Notes

Chapter 1

1. For empirical rules, see Purves and Lotto (2002). For an elementaristic approach, see Mausfeld (1998). For relativized conditions, see McLaughlin (2002). On the change in appearance of objects, consider the works of Impressionist painters such as those of Monet who distinctly varied the coloration of his Haystack series and views of the Cathedral of Rouen depending on time of day and/or weather.
2. On the ordinal order of personal spaces, it is well known that only a small percentage of color normal observers perform error-free in the Farnsworth-Munsell 100-hue test where colored caps with small differences in hue must be sorted in correct sequence.
3. For unique hue variation, see Kuehni (2001a). In the *Munsell Book of Colors* the complete hue circle has been divided into 40 perceptually equally different hue steps.
4. On the four cone types in women, tetrachromacy is well established in the animal kingdom. The possibility of tetrachromacy in human females was raised by Jordan and Mollon (1993). Jameson et al. (2001) have investigated the color experiences of females with the genetic potential for having four cone types. The estimate is from Neitz et al. (1998).
5. On adaptation, see, for example, Fairchild (1998). Current usage of the term in the vision science community is limited to processes beginning in the retinal layer. On retinal illumination, actual levels of illumination at the retina are extremely difficult to determine. Instead values based on luminance arriving at the eye, assumed pupil size as well as other assumptions are calculated. The unit of retinal illuminance is the troland.

Color Space and Its Divisions: Color Order from Antiquity to the Present, by Rolf G. Kuehni
ISBN 0-471-32670-4

6. Lux is the photometric unit of illuminance, 1 lux = 1 lumen per m^2; lumen is the unit of luminous flux. A lumen is equal to the flux emitted in a unit-solid angle from a uniform point source of one (standard) candle.
7. CIE is the French acronym for International Commission on Illumination, an international body concerned with technical aspects of lighting and color. For more details on the Munsell color system, see Chapters 2 and 7. The Munsell system is perhaps the best-known color appearance system.
8. The Nickerson-Newhall psychological color solid models are located at the Hagley Museum and Library in Wilmington, DE. The models have been manufactured by Nickerson's assistant K. F. Stultz.
9. CIELAB is a color space and difference formula recommended by the CIE; see Chapter 6.
10. On Schönfelder's law, see Schönfelder 1933.
11. The broad use of the word *sensation* in the historical psychophysical literature makes it impossible to use uniform terminology for these two terms.

Chapter 2

1. A review of color appearance spaces was provided by G. Wyszecki in 1960 and G. Derefeldt in 1991. Information is also provided on the Web site www.colorsystem.com.
2. Xenophanes as quoted in Freeman (1957).
3. Pythagoras as quoted in Mansfeld (1986), translation by the author.
4. Quote from Empedocles in Mansfeld (1986), translation by the author.
5. Quote from Democritus in Mansfeld (1986), translation by the author.
6. Photius as quoted in Gage (1993).
7. Pliny as quoted by Heinrich Meyer in Goethe, *Geschichte der Farbenlehre*, 1810, translation by the author.
8. Ancient Greek sacral colors, *Oxford Classical Dictionary*, 3d ed. New York: Oxford University Press 1996.
9. On Avicenna scales, see Gage 1993.
10. On Eraclius, see Merrifield 1967.
11. On Urso de Salerno, see Gage (1993).
12. Albertus Magnus quoted in Gage (1993).
13. For an analysis of Bacon's work on color, see Parkhurst (1990).
14. For Cennini quote, see Cennini (1933).
15. Leonardo, Codex Urbinas latinus 1270, see McMahon (1966).
16. For Ficino list, see Barasch (1978).
17. For Telesio list, see Goethe (1810), translation by the author.
18. For Cardanus list, see Barasch (1978).
19. Forsius translation and figures from Feller and Stenius (1970) and Parkhurst and Feller (1982).
20. Boethius and figure, see Murdoch (1984).

21. On Oresme, see Murdoch (1984).
22. On Fludd, see Parkhurst and Feller (1982).
23. Newton was not explicit about how he arrived at seven primary colors. It is possible that he saw seven major hues in the spectrum. It is somewhat surprising that turquoise or sea blue is not one of his primary colors, given its prominence in the spectrum. On the other hand, seven was a classical number, and there is the connection to the musical scale that Newton referred to. Perhaps he was consciously or unconsciously influenced by such associations. However, in a recent paper Jameson et al. (2001) show that 52 trichromats, when viewing the spectrum with both eyes, delineate it on average into 7.4 hue ranges.
24. Descartes's figure in Gage (1993).
25. Diderot quoted from Diderot (1798).
26. On C.B., see Parkhurst and Feller (1982) and Gage (1993).
27. On Castel, see Gage (1993) and Schwarz (1999).
28. On color of urine diagrams, see Gage (1993).
29. For a German translation of Mayer's paper, see Lang (1980). For an English translation, see Fiorentini and Lee (2000).
30. The name *gamboge* is from the word Cambodia, it is a yellow-colored gum resin from trees of the genus *Garcinia*, growing in southeast Asia.
31. For more on Frisch, see Schwarz (1999).
32. The English glassmaker George Palmer (1740–1795) had an interest in color and was active at times in France. In 1777 he published in English a pamphlet titled *Theory of Colours and Vision*. It was translated in the same year into French. Walls (1956) considers Palmer's theory "just as complete as Young's, and nowise inferior to it. . . ." Palmer's theory was reviewed in *Lichtenberg's Magazin* in Göttingen, Germany, in 1781. Thomas Young was a medical student in Göttingen from 1795–96 and knew Lichtenberg who had considerable interest in vision. It is not known if Young learned of Palmer via Lichtenberg. In 1786 Palmer also published (in French) an account of color vision deficiencies.
33. Runge translations by the author.
34. On Matthias Klotz, see Schwarz (1999).
35. On early development of psychophysics, see Boring (1929).
36. Chevreul translation from the English edition of 1854.
37. On Doppler, see Schwarz (1992).
38. Aubert quote from Aubert (1876).
39. See Donders (1881). See also Turner 1994.
40. On further development of psychophysics, see Boring (1929).
41. On Munsell system development, see Munsell (1918) and Kuehni (2002a).

Chapter 3

1. On linking propositions, see, for example, Teller and Pugh (1983).
2. For the nine-dimensional universe, see, for example, Greene (1999).

Chapter 4

1. Runge translations by the author.
2. Grassmann translation by the author.
3. Helmholtz (1909, Vol II, p. 130).
4. Hering definition of constant veiling from Hering (1964, pp. 51–52).
5. *Chromo-luminarisme*, a term invented by the French painter George Seurat (1859–1891) to designate his early style of neoimpressionist painting. The term *chromolithographe* was first mentioned in French literature in 1837.
6. On Ostwald's view of Helmholtz's brightness definition, see Schwarz (1995).
7. Godlove formula from Judd (1969).
8. Pieter van Musschenbroek (1692–1761) was the inventor of the Leyden flask, a form of electrical capacitor. The law of disk mixture was developed by Plateau in 1853 and the technique perfected by Maxwell (Boring, 1942).

Chapter 5

1. For a short history of photometry, see Walsh (1958).
2. On the Hefner lamp, see Walsh (1958).
3. Lambert comment in Lambert (1760).
4. On Treviranus and Boll, see Polyak (1957).
5. For a lively description on the CIE standard observer development, see Wright (1996).
6. The density and distribution of cone types varies throughout the retina. The macular spot has an irregular distribution and is absent in the central area of focus of the normal eyes optics. To account for the average observer, for these differences two different standard observers have been specified by the CIE, one applying to a visual field subtending 2° and the other 10°.
7. For a trenchant critique of the CIE colorimetric system, see Cohen 2001. For a jab see the comment by the eminent visual physiologist W. A. H. Rushton: "The CIE triangle is brilliantly ingenious as an aid to the calculation of chromaticities which can be upheld in a court of law where colour specification is in dispute. But the triangle is monstrous as an indication of what is going on in the mechanism of vision. It displays all colours as a mixture of three primary lights, none of which have an existence that can be easily imagined. One of the three primaries is bright: it is pure green from which is subtracted a lot of red, which it does not contain. The other primaries are quite dark; they have strong colour but zero luminance. These do not seem to me ingredients that lead to clarity in our conception of colour mechanisms and I am astonished that some physiologists and many psychologists employ them to instruct the young and bewilder the old." (*Journal of Physiology* 1972; 220:178)
8. Many people have contributed to the elucidation of the genetic basis of color vision. Among the pioneers were J. Nathans, R. and S. Yokoyama, and others. For a succinct history, see Sharpe et al. (1999).
9. On Granit and Svaetichin, see Polyak (1957).

10. The notion of a central fovea free of *S* cones was first proposed by Artur König in 1894. Since then it was confirmed in some experiments but remains controversial.
11. The effect of field size on observed appearance in unpublished results by the author.

Chapter 6

1. For an extended discussion on the concept of line element, see Wyszecki and Stiles (1982, p. 654ff). See MacAdam (1981) on Schrödinger's and Stiles's line elements.
2. The terms NBS unit or judd have not gained widespread use.

Chapter 7

1. On Munsell system development, see Munsell (1918) and Kuehni (2002a).
2. The supplier of the Munsell *Book of Colors* is GretagMacbeth LLC, New Windsor, NY.
3. On the committee experiments, see Judd and Nickerson (1967) and Judd (1955, 1957, 1965, 1967).
4. This was a forced choice experiment in which the observer could only answer in one of two ways, "larger" or "smaller."
5. MacAdam revision of OSA-UCS, personal communication by J. T. Luke.
6. Hering translations by Hurvich and Jameson; see Hering (1905–1911).
7. On the "beauty test for acceptance," see Hård et al. (1996a).

Chapter 8

1. MacAdam's ellipse 1 applies to a highly saturated reddish blue. It is more highly saturated than any other color used in any color-matching error experiment. The implicit *S* cone absorption value is very high and not in agreement with that of all other ellipses. It has been left out of the analysis for that reason.

Glossary

Acceptability Judgment of the perceived size of a color difference against an internal standard of acceptability as a color match; used in color quality control.

Achromatic color A perceived color without hue: white, gray, black.

Adaptation, visual Modification of the visual response to stimuli due to the effects of the immediate surround and the total visual field of simultaneous or preceding stimuli. There is brightness as well as chromatic adaptation.

Additive Produced by addition; specifically that the physical sum of two visual stimuli is seen as the psychological sum in the sense of matching color perceptions.

Aim color A color specification that is the target to be achieved by a color chip, typically in a systematic collection.

Antagonistic Opposition in physiological action, specifically referring to neurons with opponent color character.

Attribute An inherent characteristic; there are two sets of widely accepted primary color attributes for object colors: (1) Hue, chroma, and lightness; (2) hue, whiteness, and blackness.

Attribute measurement Process of assigning numbers or other symbols to things in a manner that their relationship reflects the relationships of the attribute being measured.

Bezold-Brücke effect A sensory effect named after German scientists, according to which the hue sensation caused under normalized viewing conditions by light of all but three wavelengths changes with changing intensity.

