Munsell color system

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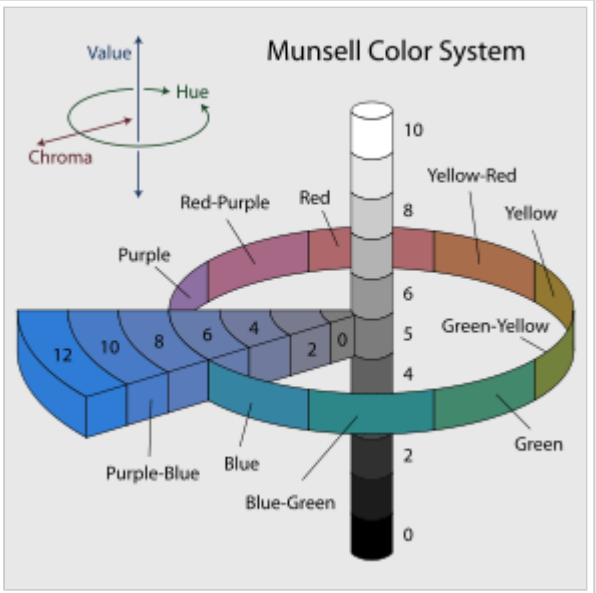


The Munsell color system, showing: a circle of hues at value 5 chroma 6; the neutral values from 0 to 10; and the chromas of purple-blue (5PB) at value 5.

In colorimetry, the **Munsell color system** is a color space that specifies colors based on three color dimensions, hue, value (lightness), and chroma (color purity or colorfulness). It was created by Professor Albert H. Munsell in the first decade of the 20th century.

Several earlier color order systems had placed colors into a three dimensional color solid of one form or another, but Munsell was the first to separate hue, value, and chroma into perceptually uniform and independent dimensions, and was the first to systematically illustrate the colors in three dimensional space.[1] Munsell's system, and particularly the later renotations, is based on rigorous measurements of human subjects' visual responses to color, putting it on a firm experimental scientific basis. Because of this basis in human visual perception, Munsell's system has outlasted its contemporary color models, and though it has been superseded for some uses by models such as CIELAB (*L*a*b**) and CIECAM02, it is still in wide use today. [2]

Contents

Explanation

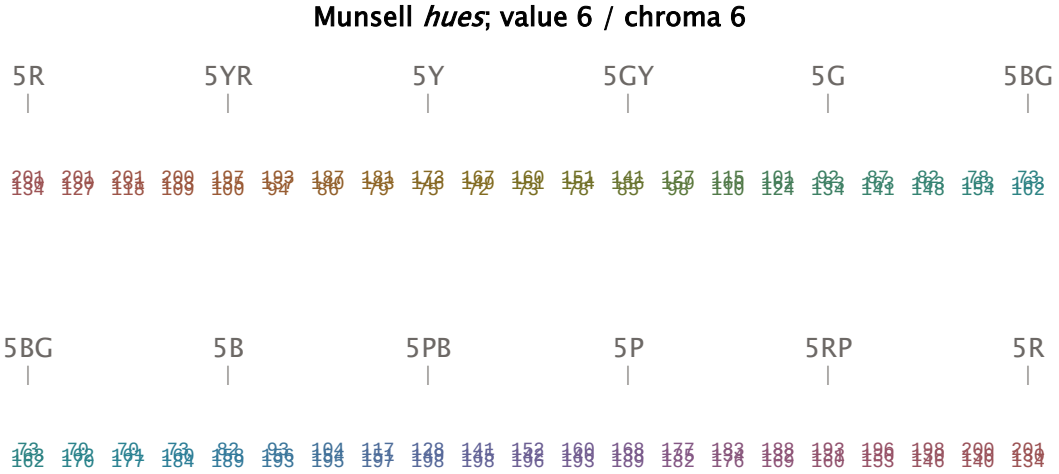
The system consists of three independent dimensions which can be represented cylindrically in three dimensions as an irregular color solid: *hue*, measured by degrees around horizontal circles; *chroma*, measured radially outward from the neutral (gray) vertical axis; and *value*, measured vertically from 0 (black) to 10 (white). Munsell determined the spacing of colors along these dimensions by taking measurements of human visual responses. In each dimension, Munsell colors are as close to perceptually uniform as he could make them, which makes the resulting shape quite irregular. As Munsell explains:

