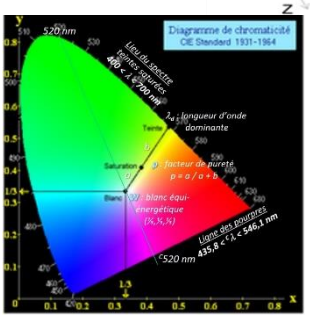
electromagnetic nature of light (1857), and of *Hermann von* ***Helmholtz*** (1821-1894) [7], made aware of Young's work. All the observations were unified and explained by a single theory known as ***the Young-Helmholtz theory of color vision***, which would perhaps be more appropriately called the « *Young-Helmholtz-Maxwell theory.* » Studies carried out from the 18th to the 20th century showed that it is possible to specify a color (tint) very precisely using three parameters : this is ***the basis of the trichromatic theory*** *of color vision*. [8] Based on this principle, the ***CIE*** (*International Commission on Illumination*) has proposed several systems (e.g. CIE 1931 and 1976) allowing any color (tint) to be defined and reproduced with increasing precision and « fitting ». [9]

Hemispherical Chevreul color space

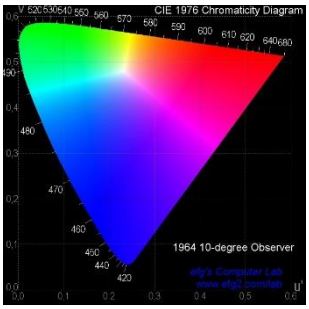


Color space vector representation
each plane corresponds to an intensity level L > 0





CIE 1931



CIE 1976

Following the previous considerations, one can reasonably ask whether scientific and artistic approaches are compatible or exclusive ? They obviously come from (very) different thought patterns, but are they necessarily incompatible or irreconcilable ? Many elements argue in favor of a beneficial complementarity for both Art and Science. *It is therefore not a question of opposing them but rather of seeking and identifying the elements which allow them to support and strengthen each other with a view to mutual emulation and complementarity*.

More information available on [10].

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7. Hermann von Helmholtz, *Handbuch der physiologischen Optik*, (1867) ; *French translation : Optique Physiologique*, Émile Javal et N. Th. Klein, Victor Masson - Paris (1867)
8. Paul Kowaliski, *Vision et mesure de la couleur*, Masson éd., Physique fondamentale et appliquée – 2d edition revised by Françoise Viénot and Robert Sève (1990) ; *CIE 1931 et 1976,* id Chapitre IV et pp.240-244
9. Op cit, pp.48-49 et 240-244 ; https://cie.co.at/publications/colorimetry-3rd-edition
10. Yvon Renotte, https://hdl.handle.net/2268/323862