Color Space and Its Divisions: Color Order from Antiquity to the Present, by Rolf G. Kuehni
ISBN 0-471-32670-4

Blackness Degree of resemblance of a visual field to the fundamental color contrast perception of black. A fundamental color attribute in the Hering system.

Brightness Attribute of a visual perception according to which an area appears to emit, or reflect, more or less light. Differences in brightness range from bright to dim.

Chroma The attribute of a visual sensation permitting the judgment of the degree to which a chromatic, related color differs from the achromatic color of the same lightness.

Chromaticness Attribute of a visual sensation according to which the perceived color of an area appears to be more or less chromatic.

Chromatic plane A plane in which all color perceptions, systematically ordered, of colors seen as equally bright or light are located.

Chromaticity diagram A two-dimensional diagram in which colors can be plotted according to their chromaticity coordinates, resulting in different locations for colors of different hue and chromaticness.

CIE colorimetric system A color specification system developed by the International Commission on Illumination (the acronym is derived from the organization's French name Commission Internationale de l'Éclairage).

Cleavage plane Cleavage is the tendency of crystalline materials to break under strain along defined lines. A cleavage plane is a surface in a crystalline structure revealed after an actual or imagined break. In a color solid it contains colors that stand in simple mathematically definable relationship to each other.

Coefficient of variation A measure of the change in data; the standard deviation of the data expressed as a percentage of the data mean.

Colorant A material that changes the absorption characteristics of other materials: dyes or pigments, certain metal salts.

Color atlas A systematically arranged collection of colored chips that are symbols of the colors of a color solid. The chips only illustrate the intended space when viewed under prescribed conditions by an average color normal observer.

Color appearance Appearance is the sense impression or aspect of a thing; color appearance is the aspect of a colored field that distinguishes it from the comparable aspect of another field that has a different color appearance. Visual appearance includes visual aspects other than color, such as glossiness, transparency, and opacity.

Color appearance models Mathematical models attempting to describe the color appearance of objects as seen by the average observer under different illumination and in different surrounds.

Color circle A circular arrangement of hues in their spectral order, with nonspectral purple colors connecting the shortwave and the long

wave ends of the spectrum; usually illustrated with high chroma pigment colorations.

Colorimeter Optical instrument for the investigation of color vision; in technology also an instrument that measures the reflectance of materials through three filters duplicating the color-matching functions of a standard observer.

Colorimetry The branch of color science concerned with the numerical specification of color stimuli.

Colorimetric purity A measure of saturation related to color stimuli and expressed in the CIE chromaticity diagram. Its relationship to perceived saturation in some standard conditions is complex.

Color difference The perceived difference between two non-identical fields of color.

Color difference formula A mathematical formula that allows the calculation from stimuli of the difference between two color fields in a given surround, as perceived by an average observer.

Color, full Translation of Hering's term *Vollfarbe*, the mental image of a color at its highest chromaticness; the color with a particular hue at the highest level of chroma on the MacAdam limit.

Color harmony The combination of color elements in objects of art or craft so that the effect is perceived as harmonious, in concord.

Color-matching error Stimulus variability in repeated matches of a standard color.

Color-matching functions Three spectral functions describing the amounts of three primary lights required to result in color perceptions matching those obtained from spectral lights.

Color metric A metric describes the mathematical structure of a geometrical space; a color metric applies to a color space, specifically a uniform color space.

Color order Systematic arrangement of color perceptions in terms of attributes and geometrical or mathematical models thereof.

Color, primary Colloquial term used in different circumstances: (1) One of three lights whose color appearance cannot be matched by the other two used with the other two to match the appearance of any other light; (2) one of three colorants used in color order systems or in color reproduction, such as yellow, red, and blue or yellow, magenta, and cyan; (3) one of the four Hering *Urfarben* or fundamental hue perceptions of yellow, red, blue, and green.

Color, related Color perception caused by light reflected from an object in the presence of other objects. The perceived color depends on the perceived color of surrounding objects.

Color, unrelated Color perceived to belong to an area seen in isolation from other areas.

Color solid Subset of color space containing, in a given experimental situation, all possible color experiences of the observer under consideration.

Color space Three-dimensional coordinate system within which color experiences can be represented as points with unique positions. The term color space should be limited to psychological spaces or psychophysical spaces based on cone sensitivity or color-matching functions.

Color stimulus A stimulus is something that excites an organism, or one of its components to functional activity. An external color stimulus normally consists of light of one or more wavelengths, viewed against a surround of different spectral composition.

Color zone theory Originally the merger of the Young-Helmholtz and the Hering theory of color vision; more generally any model of color vision consisting of two or more stages of processing.

Cones Cone-shaped light-sensitive cells in the retina. There are three types of cones differing in spectral sensitivity in the normal human retina.

Cone sensitivity functions Spectral functions that describe the response of the three cone types to light energy arriving at the surface of the retina.

Cone contrast diagram A diagram for illustrating the results of contrast experiments in terms of cone activation, such as $\Delta M/M$ versus $\Delta L/L$.

Contrast The difference between things having similar nature; specifically, the degree of difference between two adjacent fields of color. Perceptually contrast is expressed in terms of perceived difference, psychophysically in cone activation (in a cone contrast diagram) or in colorimetric terms.

Correlation coefficient A number indicating the degree of association between two sets of data.

Crispening Describes the fact that smallest increments in stimuli are necessary for a criterion perceptual difference response if the surround color is intermediate to the colors of the two fields compared, both in luminance and chromaticity.

Criterion response Perceptual response at the level of the selected criterion; the criterion is a standard on which the judgment is based.

Detection Discovery or determination of the existence or presence of something; specifically, for example, the determination of presence of redness in a perceived color.

DeVries-Rose behavior Increase of the Weber fraction with the square root of luminance instead of being constant.

Diapason The entire compass of musical notes.

Discrimination The process by which two stimuli differing in some aspect result in different responses of some sort.

Dominant wavelength (of a color stimulus) Wavelength of the monochromatic stimulus that, when additively mixed with the appropriate amount of achromatic stimulus, results in a color match with the test stimulus.

Empirical Originating in observation or experience.

Equal energy light source A theoretical light source that has a relative spectral power distribution of 1.0 across the spectrum.

Euclidean Relating to, or based on the geometry of the Greek mathematician Euclid; specifically that the three color attribute differences in a complex difference sum as the square root of the sum of the squares of the individual attribute differences.

Field of view The size of the retinal image expressed in solid angle. The CIE has specified a 2° and a 10° standard observer.

Flicker Variation in brightness or hue perceived upon stimulation by intermittent or temporally nonuniform light.

Fluorent Appearance of chromatic fields when their luminance or luminous reflectance is higher than that of the surround, but not as much as to make them appear luminous.

Fluorescence A form of luminescence, property of certain inorganic and organic molecules to reemit absorbed ultraviolet or visible light energy in the visible region of the spectrum.

Ganzfeld A situation in which the entire visual field is identical in composition. There are different degrees of *ganzfeld* mentioned in literature. In one situation, the observer has her head in a uniformly light-emitting sphere. It is still possible to see the nose and other facial features and contrast is thereby possible. In another case, the observer has, say, identical colored ping-pong balls with a section removed taped to her eyelids so that no facial or other contrasting feature can be seen. Here the *ganzfeld* is complete.

Geodesic The shortest line between two points on a given surface. The curvature of the line depends on the geometry of the space.

Gestalt psychology The study of perception and behavior based on the individual's response to configurational wholes, stressing the uniformity of the psychological events and rejecting analysis into discrete aspect.

Grade A position in a scale of ranks or qualities; specifically a fixed point in a color scale.

Gray scale A series of grades representing an achromatic color scale, usually with visually equidistant steps between neighboring grades.

Helmholtz-Kohlrausch effect Describes the fact of heterochromatic brightness matching that chromatic colors are perceived as brighter than achromatic colors of the same luminance. The effect is dependent on the dominant wavelength of the color.

Heterochromatic Of mixed chromatic appearance.

Hue Attribute of a visual perception according to which an area appears to be similar to one of the colors yellow, red, blue, or green or to a combination of adjacent pairs of these colors considered in a closed ring.

Hues, unique The four hues of the color circle that can not be matched with colors other than themselves; the psychological primary hues yellow, red, blue, and green. Unique red is a red hue that is neither yellowish nor bluish, for example.

Hue superimportance Refers to the fact that a smaller stimulus increment is required for a criterion difference response if it represents a hue difference than if it represents a chroma or saturation difference of the same perceived magnitude.

Illuminant An illuminating device; technically a set of numbers representing the spectral power distribution of a light source.

Isomorphism A one-to-one correspondence between mathematical sets; specifically, mapping of objects of color experience to objects in a geometrical space so that a one-to-one correspondence is obtained.

Just noticeable difference (JND) Threshold difference; the initial perceptual difference that can be seen when one of two originally identical fields of color changes in any given direction.

Lateral geniculate nucleus A mass of cells in the brain along the visual passageway between the retina and the visual area at the back of the brain.

Lattice A regular geometrical arrangement of points over an area or in a space; specifically related to the arrangement of colors in a color space.

Lightness Perceptual attribute of related colors according to which a color field appears to emit equal or less light compared to a white field. Lightness can be understood as relative brightness.

Line element The first fundamental form of a regular surface. It is defined by the Riemannian metric. In connection with color the term is used to describe a certain kind of color space defined by (weighted) increments of color fundamentals.

Linear model Of the first degree with respect to variables; having a graph that is a straight line.

Linear regression A functional relationship between two or more variables in which the variables are linearly related.

Linking proposition Postulated link between two sets of facts that are only indirectly related.

Luminance Luminous flux of a light beam emanating from a surface in a given direction, per unit solid angle.

Luminous reflectance Luminance of the surface of an object compared to the luminance of the surface of a perfectly reflecting diffuser, illuminated with the same light source and viewed at the same angle. Also known as luminance factor Y.

Macula "Yellow spot," an irregularly formed ring-like area of yellowish pigment in the central region of the retina. The fovea is located in the central area of the macular ring, free of macular pigment.

Magnitude, sensory A numerical or symbolic quantitative measure of the result of a sensory perception.

Magnocellular Relates to layers in the lateral geniculate nucleus in which relatively large cells are located believed to relay information necessary for motion perception.

Masking The reduction or suppression of one percept by the presence of another.

Maximal color See full color.

Metamers Two or more differing spectral power distributions resulting in identical color perceptions for an observer. Also used for objects with different reflectance functions seen as having identical color when viewed in standard conditions under a given light source.

Monochromatic Light of a single wavelength or a very narrow band of wavelengths seen as having identical color.

Monolexemic Describes a word consisting of a single meaningful linguistic unit.

Neuron Cell in the nervous system specialized in the transmission of electrical signals.

Neurophysiology Organic processes and phenomena of the nervous system.

Object color Apparent color of an object. The color of an object can vary depending on the surround and contextual conditions in which it is viewed.