> Desire to fit a chosen contour, such as the pyramid, cone, cylinder or cube, coupled with a lack of

> proper tests, has led to many distorted statements of color relations, and it becomes evident, when physical measurement of pigment values and chromas is studied, that no regular contour will serve.
>
> —Albert H. Munsell, “A Pigment Color System and Notation”[3]

Hue

Each horizontal circle Munsell divided into five principal *hues*: **R**ed, **Y**ellow, **G**reen, **B**lue, and **P**urple, along with 5 intermediate hues halfway between adjacent principal hues.[4] Each of these 10 steps is then broken into 10 sub-steps, so that 100 hues are given integer values. Two colors of equal value and chroma, on opposite sides of a hue circle, are complementary colors, and mix additively to the neutral gray of the same value. The diagram below shows 40 evenly-spaced Munsell hues, with complements vertically aligned.



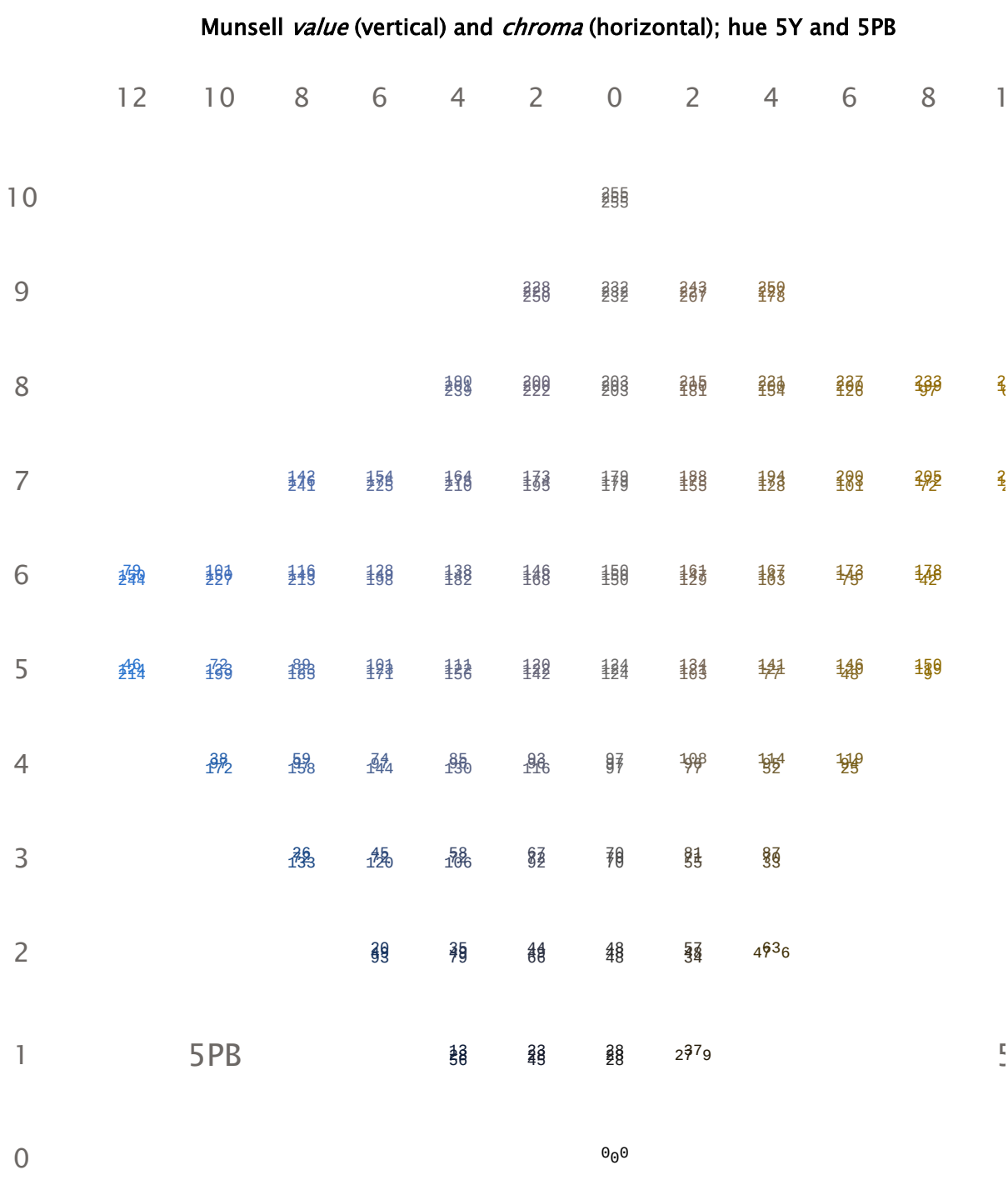
Value

Value, or lightness, varies vertically along the color solid, from black (value 0) at the bottom, to white (value 10) at the top.[5] Neutral grays lie along the vertical axis between black and white.

Several color solids before Munsell’s plotted luminosity from black on the bottom to white on the top, with a gray gradient between them, but these systems neglected to keep perceptual lightness constant across horizontal slices. Instead, they plotted fully-saturated yellow (light), and fully saturated blue and purple (dark) along the equator.

Chroma

Chroma, measured radially from the center of each slice, represents the “purity” of a color, with lower chroma being less pure (more washed out, as in pastels).[6] Note that there is no intrinsic upper limit to chroma. Different areas of the color space have different maximal chroma coordinates. For instance light yellow colors have considerably more potential chroma than light purples, due to the nature of the eye and the physics of color stimuli. This led to a wide range of possible chroma levels—up to the high 30s for some hue-value combinations (though it is difficult or impossible to make physical objects in colors of such high chromas, and they cannot be reproduced on current computer displays).