Opponent color theory A theory according to which color perception is based on unique hues forming opposing pairs: red-green, yellow-blue, as well as the non-hued pair black and white.

Orthogonal To intersect or lie at right angles.

Parabolic Refers to a type of curved line resulting from slicing a cone at a certain range of angles.

Parvocellular Relates to layers in the lateral geniculate nucleus in which relatively small cells are located believed to relay information necessary for brightness and color perception.

Perception The subjective, conscious awareness of any aspect of the external or internal environment.

Photometry The measurement of light as related to the average human observer.

Power law A mathematical, exponential relationship between two variables; specifically between a physical stimulus and the perception resulting from it.

Psychometric function Plots the relative frequency of judgments "smaller than," "equal," and "larger than" relative to the magnitude of the stimulus.

Psychophysics The study of mental processes by quantitative methods; specifically the reports of human subjects of the perceptions resulting from carefully measured light stimuli.

Reflection The process by which a smooth surface returns electromagnetic radiation, specifically light. In reflection the radiation is returned by a simple optical law: the angle of reflection equals the angle of incidence.

Relativize To treat or describe as not absolute or independent.

Retina A layer coating the inside of the camera type eye, containing the light-sensitive rod and cone cells and cells connected to them. The retina is continuous with the optical nerve.

Riemannian geometry Non-euclidean geometry with positive curvature in which the parallel line postulate is replaced by the postulate that every pair of straight lines intersects.

Rods Rod-shaped light-sensitive cells in the retina, specialized to operate primarily at low light levels resulting in brightness perception only.

Root mean square error The square root of the arithmetic mean of the squares of the deviations of the various items from the arithmetic mean of the whole; also termed standard deviation.

Saturation Attribute of a visual perception which permits a judgment to be made of the degree to which a chromatic stimulus differs in appearance from that of an achromatic stimulus, regardless of their brightness.

Sensation Mental process due to bodily stimulation, now distinguished from awareness of the result of the process.

Spectral spaces Spaces created from reflectance or spectral power distribution data by dimension reduction techniques other than those involving color matching or cone sensitivity functions.

Spectrophotometer An instrument for measuring the relative intensities of light in different spectral regions.

Stimulus An agent that directly influences the activity of a living organism or one of its parts; specifically electromagnetic radiation within the visible band.

Suprathreshold Exceeding the threshold; specifically a difference that is larger than a threshold difference.

Symbolic A formal system of notation representing relationships.

Tetractys The pythagorean name for the sum of the first four integers regarded as the source of all things.

Threshold Visual, the lowest level or increment of stimulus resulting in a visual perception or a difference perception.

Trichromacy Relates to the theory that human color vision is based on the activity of three cone types.

Tristimulus values The scalar values of the amounts of three primary lights required to match a given light. The CIE tristimulus values *X, Y,* and *Z* refer to non-real lights **X**, **Y**, and **Z**.

Tone A tint or shade of color, typically achieved by adding white and/or black pigments to highly chromatic pigments.

Value Munsell's term for the grades of a perceptually uniform gray scale.

Vision Process by which the extended visual system extracts information from light energy to help generate appropriate response behavior.

Weber fraction Proportionality constant between the stimulus increment and the absolute value of the stimulus.

Weighting To apply a statistically or otherwise determined weighting factor to a variable.

Whiteness Attribute of a diffusing surface permitting, when viewed under a standard light source, the judgment of similarity to a standard white surface viewed in the same light.

References

Abney, W. de W. 1910. On the change in hue of spectrum colors by dilution with white light. *Proceedings of the Royal Society* (London) A83:120–127.

Abney, W. de W. 1914. *Researches in Colour Vision and the Trichromatic Theory*. London: Longmans, Green.

Ackerman, J. S. 1980. On early Renaissance color theory and practice. In H. A. Millon ed. *Studies in Italian Art and Architecture, 15th through 18th Centuries*. Cambridge: MIT Press.

Adams, E. Q. 1923. A theory of color vision. *Psychological Review* 30:56–76.

Adams, E. Q. 1942. *X-Z* planes in the 1931 I.C.I. system of colorimetry. *Journal of the Optical Society of America* 32:168–173.

Adams, E. Q., and Cobb, P. W. 1922. The effect on foveal vision of bright (and dark) surroundings. *Journal of Experimental Psychology* 5:39–45.

Agoston, G. A. 1987. *Color Theory and Its Application in Art and Design*. Berlin: Springer.

Aguilonius, F. 1613. *Opticorum libri sex*. Antwerp: Plantin (with illustrations by PP Rubens).

Alberti, L. B. *Leon Battista Alberti on painting*, ed. J. Spenser. New Haven: New Haven University Press, 1956.

Albertus Magnus. *Opera omnia*, 38 vols, ed. A. Borgnet. Paris: Vivès, 1890–99.

Allen, E., and Yuhas, B. 1984. Setting up acceptability tolerances: A case study. *Color Research and Application* 9:37–48.

Anonymous (C.B.). 1708. *Traité de la peinture en mignature*. The Hague: van Dole.

Arago, D. F. J. 1850. Un movement modéré rend la visibilité des objets plus facile. In *Oeuvres complètes de François Arago*, vol. 10. Paris: Gide, pp. 255–260.

Color Space and Its Divisions: Color Order from Antiquity to the Present, by Rolf G. Kuehni
ISBN 0-471-32670-4

Aristotle. In J. Barnes, *The complete works of Aristotle*, vol 1. Princeton: Princeton University Press, 1984.

ASTM E284. 1996. *Standard Terminology of Appearance*. West Conshohocken PA, American Society of Testing Materials.

ASTM E1360. 1996. *Standard Practice for Specifying Color by Using the Optical Society of America Uniform Color Scales System*. West Conshohocken PA, American Society of Testing Materials.

Aubert, H. 1865. *Physiologie der Netzhaut*. Breslau: Morgenstern.

Aubert, H. 1876. *Grundzüge der physiologischen Optik*. Leipzig: Engelmann.

Averroës. *Epitome of Aristotle's Parva naturalia*, transl. H. Blumberg. Cambridge, MA: Medieval Academy of America, 1961.

Avicenna. *Liber de anima, seu sextus de naturalibus*, ed. S. van Riet. Leyden: Louvain, 1972.

Ayama, M., Nakatsue, T., and Kaiser, P. K. 1987. Constant hue loci of unique and binary balanced hues at 10, 100, and 1000 Td. *Journal of the Optical Society of America* A4:1136–1144.

Bacon, R. *The "Opus Majus" of Roger Bacon*, 3 vols., ed. J. H. Bridges. Oxford: Clarendon Press, 1897.

Bacon, R. De multiplicatione specierum. In D. C. Lindberg, ed., *Roger Bacon's Philosophy of Nature*. Oxford: Clarendon Press, 1983.

Bacon, R. *Opera hactenus inedita*, ed. R. Steele. Oxford: Clarendon Press, 1937.

Badu, A. 1986. Large colour differences between surface colours. Ph.D. thesis. University of Bradford.

Baird, J. C. 1997. *Sensation and Judgment*. Mahwah, NJ: Erlbaum.

Balinkin, I. 1941. Measurement and designation of small color differences. *Bulletin of the American Ceramical Society* 20:392–402.

Barasch, M. 1978. *Light and Color in the Italian Renaissance Theory of Art*. New York: New York University Press.

Bäuml, K. H. 2002. Color appearance of spatial pattern: the role of increments and decrements. *Vision Research* 42:1627–1637.

Bedford, R. E., and Wyszecki, G. 1958. Wavelength discrimination for point sources. *Journal of the Optical Society of America* 48:129–135.

Bellamy, B. R., and Newhall, S. M. 1942. Attributive limens in selected regions of the Munsell color solid. *Journal of the Optical Society of America* 32:456–473.

Benary, W. 1924. Beobachtungen zu einem Experiment über Helligkeitskontrast. *Psychologische Forschung* 5:131–142.

Benson, W. 1868. *Principles of the Science of Colours Concisely Stated to Aid and Promote Their Useful Application in the Decorative Arts*. London: Chapman and Hall.

Berlin, B., and Kay, P. 1969. *Basic Color Terms*. Berkley CA: University of California Press.

Bernoulli, D. 1744. *Opera*. Geneva: Cramer, (Exposition of a new theory on the measurement of risk). Translation in *Econometrica*, 1954, 22:23–35.

Berns, R. S. 1993. The mathematical development of CIE TC 1-29 proposed color difference equation. *Proceedings of the 7th Congress of the International Colour Association*, Vol. B: C19-1–C19-4.

Berns, R. S. 1996. Deriving instrumental tolerances from pass-fail and colorimetric data. *Color Research and Application* 21:459–472.

Berns, R. S. 2000. *Billmeyer and Saltzman's Principles of Color Technology*, 3d ed. New York: Wiley.

Berns, R. S. 2001. Derivation of a hue-angle dependent, hue-difference weighting function for CIEDE2000. *Proceedings AIC Color 01*. Bellingham WA: SPIE.

Berns, R. S., and Billmeyer, F. W. 1985. Development of the 1929 Munsell Book of Color: A historical review. *Color Research and Application* 10:246–250.

Berns, R. S., Alman, D. H., Reniff, L., Snyder, G. D., and Balonon-Rosen, M. R. 1991. Visual determination of supra-threshold color-difference tolerances using probit analysis. *Color Research and Application* 16:297–316.

Bezold, W. von. 1874. *Die Farbenlehre im Hinblick auf Kunst und Kunstgewerbe*. Braunschweig: Westermann. American edition: *The Theory of Color in Its Relation to Art and Art-Industry*. Boston: Prang, 1876.

Billmeyer, F. W., and Bencuya, A. K. 1987. Interrelation of Natural Color System and the Munsell color order system. *Color Research and Application* 12:243–255.

Billock, V.A., Gleason, G. A., and Tsou, B. H. 2001. Perception of forbidden colors in retinally stabilized images: an indication of softwired cortical color opponency? *Journal of the Optical Society of America* A18:2398–2403.

Birren, F. 1987. M. E. Chevreul, *The Principles of Harmony and Contrast of Colors and Their Application to the Arts*. With a special introduction and newly revised commentary by Faber Birren. West Chester, PA: Schiffer.

Boll, F. 1877. Zur Anatomie und Physiologie der Retina. *Archiv für Physiologie*, p.4.

Boring, E. G. 1929. *A History of Experimental Psychology*. New York: Century.

Boring, E. G. 1939. *Introduction to Psychology*. New York: Wiley.

Boring, E. G. 1942. *Sensation and Perception in the History of Experimental Psychology*. New York: Appleton.

Bouguer, P. 1729. *Essai d'optique*. Paris: Jombert.

Bouguer, P. 1760. *Traité d'optique sur la gradation de la lumière*. Paris: Guerin et Delatour.

Boyle, R. 1664. *Experiments and Considerations Touching Colours*. London: Herringman.

Boynton, R. M. 1983. Ten years of research with the minimally distinct border. In J. D. Mollon and L. T. Sharpe, eds., *Colour vision: Physiology and Psychophysics*. London: Academic Press, pp. 193–206.

Boynton, R. M., and Kambe, N. 1980. Chromatic difference steps of moderate size along theoretically critical axes. *Color Research and Application* 5:13–24.

Boynton, R. M., Nagy, A. L., Olson, C. X. 1983. A flaw in equations for predicting chromatic differences. *Color Research and Application* 8:

Breckenridge, F. C., and Schaub, W. R. 1939. Rectangular uniform-chromaticity-scale coordinates. *Journal of the Optical Society of America* 29:370–377.

Brenner, E. 1680. *Nomenclatura et species colorum*. Stockholm.

Brewster, D. 1831. *A Treatise on Optics*. London: Longman, Rees.

Brill, M. H., Fairman, H. S., Hemmendinger, H., and Ladson, J. A. 2002. The color-order screen book: A softcopy simulated color atlas with selectable observer and illuminant. *Proceedings AIC Color 01*. Bellingham, WA: SPIE.

Brücke, E. 1866. *Die Physiologie der Farben für die Zwecke der Kunstgewerbe*. Leipzig: Hirzel.

Brown, W. R. J., and MacAdam, D. L. 1949. Visual sensitivities to combined chromaticity and luminance differences. *Journal of the Optical Society of America* 39:808–834.

Brown, W. R. J. 1952. The effect of field size and chromatic surroundings on color discrimination. *Journal of the Optical Society of America* 47:137–142.

Brown, W. R. J. 1957. Color discrimination of twelve observers. *Journal of the Optical Society of America* 47:137–143.

Burnham, R. W. 1949. Comparison of color systems with respect to uniform visual spacing. *Journal of the Optical Society of America* 39:387–392.

Burns, S. A., Cohen, J. B., and Kuznetsov, E. N. 1990. The Munsell color cystem in fundamental color space. *Color Research and Application* 15:25–51.

Cardanus, H. 1563. *Hieronimi Cardani opera omnia*, 10 vols. Lyon (vol. 2, p. 552ff).

Carroll, J. D., and Chang, J. J. 1970. Analysis of individual differences in multidimensional scaling via an *N*-way generalization of "Eckhardt-Young" decomposition. *Psychometrika* 35:283–319.

Castel, L. B. 1739. Projet d'une nouvelle optique des couleurs fondée sur les observations et uniquement relative à la teinture et les autres arts coloristes. *Journal de Trévoux*, April.

Chalcidius. *Platonis Timaeus interprete Chalcidio*, ed. J. Wrobel. Leipzig: Teubner, 1876.

Chalmers, D. J. 1996. *The Conscious Mind.* New York: Oxford University Press.

Charpentier, A. 1888. *La lumière et les couleurs au point de vue physiologique*. Paris: Baillière.

Cheung, M., and Rigg, B. 1986. Colour-difference ellipsoids for five CIE colour centres. *Color Research and Application* 11:185–195.

Cennini, C. 1400. *The craftsman's handbook: "Il libro dell' arte,"* transl. D. V. Thompson. New Haven: Yale University Press, 1933.

Chevreul, M. E. 1839. *De la Loi du contraste simultané des couleurs*. Paris: Pitois-Levraux.

Chichilnisky, E. J., and Wandell, B. A. 1999. Trichromatic opponent color classification. *Vision Research* 39:3444–3458.

Chou, W., Lin, H., Luo, M. R., Westland, S., Rigg, B., and Nobbs, J. 2001. Performance of lightness difference formulae. *Coloration Technology* 117:19–29.

Chroma Cosmos 5000 1978. Tokyo: Japan Color Research Institute.

Chromaton 707 1982. Tokyo: Japan Color Research Institute.

CIE 1924. *CIE Proceedings*. Cambridge: Cambridge University Press, 1926.

CIE 1964 (U*V*W*)-System. 1963. *CIE Proccedings*. Vienna, Austria: Commission Internationale de l'Éclairage.

CIE 1976 (L*u*v*)-System. 1986. *No. 15.2, Colorimetry*, 2nd ed. Vienna, Austria: Commission Internationale de l'Éclairage.

CIE 1976 (L*a*b*)-System. 1986. *No. 15.2, Colorimetry*, 2nd ed. Vienna, Austria: Commission Internationale de l'Éclairage.

CIE 1987. *International lighting vocabulary*, 4th ed. Vienna, Austria: Commission Internationale de l'Éclairage.

CIE 1990. *CIE 86, 2° Spectral Luminous Efficiency Function for Photopic Vision*. Vienna: Commission Internationale de l'Éclairage.

Clark, F. J. J., McDonald, R., and Rigg, B. 1984. Modification to the JPC79 colour-difference formula. *Journal of the Society of Dyers and Colourists* 100:128–132.

Cohen, J. B. 1964. Dependency of the reflectance curves of the Munsell color chips. *Psychonomic Science* 1:369–370.

Cohen, J. B. 2001. *Visual Color and Color Mixture*. Urbana: University of Illinois Press.

Cohen, J. B., and Kappauf, W. E. 1982. Metameric color stimuli, fundamental metamers, and Wyszecki's metameric blacks. *American Journal of Psychology* 95:537–564.

Cohn, J. 1894. Experimentelle Untersuchungen über die Gefühlsbetonung der Farben, Helligkeiten und ihrer Combinationen. *Philosophische Studien* 10:562–602.

Craik, K. J. W. 1938. The effect of adaptation on differential brightness discrimination. *Journal of Physiology* 92:406–421.

Crane, H. D., and Piantanida, T. P. 1983. On seeing reddish green and yellowish blue. *Science* 221:1078–1080.

Cronin, T. W., and Marshall, N. J. 1989. A retina with at least ten spectral types of photoreceptors in a stomatopod crustacean. *Nature* 339:137.

Cui, G., Luo, M. R., Rigg, B., Roesler, G., and Witt, K. 2002. Uniform colour spaces based on the DIN99 colour-difference formula. *Color Research and Application* 27:282–290.

Davidson, H. R., and Friede, E. 1953. The size of acceptable color differences. *Journal of the Optical Society of America* 43:581–589.

Delboeuf, J. R. L. 1873. *Étude psychophysique*. Mémoires couronnés et autres mémoires publiés par l'Academie Royales des Sciences, des Lettres, et des Beaux-Arts de Belgique, vol. 23. Brussels: Hayez.

Delboeuf, J. R. L. 1883. *Examen critique de la loi psychophysique: sa base et sa signification*. Paris: Baillière.

De Matiello, M. L. F., Salinas, H., and Benavente, C. 2001. Dichoptic discrimination of saturation. *Color Research and Application* 26 (suppl):S53–S56.

Democritus of Abdera. In *Die Vorsokratiker II*. Stuttgart: Reclam, 1986.

Dennett, D. C. 1991. *Consciousness Explained*. Boston: Little, Brown.

Derby, 1999. Available at *ftp//colour.derby.ac.uk*.

Derefeldt, G. 1991. Colour appearance systems. In P. Gouras, ed., *The Perception of Colour*. Boca Raton, FL: CRC Press.

Derefeldt, G., and Sahlin, C. 1986. Transformation of NCS data into CIELAB colour space. *Color Research and Application* 11:146–152.

Derefeldt, G., and Hedin, C. E. 1987. A color atlas for graphical displays. In B. Knave and P. G. Wiedebäck, eds., *Work with Display Units 86*. Amsterdam: North-Holland.

Derrington, A. M., Krauskopf, J. and Lennie, P. 1984. Chromatic mechanisms in lateral geniculate nucleus of macaque. *Journal of Physiology* 357:241–265.

De Valois, K. K., ed. 2000. *Seeing*. San Diego, CA: Academic Press.

De Valois, R. L. 1965. Analysis and coding of color vision in the primate visual system. *Cold Spring Harbor Symposium on Quantitative Biology* 30:565–579.

De Valois, R. L., and De Valois, K. K. 1993. A multi-stage color model. *Vision Research* 33:1053–1065.

De Valois, R. L., and De Valois, K. K. 1996. On "A three-stage color model." *Vision Research* 36:833–836.

De Valois, R. L., De Valois, K. K., Switkes, E., and Mahon, L. 1993. Hue scaling of isoluminant and cone-specific lights. *Vision Research* 37:885–897.

De Valois, R. L., Cottaris, N. P., and Elfar, S. 1997. S-cone inputs to striate cortex cells. *Investigative Ophtalmology and Visual Science* 38:S15.

DeVries, H. 1946. The luminosity curve of the eye as determined by measurements with the flicker photometer. *Physica* 14:319–348.

Diderot, D. 1766. Essai sur la peinture. In *Oeuvres complètes*, 20 vols. Paris: P. Garnier 1875–1879.

DIN Farbenkarte, German Standard DIN 6164. 1962. Berlin: Beuth.

DIN 6176: Farbmetrische Bestimmung von Farbabständen bei Körperfarben nach der DIN99 Formel. 2000. Berlin: Deutsches Institut für Normung.

Dobrowolsky, W. 1872. Beiträge zur physiologischen Optik. *Archiv für Ophtalmologie* 18:53–103.

Donders, F. C. 1881. Über Farbensysteme. *Archiv für Ophtalmologie* 26:155–223.

Doppler, C. 1848. Zwei weitere Abhandlungen aus dem Gebiete der Optik. 2. Versuch einer systematischen Classification der Farben. *Abhandlungen der königlichen bömischen Gesellschaft der Wissenschaften* 5(5):401–412. Reprinted in Schwarz, A. 1991/2. Christian Doopler's Kugeloctant von 1847. *Die Farbe* 38:49–81.

Ebbinghaus, H. 1887. Die Gesetzmässigkeit des Helligkeitscontrastes. *Sitzungsberichte der Preussischen Akademie der Wissenschaften* 2:995–1009.

Ebbinghaus, H. 1902. *Grundzüge der Psychologie*, Vol. 1. Leipzig: Viet.

Empedocles of Acragas. In *Die Vorsokratiker II*. Stuttgart: Reclam, 1986.

Eraclius. De coloribus et artibus romanorum. Original and translation in M. P. Merrifield, de., *Medieval and Renaissance Treatises on the Arts of Painting*. New York: Dover, 1967.

Eskew, R. T., McLellan, J. S., and Giulianini, F. 1999 Chromatic detection and discrimination. In K. R. Gegenfurtner and L.T. Sharpe, eds., *Color Vision*. Cambridge: Cambridge University Press.

Evans, R. M. 1974. *The Perception of Color*. New York: Wiley.

Evans, R. M., and Swenholt, B. K. 1968. Chromatic strengths of colors, Part II: The Munsell System. *Journal of the Optical Society of America* 58:580–584.

Fechner, G. T. 1851. *Zend-Avesta.* Leipzig: Voss.

Fechner, G. T. 1860. *Elemente der Psychophysik*, transl. H.S. Langfeld. Leipzig: Breitkopf und Härtel.

Farnsworth, D. 1944. The Farnsworth rectilinear uniform chromaticity diagram No. 38. Memorandum 44-1. Medical Laboratory of the U.S. Submarine Base, New London, CT.