Specifying a color

A color is fully specified by listing the three numbers for hue, value, and chroma. For instance, a fairly saturated purple of medium lightness would be 5P 5/10 with 5P meaning the color in the middle of the purple hue band, 5/ meaning medium lightness, and a chroma of 10 (see the swatch to the right).

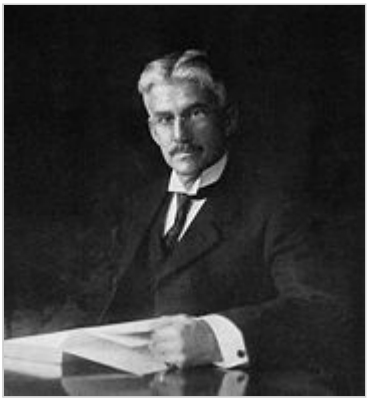
5P 5/10 (#9966B6)

5P 5/10

History and influence

The idea of using a three-dimensional color solid to represent all colors was developed during the 18th and 19th centuries. Several different shapes for such a solid were proposed, including: a double triangular pyramid by Tobias Mayer in 1758, a single triangular pyramid by Johann Heinrich Lambert in 1772, a sphere by Philipp Otto Runge in 1810, a hemisphere by Michel Eugène Chevreul in 1839, a cone by Hermann von Helmholtz in 1860, a tilted cube by William Benson in 1868, and a slanted double cone by August Kirschmann in 1895.[7] These systems became progressively more sophisticated, with Kirschmann's even recognizing the difference in value between bright colors of different hues. But all of them remained either purely theoretical or encountered practical problems in accommodating all colors. Furthermore, none was based on any rigorous scientific measurement of human vision; before Munsell, the relationship between hue, value, and chroma was not understood.[7]

Runge's *Farbenkugel* (Colour Sphere), 1810



Professor Albert H. Munsell

Professor Munsell, an artist, wanted to create a "rational way to describe color" that would use decimal notation instead of color names (which he felt were "foolish" and "misleading"), which he could use to teach his students about color. He first started work on the system in 1898 and published it in full form in *A Color Notation* in 1905.