Fairchild, M. D. 1998. *Color Appearance Models*. Reading, MA: Addison-Wesley.

Fairchild, M. D., and Pirotta, E. 1991. Predicting the lightness of chromatic object colors using CIELAB. *Color Research and Application* 16:385–393.

Fechner, G. T. 1860. *Elemente der Psychophysik*, Vols. 1 and 2. Leipzig: Breitkopf und Härtel. Translation: *Elements of Psychophysics*. Vol. 1, eds. E. G. Boring and D. H. Howes. New York: Holt, Rinehart and Winston, 1966.

Feller, R. L., and Stenius, A. 1970. On the color space of Sigfrid Forsius, 1611. *Color Engineering* 8:51–58.

Ficino M. 1519. *Opera*, I. Basel, pp. 825–826.

Field, G. 1835. *Chromatography; or a Treatise on Colours and Pigments, and of their Powers in Painting*. London: Tilt.

Fiorentini, A., and Lee, B. B. 2000. Tobias Mayer's On the relationship between colors. *Color Research and Application* 25:66–74.

Fludd, R. 1629–31. *Medicina catholica*, 2 vols. Frankfurt: C. Rötelli.

Forsius, S. A. 1611. *Physica, Codex Holmiensis D. 6*, Royal Library, Stockholm.

Foss, C. E. 1947. Representations of color space and their applications. *American Ceramic Society Bulletin* 27:55–63.

Foss, C. E. 1978. Space lattice used to sample the color space of the Committee on Uniform Color Scales of the Optical Society of America. *Journal of the Optical Society of America* 68:1616–1619.

Foss, C. E., Nickerson, D., and Granville, W. C. 1944. Analysis of the Ostwald color system. *Journal of the Optical Society of America* 34:361–382.

Freeman, K. 1957. *Ancilla to the pre-Socratic Philosophers*. Cambridge: Harvard University Press.

Friele, L. F. C. 1961. Analysis of the Brown and Brown-MacAdam colour discrimination data. *Die Farbe* 10:193–202.

Friele, L. F. C. 1965. Further analysis of colour discrimination data. *Proceedings of the International Colour Meeting* (Lucerne 1965). Göttingen: Musterschmidt, 1966.

Friele, L. F. C. 1978. Fine color metric (FCM). *Color Research and Application* 3:53–64.

Frisch, J. C. 1788. Ueber eine harmonische Farben-Tonleiter, und die Wirkungen und Verhältnisse der Farben im Colorite. *Monatsschrift der Akademie der Künste und mechanischen Wissenschaften zu Berlin* 2(8):58–77.

Fullerton, G. S., and Cattell, J. K. 1892. *On the Perception of Small Differences*. Philadelphia: University of Pennsylvania Press.

Gage, J. 1993. *Color and Culture*. Boston: Little, Brown.

Gage, J. 1999. *Color and Meaning*. Berkley: University of California Press.

Gavel, J. 1979. Colour, *A Study of its Position in the Art Theory of the Quattro- & Cinquecento.* Stockholm: Almquist and Wiksell.

Gelb, A. 1929. Die "Farbenkonstanz" der Sehdinge. In W. A. von Bethe, ed., *Handbuch der normalen und pathologischen Sehphysiologie*, Vol 12:594–678. Berlin: Springer.

Gerritsen, F. 1984. Entwicklung der Farbenlehre. Göttingen: Muster-Schmidt.

Gerstner, K. 1986. The forms of color. Cambridge: MIT Press.

Gilchrist, A. L., ed. 1994. *Lightness, Brightness, and Transparency*. Hillsdale NJ: Erlbaum.

Gilchrist, A. L., Kossyfidis, C., Agostini, T., Bonato, F., Cataliotti, J., Li, X., Spehar, B., Annan, V., and Economou, E. 1999. An anchoring theory of lightness perception. *Psychological Review* 106:795–834.

Gibson, K. S., and Nickerson, D. 1940. An analysis of the Munsell Color System based on measurements made in 1919 and 1926. *Journal of the Optical Society of America* 30:591–608.

Gibson, K. S., and Tyndall, E. P. T. 1923. Visibility of radiant energy. *Bulletin Bureau of Standards* 19:131.

Giulianini, F., and Eskew Jr., R. T. 1998. Chromatic masking in the (ΔL/L, ΔM/M) plane of constant-contrast space reveals only two detection mechanisms. *Vision Research* 38:3913–3926.

Glasser, L. G., McKinney, A. H., Reilly, C. D., and Schnelle, P. D. 1958. Cube-root color coordinate system. *Journal of the Optical Society of America* 48:736–740.

Glenn, J. T., and Killian, J. T. 1940. Trichromatic analysis of the Munsell Book of Color. *Journal of the Optical Society of America* 30:609–616.

Glisson, F. 1677. *Tractatus de ventriculo et intestinis*. London: Brome.

Godlove, I. H. 1933. Neutral value scales: II. Comparison of results and equations describing value scales. *Journal of the Optical Society of America* 23:419–425.

Godlove, I. H. 1951. Improved color-difference formula, with applications to the perceptibility and acceptability of fadings. *Journal of the Optical Society of America* 41:760–772.

Goethe, J. W. v. 1810. *Zur Farbenlehre*. Tübingen: Cotta.

Granville, W. C. 1994. The Color Harmony Manual. *Color Research and Application* 19:77–98.

Grassmann, H. G. 1853. Zur Theorie der Farbenmischung, *Poggendorff's Annalen der Physik und Chemie* 29:69–84.

Green, D. M., and Swets, J. A. 1966. *Signal Detection Theory and Psychophysics.* New York: Wiley.

Greene, B. 1999. *The Elegant Universe*. New York: Norton.

Guan, S. S., and Luo, M. R. 1999. A colour-difference formula for assessing large colour differences. *Color Research and Application* 24: 344–355.

Guild, J. 1931. The colorimetric properties of the spectrum. *Philosophical Transactions of the Royal Society* (London) A230:149–187.

Guilford, J. P. 1932. A generalized psychological law. *Psychological Review* 39:73–85.

Guth, S. L. 1972. A new vector model. In J. J. Vos, L. F. C. Friele and P. L. Walraven, eds., *Color Metrics*. Soesterberg: Institute for Perception TNO, pp. 82–98.

Guth, S. L. 1991. Model for color vision and light adaptation. *Journal of the Optical Society of America* A8:976–993.

Guth, S. L. 2001. ATD01 model for color appearances and differences. *Proceedings AIC Color 01*. Bellingham, WA: SPIE, 2002.

Hall, M. 1992. *Color and Meaning.* Cambridge: Cambridge University Press.

Hård, A., and Sivik, L. 1981. NCS-Natural Color System: A Swedish standard for color notation. *Color Research and Application* 6:129–138.

Hård, A., Sivik, L., and Tonnquist, G. 1996. NCS, Natural Color System—From concept to research and applications. Part I. *Color Research and Applications* 21:180–205. Part II. *Color Research and Applications* 21:206–220.

Hardin, C. L. 1988. *Color for Philosophers.* Indianapolis IN: Hackett.

Harris, M. 1766. *The Natural System of Colours*. London: Laidler.

Hasegawa, I., and Miyashita, Y. 2002. Categorizing the world: Expert neurons look into key features. *Nature Neuroscience* 5:90–91.

Hayter, C. 1826. *A New Practical Treatise on the Three Primitive Colours*. London: printed for the author.

Helmholtz, H. v. 1856. *Handbuch der physiologischen Optik*, Teil I. Hamburg: Voss.

Helmholtz, H. v. 1860. *Handbuch der physiologischen Optik*, Teil II. Hamburg: Voss.

Helmholtz, H. v. 1866. *Handbuch der physiologischen Optik*, Teil III. Hamburg: Voss.

Helmholtz, H. v. 1891. Versuch einer erweiterten Anwendung des Fechnerschen Gesetzes im Farbensystem. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane* 2:1–30.

Helmholtz, H. v. 1896. *Handbuch der physiologischen Optik*, 2nd ed. Hamburg: Voss.

Helmholtz, H. v. 1909. *Handbuch der physiologischen Optik*, 3rd ed. Hamburg: Voss, 1909–1911. English translation: *Helmholtz's Treatise on Physiological Optics*, transl. from the third edition, J. P. C. Southhall ed. Washington: Optical Society of America, 1924.

Henry, C. 1888. Cercle chromatique et sensation des couleurs. *La Revue Indépendante* (June):238–289.

Herbart, J. F. 1824–25. *Die Psychologie als Wissenschaft*. Königsberg: Unzer.

Hering, E. 1874. Zur Lehre vom Lichtsinn V. Grundzüge einer Lehre des Lichtsinnes. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien. *Mathematisch-Naturwissenschaftliche Classe. Abtheilung III* 69:85–104.

Hering, K. E. K. 1878. *Zur Lehre vom Lichtsinne*. Wien: Gerold.

Hering, E. 1905–11. *Grundzüge der Lehre vom Lichtsinn*. Berlin: Springer. Published in installments 1905, 1907, 1911. English translation: *Outlines of a Theory of the Light Sense*, transl. L. M. Hurvich and D. Jameson. Cambridge: Harvard University Press, 1964.

Hesselgren, S. 1952. *Hesselgrens Färgatlas korfattad färglära*. Stockholm: Palmer.

Hicketier, E. A. 1974. *Color Atlas*. New York: Van Nostrand Reinhold.

Höfler, A. 1897. *Psychologie*. Vienna: Tempsky.

Hunt, R. W. G. 1977. The specification of colour appearance. I. Concepts and terms. *Color Research and Application* 2:55–68.

Hunter, R. S. 1942. *Photoelectric Tristimulus Colorimetry with Three Filters*. Circular C429. National Bureau of Standards, Washington.

Hurvich, L. M. 1981. *Color Vision*. Sunderland: Sinauer.

Hurvich, L. M., and Jameson, D. 1955. Some quantitative aspects of an opponent-colors theory. II. Brightness, saturation, and hue in normal and dichromatic vision. *Journal of the Optical Society of America* 45:602–616.

Indow, T. 1988. Multidimensional studies of Munsell color solid. *Psychological Review* 95:456–470.

Indow, T. 1995. Psychophysical scaling: Scientific and practical applications. In R. D. Luce et al, eds., *Geometric Representations of Perceptual Phenomena*, Mahwah NJ: Erlbaum.

Indow, T. 1999a. Predictions based on Munsell notation: I. Perceptual color differences. *Color Research and Application* 24:10–18.

Indow, T. 1999b. Predictions based on Munsell notation: II. Principal hue components. *Color Research and Application* 24:19–32.

Indow, T. 1999c. Principal hue curves and color difference. *Color Research and Application* 24:266–279.

Indow, T. 2001. Uniformities in OSA-UCS and in NCS tested by color difference prediction based on principal hue components. *Proceedings AIC Color 01*. Bellingham, WA: SPIE, 2002.

Indow, T. 2002. Color differences predicted by color component differences. *Color Research and Application* 27:425–429.

Indow, T., and Aoki, N. 1983. Multidimensional mapping of 178 Munsell colors. *Color Research and Application* 8:145–152.

Indow, T., and Ohsumi, K. 1972. Multidimensional mapping of sixty Munsell colors by non-metric procedure. In J. J. Vos, L. F. C. Friele and P. L. Walraven, eds., *Color Metrics.* Soesterberg, Netherlands: Institute for Perception.

Indow, T., and Morrison, M. L. 1991. Construction of discrimination ellipsoids for surface colors by the method of constant stimuli. *Color Research and Application* 16:42–56.

Ives, H. E. 1912. Studies in the photometry of lights of different colours: I. Spectral luminosity curves obtained by the equality of brightness photometer and flicker photometer under similar conditions. *Philosophical Magazine Series 6*, 24:149–188.

Jacobson, E., Granville, W. C., and Foss, C. E. 1942. *Color Harmony Manual*. Chicago: Container Corporation of America.

Jaeckel, S. M. 1975. The HATRA data on colour differences and visual colour passing. *Journal of the Society of Dyers and Colourists* 91:242.

Jain, A. K. 1972. Color distance and geodesics in color 3-space. *Journal of the Optical Society of America* 62:1287–1291.

Jameson, D. 1972. Theoretical issues of color vision. In D. Jameson and L. M. Hurvich, eds., *Handbook of Sensory Physiology*, Vol 7/4 *Visual Psychophysics.* Berlin: Springer.

Jameson, D., and Hurvich, L. M. 1964. Theory of brightness and color contrast in human vision. *Vision Research* 4:135–154.

Jameson, K. A., Highnote, M. S., and Wasserman, L. M. 2001. Richer color experience in observers with multiple photopigment opsin genes. *Psychonomic Bulletin and Review* 8:244–261.

Jastrow, J. 1888. Critique of psychophysical methods. *American Journal of Psychology* 1:271–309.

Johannsen, T. 1937. *Färg*. Stockholm: Lindfors.

Jones, L. A. 1917. The fundamental scale of pure hue and retinal sensibility to hue differences. *Journal of the Optical Society of America* 1:63–77.

Jordan, C., and Mollon, J. D. 1993. A study of women heterozygous for color deficiencies. *Vision Research* 33:1495–1508.

Judd, D. B. 1932. Chromaticity sensibility to stimulus differences. *Journal of the Optical Society of America* 22:72–108.

Judd, D. B. 1935. A Maxwell triangle yielding uniform chromaticity scales. *Journal of the Optical Society of America* 25:24–35.

Judd, D. B. 1936. Estimation of chromaticity differences and nearest color temperature on the standard (ICI) colorimetric coordinate system. *Journal of the Optical Society of America* 26:421–426.

Judd, D. B. 1940. The Munsell color system. *Journal of the Optical Society of America* 30:574–645.

Judd, D. B. 1955. Progress report by Optical Society of America Committee on Uniform Color Scales. Journal of the Optical Society of America 45:673–676.

Judd, D. B. 1957. Progress report by Optical Society of America Committee on Uniform Color Scales. *Journal of the Optical Society of America* 47:336.

Judd, D. B. 1965. Progress report for OSA Committee on Uniform Color Scales. *Die Farbe* 14:287–295.

Judd, D. B. 1967. Committee on Uniform Color Scales—Fourth progress report. *Journal of the Optical Society of America* 57:557.

Judd, D. B. 1969. Ideal color space. *Palette* 29:25–31, 30:21–28, 31:23–29.

Judd, D. B., and Kelly, K. L. 1939. Method of designating colors. *Journal of Research of the National Bureau of Standards* 23:355–381.

Judd, D. B., Scofield, F., and Hunter, R. S. 1941. A proposed method of designating color. *ASTM Bulletin* (May):19–24.

Judd, D. B., MacAdam, D. L., and Wyszecki, G. 1964. Spectral distribution of typical daylight as a function of correlated color temperature. *Journal of the Optical Society of America* 54:1031–1040.

Judd, D. B., and Nickerson, N. 1967. One set of Munsell Re-renotations. National Bureau of Standards Report 192693 of December 26, 1967. Washington: U.S. Department of Commerce.

Judd, D. B., and Yonemura, G. T. 1970. CIE 1960 UCS diagram and the Müller theory of color vision. *Journal of Research of the National Bureau of Standards* 74A:23–30.

Judd, D. B., and Wyszecki, G. 1975. *Color in Business, Science, and Industry*, 3d ed. New York: Wiley.

Kaneko, T. 1964. A reconsideration of the Cobb-Judd lightness function. *Acta Chromatica* 1:103–110.

Katz, D. 1909. Die Erscheinungsweisen der Farben und ihre Beeinflussung durch die individuelle Erfahrung. *Zeitschrift für Psychologie*, Abteilung 1, Ergänzungsband 7. Leipzig: J.A. Barth. Translation: Katz, D. 1935. *The World of Colour*. London: Kegan, Paul.

Kelly, K. L., and Judd, D. B. 1976. *Color: Universal Language and Dictionary of Names*. Washington: U.S. Government Printing Office, National Bureau of Standards Special Publication 440.

Kim, D. H., and Nobbs, J. H. 1997. New weighting functions for the weighted CIELAB colour difference formula. *Proceedings 8th Congress of the International Colour Association*, Vienna: CIE, pp. 446–449.

Kircher A. 1671. *Ars magna lucis et umbrae*. Amsterdam: Jansson and Waesberge.

Kirschmann, A. 1895. Color-saturation and its quantitative relations. *American Journal of Psychology* 7:386–404.

Klotz M. 1816. *Gründliche Farbenlehre*. München: Zängl.

Kohlrausch, V. A. 1935. Zur Photometrie farbiger Lichter. *Das Licht* 5:259–275.

König, A. 1886. Über die neuere Entwicklung von Thomas Young's Farbentheorie (On the more recent development of Thomas Young's theory of color). In *Gesammelte Abhandlungen zur physiologischen Optik*. Leipzig: Barth, 1903.

König, A. 1891. Ueber den Helligkeitswert der Spectralfarben bei verschiedener absoluter Intensität. In *Beiträge zur Psychologie und Physiologie der Sinnesorgane*. Hamburg: Voss, pp. 309–388.

König, A. 1892. Die Grundempfindungen in normalen und anomalen Farbensystemen und ihre Intensitätsvertheilung im Spectrum (In Gemeinschaft mit Conrad Dieterici). *Zeitschrift für die Physiologie und Psychologie der Sinnesorgane* 4:241–347.

König, A., and Dietrici, C. 1884, Über die Empfindlichkeit des normalen Auges für Wellenlängenunterschiede des Lichtes. *Annalen der Physik und Chemie* 22:579–589.

König, A., and Brodhun, E. 1888–89. Experimentelle Untersuchungen über die psychophysische Fundamentalformel in Bezug auf den Gesichtssinn. *Sitzungsberichte der preussischen Akademie der Wissenschaften* 1888:917–931; 1889:641–644.

König, A., and Dietrici, C. 1892. Die Grundempfindungen in normalen und anomalen Farbsystemen und ihre Intensitätsvertheilung im Spectrum. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane* 4:241–347.

Krantz, D. H., Luce, R. D., Suppes, P., and Tversky, A. 1971. *Foundations of Measurement, Vol. 1: Additive and Polynomial Representations*. New York: Academic Press, 1971. Vol. 2: *Geometrical, Threshold, and Probabilistic Representations* (Suppes, Krantz, Luce, and Tversky. Academic Press, 1989). *Vol. 3: Representation, Axiomatization, and Invariance* (Luce, Krantz, Suppes, and Tversky. Academic Press, 1990).

Krauskopf, J. 1999. Higher order color mechanisms. In K. R. Gegenfurtner and L. T. Sharpe, eds. *Color vision*. Cambridge: Cambridge University Press.

Krauskopf, J., and Gegenfurtner, K. 1992. Color discrimination and adaptation. *Vision Research* 32:2165–2175.

Kries, J. von. 1882. Die Gesichtsempfindungen und ihre Analyse. *Archiv für Anatomie, Physiologie und wissenschaftliche Medicin* (Suppl. Physiologische Abteilung): 1–178.

Kuehni, R. G. 1971a. Acceptability contours and small color difference formulas. *Journal of Color and Appearance* 1(1):30–35,42.

Kuehni, R. G. (chairman). 1971b. Acceptability contours of selected textile matches in color space. *Textile Chemist and Colorist* 3:248–255.

Kuehni, R. G. 1972. Color difference and objective acceptability evaluation. *Journal of Color and Appearance* 1(3):4–10,15.

Kuehni, R. G. 1975. Visual and instrumental determination of small color differences. *Journal of the Society of Dyers and Colourists* 91:68–71.

Kuehni, R. G. 1982. Advances in color difference formulas. *Color Research and Application* 7:19–23.

Kuehni, R. G. 1999. Towards an improved uniform color space. *Color Research and Application* 24:253–265.

Kuehni, R. G. 2000a. Uniform color space modeled with cone responses. *Color Research and Application* 25:56–63.

Kuehni, R. G. 2000b. A comparison of five color order systems. *Color Research and Application* 25:123–131.

Kuehni, R. G. 2000c. A structural comparison of the Munsell Renotation and the OSA-UCS uniform color systems. *Color Research and Application* 25:186–192.

Kuehni, R. G. 2000d. An opponent-color model for the Sanders-Wyszecki Helmholtz-Kohlrausch effect data set. *Color Research and Application* 25:292–293.

Kuehni, R. G. 2001a. Determination of unique hues using Munsell color chips. *Color Research and Application* 26:61–66.

Kuehni, R. G. 2001b. Analysis of five sets of color difference data. *Color Research and Application* 26: 141–150.

Kuehni, R. G. 2001c. Color space and its divisions. *Color Research and Application* 26:209–222.

Kuehni, R. G. 2001d. From color matching error to large color differences. *Color Research and Application* 26:384–393.

Kuehni, R. G. 2001e. "Uniform" color space is not homogeneous. *Proceedings AIC Color 01*. Bellingham, WA: SPIE, 2002.

Kuehni, R. G. 2002. The early development of the Munsell system. *Color Research and Application* 27:20–27.

Kuehni, R. G., and Marcus, R. T. 1979. An experiment in visual scaling of small color differences. *Color Research and Application* 4:81–91.

Kuehni, R. G., and Stanziola, R. 2002. Francis Glisson's color specification system of 1677. *Color Research and Application* 27:15–19.

Küppers, H. 1968. *Das Grundgesetz der Farbenlehre.* Köln: DuMont.

Lambert, J. H. 1760. *Photometria, sive de mensura et gradibus luminis, colorum et umbra.* Augsburg.

Lambert, J. H. 1772. *Beschreibung einer mit dem Caulauischen Wachse ausgemalten Farbenpyramide.* Berlin: Haude und Spener.

Lang, H. 1980. Tobias Mayers Abhandlung über die Verwandtschaft der Farben 1758. *Die Farbe* 28:1–34.