The original embodiment of the system (the 1905 Atlas) had some deficiencies as a physical representation of the theoretical system. These were improved significantly in the 1929 *Munsell Book of Color* and through an extensive series of experiments carried out by the Optical Society of America in the 1940s resulting in the notations (sample definitions) for the modern *Munsell Book of Color*. Though several replacements for the Munsell system have been invented, building on Munsell's foundational ideas—including the Optical Society of America's Uniform Color Scales, and the International Commission on Illumination's CIELAB (*L*a*b**) and CIECAM02 color models—the Munsell system is still widely used, by, among others, ANSI to define skin and hair colors for forensic pathology, the USGS for matching soil colors, and breweries for matching beer colors.[8][9]

Notes

1. ^ Kuehni (2002), p 21
2. ^ Landa (2005), pp 437–438 (http://www.americanscientist.org/template/AssetDetail/assetid/45931/page/2;jsessionid=aaa5LVF0),
3. ^ Munsell (1912), pp 239 (http://books.google.com/books?id=FdQLAAAAIAAJ&pg=PA239)
4. ^ Cleland (1921), Ch. 1 (http://www.applepainter.com/Chap01/)
5. ^ Cleland (1921), Ch. 2 (http://www.applepainter.com/Chap02/)
6. ^ Cleland (1921), Ch. 3 (http://www.applepainter.com/Chap03/)
7. ^ ***a b*** Kuenhi (2002), pp 20–21
8. ^ MacEvoy (2005)

9. ^ Landa (2005), pp 442–443 (http://www.americanscientist.org/template/AssetDetail/assetid/45931/page/5;jsessionid=aaa5LVF0). Beer color is measured in Degrees Lovibond, a metric based on the Munsell system

References

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- Kuehni, Rolf G. (February 2002). "The early development of of the Munsell system (http://dx.doi.org/10.1002/col.10002)". *Color Research and Application* **27** (1): 20–27. A description of color systems leading up to Munsell's, and a biographical explanation of Munsell's changing ideas about color and development of his color solid, leading up to the publication of *A Color Notation* in 1905.
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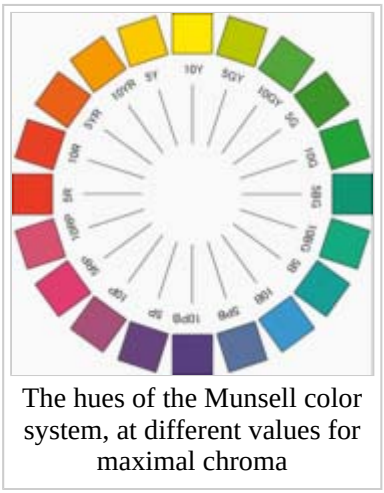
- Nickerson, Dorothy (1976). "History of the Munsell color system, company, and foundation (http://www3.interscience.wiley.com/cgi-bin/jissue/114188682)". *Color Research and Application* **1** (1): 7–10.



The hues of the Munsell color system, at different values for maximal chroma

External links

- Munsell Color Products (http://www.xrite.com/top_munsell.aspx), from X-Rite, current owners of the Munsell Color Company.
- Munsell Color Science Laboratory (http://mcsl.rit.edu/) at the Rochester Institute of Technology, an academic laboratory dedicated to color science, funded by the Munsell Foundation.
  - Munsell renotation data (http://www.cis.rit.edu/mcsl/online/munsell.php) in plain text format (from the 1940s Optical Society of America renotations).
- ApplePainter.com (http://www.applepainter.com/), a site explaining the Munsell color chart, including an edited version of Cleland's book, *A practical description of the Munsell color system*.

- An explanation of the Munsell system (http://web.archive.org/web/20030813092028/www.adobe.com/support/techguides/color/colorn at Adobe.com. Retrieved 13 August 2003
- A brief explanation (http://www.daicolor.co.jp/english/color_e/color_e01.html#Munsell) at the site of the Japanese company Dainichiseika Color & Chemicals, including a nice diagram of the Munsell color solid.
- A flash-based Munsell Palette (http://www.triplecode.com/munsell/) color-picker from web-design firm Triplecode (based on a version originally created at the MIT Media Lab).

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