Larimer, J., Krantz, D. H., and Cicerone, C. M. 1974. Opponent-process additivity. I. Red/green equilibria. *Vision Research* 14:1127–1140.

Larimer, J., Krantz, D. H., and Cicerone, C. M. 1975. Opponent-process additivity. II. Yellow/blue equilibria and nonlinear models. *Vision Research* 15:723–731.

Le Blon, J. C. 1725. *Coloritto or the harmony of colouring in painting reduced to mechanical practice.* London.

Lee, B. B. 1998. Receptors, channels and color in primate retina. In W. G. K. Backhaus, R. Kliegl, J. S. Werner, eds., *Color Vision.* Berlin: Walter de Gruyter.

LeGrand, Y. 1949. Les seuils différentiels de couleurs dans la theorie de Young. *Revue d'Optique* 28:261–278. Translated in: *Color Research and Application* 1994;19: 296–309.

Lennie, P. 1999. Color coding in the cortex. In K. R. Gegenfurtner and L. T. Sharpe, eds., *Color Vision.* Cambridge: Cambridge University Press.

Lenz, R., Österberg, M., Hiltunen, J., Jaaskelainen, T., and Parkkinen, J. 1996. Unsupervised filtering of color spectra. *Journal of the Optical Society of America* A13: 1315–1324.

Long, J., and Luke, J. T. 2001. *The New Munsell Student Color Set.* Lebanon, PA: Maple Press.

Lotto, R. B., and Purves, D. 1999. The effect of color on brightness. *Nature Neuroscience* 2:1010–1014.

Lotto, R. B., and Purves, D. 2002. A rationale for the structure of color space. *Trends in Neuroscience* 25:84–89..

Lübbe, E. 1999. *Empfindungsgemässe Farbbeschreibung unter Berücksichtigung des Umfeldes.* Dissertation. Aachen: Shaker Verlag.

Lucretius. 1968. *De rerum natura* (The way things are). Transl. R. Humphries. Bloomington: Indiana University Press.

Luke, J. T. 2002. Color Cleaver® software. Marketed by Michael Wilcox School of Colour, Bristol, England.

Luneburg, R. K. 1950. The metric of binocular visual space. *Journal of the Optical Society of America* 40:627–642.

Luther, R. 1927. Aus dem Gebiete der Farbreizmetrik. *Zeitschrift für technische Physik* 8:540–558.

Luo, M. R., and Rigg, B. 1986. Chromaticity-discrimination ellipses for surface colours. *Color Research and Application* 11:25–42.

Luo, M. R., and Rigg, B. 1987. BFD (l:c) colour-difference formula, Part I – Development of the formula. *Journal of the Society of Dyers and Colourists* 103:86–94. Part II – Performance of the formula. *Journal of the Society of Dyers and Colourists* 103:126–132.

Luo, M. R., Cui, G., and Rigg, B. 2001. The development of the CIE 2000 colour-difference formula: CIEDE2000. *Color Research and Application* 26:340–350.

MacAdam, D. L. 1935. Maximum visual efficiency of colored materials. *Journal of the Optical Society of America* 25:361–367.

MacAdam, D. L. 1937. Projective transformations of I.C.I. color specifications. *Journal of the Optical Society of America* 27:294–299.

MacAdam, D. L. 1942. Visual sensitivities to color differences in daylight. *Journal of the Optical Society of America* 32:247–274.

MacAdam, D. L. 1947. Note on the number of distinct chromaticities. *Journal of the Optical Society of America* 37:308–309.

MacAdam, D. L. 1965. Specification of color differences. *Acta Chromatica* 1:147–156.

MacAdam, D. L. 1974. Uniform color scales. *Journal of the Optical Society of America* 64:1691–1702.

MacAdam, D. L. 1978. Colorimetric data for samples of OSA uniform color scales. Journal of the Optical Society of America 68:121–130.

MacAdam, D. L. 1981. *Color Measurement.* Berlin: Springer.

MacAdam, D. L. 1990. Redetermination of colors for uniform scales. *Journal of the Optical Society of America* A7:113–115.

MacAdam, D. L. 1995. Letter to Joy Turner Luke of March 22, 1995, with permission of the recipient.

Mahy, M., Van Eycken, L., and Oosterlinck, A. 1994. Evaluation of uniform color spaces developed after the adoption of CIELAB and CIELUV. *Color Research and Application* 19:105–121.

Maloney, L. T. 1999. Physics-based approaches to modeling surface color perception. In K. R. Gegenfurtner and L. T. Sharpe, eds., *Color Vision*. Cambridge: Cambridge University Press.

Mandelstamm, E. 1867. Beitrag zur Physiologie der Farben. *Archiv für Ophtalmologie* 13:399–406.

Mansfeld, J. 1986. *Die Vorsokratiker I and II.* Stuttgart: Reclam.

Marks, L. E. 1978. *The Unity of the Senses: Interrelations among the Modalities.* New York: Academic Press.

Marks, L. E., and Algom, D. 1998. Psychophysical scaling. In M. H. Birnbaum, ed., *Measurement*, *Judgment*, *and Decision Making*. New York: Academic Press.

Masson, V. 1845. Étude de photométrie électrique. *Annales de chimie et de physique* 14:129–195.

Mausfeld, R. 1998. Color perception: from Grassmann codes to a dual code for object and illumination colors. In W. G. K. Backhaus, R. Kliegl and J. S. Werner, eds., *Color Vision*. Berlin: Walter de Gruyter.

Mayer, T. 1775. *Opera inedita Tobiae Mayeri*; ed. G. C. Lichtenberg. Göttingen.

Maxwell, J. C. 1856. On the theory of colours in relation to colour-blindness. *Transactions of the Royal Scottish Society of Arts* 4:394–400.

Maxwell, J. C. 1860. Theory of compound colours, and the relations of the colours of the spectrum. *Proceedings Royal Society (London)* 10:57–84.

McDonald, R. 1974. The effect of non-uniformity in the ANLAB colour space on the interpretation of visual colour differences. *Journal of the Society of Dyers and Colourists* 90:189–198.

McDonald, R. 1980. Industrial pass-fail colour matching: Part I. Preparation of visual colour-matching data. *Journal of the Society of Dyers and Colourists* 96: 372–376. Part II. Methods of fitting tolerance ellipsoids. *Ibid.* 96:418–433. Part III. Development of pass-fail formula for use with instrumental measurement of colour difference. *Ibid.* 96:486–495.

McLaren, K. 1971. Multiple linear regression: A new technique for improving colour-difference formulae. *Color Metrics.* Soesterberg: AIC, pp. 296–307.

McLaren, K. 1976. An introduction to instrumental shade passing and sorting and a review of recent developments. *Journal of the Society of Dyers and Colourists* 92:317–326.

McLaughlin, B. P. 2002. Color, consciousness, and color consciousness. In Q. Smith and A. Jokic, eds., *Aspects of Consciousness*. Oxford: Oxford University Press.

McMahon, E. 1956. Leonardo da Vinci: Treatise on Painting Codex Urbinas Latinus 1270. Princeton: Princeton University Press.

Melgosa, M., Hita, E., Romero, J., and Jiménez del Barco, L. 1992. Some classical color differences calculated with new formulas. *Journal of the Optical Society of America* A9:1247–1254.

Melgosa, M., Hita, E., Poza, A. J., Alman, D. H., and Berns, R. S. 1997. Suprathreshold color-difference ellipsoids for surface colors. *Color Research and Application* 22:148–155.

Melgosa, M., Rivas, M. J., Hita, E., and Viénot, F. 2000. Are we able to distinguish color attributes? *Color Research and Application* 25:356–367.

Merrifield, M. P. 1967. *Medieval and Renaissance Treatises on the Art of Painting.* New York: Dover.

Müller, A. E. 1963. *Swiss Color Atlas 2541.* Winterthur: Chromos.

Müller, G. E. 1896–97. Zur Psychophysik der Gesichtsempfindungen. *Zeitschrift für Psychologie* 10:1–82, 321–413. *Ibid.* 14:1–76, 161–196.

Müller, G. E. 1930. Über die Farbenempfindungen. *Zeitschrift für Psychologie*, Ergänzungsband 17 and 18. Leipzig: Barth.

Munsell, A. H. 1905. *A Color Notation.* Boston: Ellis. Current edition available from Gretag-Macbeth, New Windsor, NY.

Munsell, A. H. 1907. *Atlas of the Munsell Color System.* Malden, MA: Wadsworth-Howland.

Munsell, A. H. 1915. *Atlas of the Munsell Color System*, 2nd ed. Malden: Wadsworth-Howland.

Munsell, A. H. 1918. Color diary 1899–1918. Unpublished.

Munsell Book of Color. Baltimore: Munsell Color Company, 1929. Modern editions available from Gretag-Macbeth, New Windsor, NY.

Munsell, A. E. O., Sloan, L. L., and Godlove, I. H. 1933. Neutral value scales: I. Munsell neutral value scale. *Journal of the Optical Society of America* 23:394–411.

Murdoch, J. E. 1984. *Album of Science, Antiquity and the Middle Ages.* New York: Scribner.

Murray, D. J. 1993. A perspective for viewing the history of psychophysics. *Behavioral and Brain Sciences* 16:115–186.

Musschenbroek, P. van. 1768. *Introductio ad philosophiam naturalem*, Vol 2. Amsterdam.

Morley, D. I., Munn, R., and Billmeyer, F. W. 1975. Small and moderate colour differences II: The Monley data. *Journal of the Society of Dyers and Colourists* 91:229–242.

Nagy, A. L., Eskew, R. T., and Boynton, R. M. 1987. Analysis of color-matching ellipses in cone excitation space. *Journal of the Optical Society of America* A4:756–768.

Natural Colour System Atlas. 1979. Stockholm: Scandinavian Colour Institute.

Nayatani, Y. 1997. Simple estimation methods for the Helmholtz-Kohlrausch effect. *Color Research and Application* 22:385–401.

Nayatani, Y. 1998. A colorimetric explanation of the Helmholtz-Kohlrausch effect. *Color Research and Application* 23:374–378.

Nayatani, Y., Sobagaki, H., and Hashimoto, K. 1994. Existence of two kinds of representations of the Helmholtz-Kohlrausch Effect: I. The experimental confirmation. *Color Research and Application* 19:246–261. II. The models. *Color Research and Application* 19:262–272.

Neitz, M., Kraft, T. W., and Neitz, J. 1998. Expression of *L*-cone pigment gene subtypes in females. *Vision Research* 38:3221–3225.

Newton, I. 1670. *The Optical Papers of Isaac Newton*: Vol. 1. *The Optical Lectures 1670–1672*, transl. ed. A. E. Shapiro. Cambridge: Cambridge University Press, 1984.

Newton, I. 1704. *Opticks.* London: Smith and Walford.

Newhall, S. M. 1940. Preliminary report of the OSA subcommittee on the spacing of the Munsell colors. *Journal of the Optical Society of America* 33:617–645.

Newhall, S. M., Nickerson, D., and Judd, D. B. 1943. Final report of the O.S.A. subcommittee on the spacing of the Munsell colors. *Journal of the Optical Society of America* 33:385–418.

Nickerson, D. 1936. The specification of color tolerances. *Textile Research* 6:509–514.

Nickerson, D. 1940. History of the Munsell color system and its scientific application. *Journal of the Optical Society of America* 30:575–586.

Nickerson, D. 1969. History of the Munsell color system. *Color Engineering* 7(5):42–51.

Nickerson, D. 1976. History of the Munsell color system, company, and foundation. *Color Research and Application* 1:7–10.

Nickerson, D. 1977. History of the OSA Committee on Uniform Color Scales. *Optics News*, Winter 1977:8–17.

Nickerson, D. 1978. Munsell Renotations for samples of OSA uniform color scales. *Journal of the Optical Society of America* 68:1343–1347.

Nickerson, D., and Newhall, S. M. 1943. A psychological color solid. *Journal of the Optical Society of America* 33:419–422.

Nickerson, D., and Stultz, K. F. 1944. Color tolerance specification. *Journal of the Optical Society of America* 34:550–570.

Norwich, K. H. 1993. *Information, Sensation, and Perception*. New York: Academic Press.

Nyberg, N. D. 1929. Zum Aufbau des Farbkörpers im Raume aller Lichtempfindungen. *Zeitschrift für technische Physik* 52:406–411.

Oleari, C. 1999. Inter-observer comparison of color-matching functions. *Color Research and Application* 24:177–184.

Oleari, C. 2001. Comparisons between color space scales, uniform-color-scale atlases, and color-difference formulas. *Color Research and Application* 26:351–361.

O'Regan, J. K., and Noë, A. 2001. A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences* 24:912–1031.

OSA Uniform Color Scales. 1977. Washington: Optical Society of America.

Osgood, C. E. 1953. *Method and Theory in Experimental Psychology.* New York: Oxford University Press.

Ostwald, W. 1918. *Die Farbenlehre: Vol. 1. Mathetische Farbenlehre.* Leipzig: Unesma.

Ostwald, W. 1919. *Der Farbkörper.* Leipzig: Unesma.

Palmer, G. 1777. *Theory of Colours and Vision.* London: Leacroft.

Palmer, S. E. 1999. *Vision Science, Photons to Phenomenology.* Cambridge: MIT Press.

Parkhurst, C. 1990. Roger Bacon on color. In K. L. Selig and E. Sears, eds., *The Verbal and the Visual*, New York: Italica Press.

Parkhurst, C., and Feller, R. L. 1982. Who invented the color wheel? *Color Research and Application* 7:217–230.

Photius. *Bibliothèque*, 8 vols., transl. R. Henry. Paris: Société d'éditions Les Belles Lettres, 1959–1991.

Plateau, J. A. F. 1872. Sur la mesure des sensations physiques, et sur la loi qui lie l'intensité et ces sensations a la cause excitante. *Bulletins de l'Académie Royales des Sciences, des Lettres et des Beaux-Arts de Belgique* 33:376–388.

Plato. *The Collected Dialogues*, eds. E. Hamilton and H. Cairns. Princeton: Princeton University Press, 1961.

Pointer, M. R., and Attridge, G. G. 1997. Some aspects of the visual scaling of large colour differences. *Color Research and Application* 22:298–307.

Pointer, M. R., and Attridge, G. G. 1998. The number of discernible colours. *Color Research and Application* 23:52–54.

Pointer, M. R., and Attridge, G. G. 2000. Some aspects of the visual scaling of large colour differences–II. *Color Research and Application* 25:116–122.

Pokorny, J., Smith, V. C., and Starr, S. J. 1976. Variability of color mixture data: II The effect of viewing field size on the unit coordinates. *Vision Research* 16:1095–1098.

Polyak, S. 1957. *The Vertebrate Visual System.* Chicago: University of Chicago Press.

Pope, A. 1929. *The Painter's Terms.* New Haven, CT: Yale University Press.

Porphyry. *Isagoge*, *Porphyry the Phoenician*, trans. E. W. Warren. Toronto: Pontifical Institute of Mediaeval Studies, 1975.

Priest, I. G., Gibson, K. S., and McNicholas, H. J. 1920. An examination of the Munsell color system. I. Spectral and total reflection and the Munsell scale of value. U.S. National Bureau of Standards Technical Paper 167.

Priest, I. G., and Brickwedde, F. G. 1938. The perceptible colorimetric purity as a function of dominant wavelength. *Journal of the Optical Society of America* 28:133–139.

Purves, D., Lotto, B., and Polger, T. 2000. Color vision and the four-color-map problem. *Journal of Cognitive Neuroscience* 12:233–237.

Purves, D., and Lotto, R. B. 2002. *Why We See What We Do: Evidence for a Wholly Probabilistic Strategy of Vision.* Sunderland: Sinauer Associates.

Qiao, Y., Berns, R. S., Reniff, L., and Montag, E. 1998. Visual determination of hue suprathreshold color-difference tolerances. *Color Research and Application* 23:302–313.

Ramanath, R., Kuehni, R., Snyder, W. E., and Hinks, D. 2003. Spectral spaces and color spaces. *Color Research and Application* 28: forthcoming.

Rich, R. M., Billmeyer, F. W., and Howe, W. G. 1975. Method for deriving color-difference-perceptibility ellipses for surface-color samples. *Journal of the Optical Society of America* 65:956–959.

Richter, K. 1985. *Farbempfindungsmerkmal Elementarbuntton und Buntheitsabstände als Funktion von Farbart und Leuchdichte von In- und Umfeld.* Bremerhaven: Wirtschaftsverlag.

Richter, K. 1980. Cube-root color spaces and chromatic adaptation. *Color Research and Application* 5:25–43.

Richter, K. 1996. *Computergrafik und Farbmetrik*. Berlin: VDE Verlag.

Richter, M. 1976. *Einführung in die Farbmetrik*. Berlin: Walter de Gruiter.

Richter, M., and Witt, K. 1986. The story of the DIN color system. *Color Research and Application* 11:138–145.

Ridgway, R. 1912. *Color Standards and Color Nomenclature.* Washington: published by the author.

Robertson, A. R. 1978. CIE guidelines for coordinated research on colour-difference evaluation. *Color Research and Application* 3:149–151.

Robinson, F. D. 1962. Acceptability of color matches. *Journal of the Oil Colour Chemist Association* 52:15–45.

Rohner, E., and Rich, D. C. 1996. Eine angenähert gleichförmige Farbabstandsformel für industrielle Farbtoleranzen von Körperfarben. *Die Farbe* 42:207–220.

Rood, N. O. 1879. *Modern Chromatics.* New York: Appleton.

Rösch, S. 1928. Zur Kennzeichnung der Farben. *Physikalische Zeitschrift* 29:83–91.

Runge, P. O. 1810. *Die Farben-Kugel oder Construction des Verhältnisses aller Mischungen der Farben zueinander.* Hamburg: Perthes.

Russell, B. 1912. *The Problems of Philosophy.* London: Oxford University Press.

Sanders, C. L., and Wyszecki, G. 1964. Correlate for brightness in terms of CIE color matching data. In *CIE Proceedings 15th Session*, Vienna, 1963. Paris: CIE Central Bureau.

Sankeralli, M. J., and Mullen, K. T. 1996. Estimation of the *L*-, *M*-, and *S*-cone weights of the postreceptoral detection mechanisms. *Journal of the Optical Society of America* A13:906–915.

Sankeralli, M. J., and Mullen, K. T. 1999. Ratio model for suprathreshold hue-increment detection. *Journal of the Optical Society of America* A16:2625–2637.

Sarle, W. S. 1995. Measurement theory: Frequently asked questions. In *Disseminations of the International Statistical Applications Institute*, 4th ed., Wichita: ACG Press, pp. 61–66.

Saunders, B., and van Brakel, J. 2002. *Theories, Technologies, Instrumentalities of Color.* Lanham MA: University Press of America.

Saunderson, J. L., and Milner, B. I. 1946. Modified chromatic value space. *Journal of the Optical Society of America* 36:36–42.

Schiffermüller, I. 1771. *Versuch eines Farbensystems.* Vienna.

Schönfelder, W. 1933. Der Einfluss des Umfeldes auf die Sicherheit der Einstellung von Farbgleichungen. *Zeitschrift für Sinnesphysiologie* 63:228–236.

Schrödinger, E. 1920. Grundlinien einer Theorie der Farbmetrik im Tagessehen. *Annalen der Physik* 63:297–447, 481–520. (Outline of a theory of color measurement for daylight vision.) Transl.: D. L. MacAdam, ed., *Sources of Color Science*. Cambridge: MIT Press.

Schrödinger, E. 1926. Über das Verhältnis der Vierfarben-zur Dreifarbentheorie. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien. *Mathematisch-naturwissenschaftliche Classe* 134(2a):471–490. Transl.: National Translation Center in Color Research and Application 1994;19:37–47.

Schultze, M. J. S. 1866. *Über den gelben Fleck der Retina, seinen Einfluss auf normales Sehen und auf Farbenblindheit.* Bonn: Cohen.

Schultze, W., and Gall, L. 1971. Application of color difference formulas to highly saturated colors differing only in lightness and saturation. *Journal of Color and Appearance* 1(1):17–24.

Schwarz, A. 1992. Christian Doppler's Kugeloctant von 1847–Ein vergessenes Farbsystem. *Die Farbe* 38:49–81.

Schwarz, A. 1995. Physikalisch begründete Farbsysteme. *Die Farbe* 41:31–60.

Schwarz, A. 1999. *Die Lehren von der Farbenharmonie* (The doctrines of color harmony). Göttingen: Muster-Schmidt.

Seim, T., and Valberg, A. 1986. Towards a uniform color space: A better formula to describe the Munsell and OSA color scales. *Color Research and Application* 11:11–24.

Semmelroth, C. C. 1970. Prediction of lightness and brightness on different backgrounds. *Journal of the Optical Society of America* 60:1685–1689.

Semmelroth, C. C. 1971. Adjustment of the Munsell-value and *W**-scale to uniform lightness steps for various background reflectances. *Applied Optics* 10:14–18.

Sève, R. 1979. A bibliography on whiteness. *Die Farbe* 26:89–104.

Sharpe, L. T., Stockman, A., Jägle, H., Knau, H., and Nathans, J. 1999. *L*, *M* and *L-M* hybrid cone photopigments in man: Deriving λ_{max} from flicker photometric spectral sensitivities. *Vision Research* 39:3513–3525.

Shepard, R. N. 1962. The analysis of proximities: multidimensional scaling with an unknown distance function (parts 1 and 2). *Psychometrica* 27:125–140, 219–246.

Shepard, R. N. 1992. The perceptual organization of colors: An adaptation to regularities of the terrestrial world? In J. H. Barkow, L. Cosmides and J. Tooby, eds., Oxford: *The Adapted Mind*. Oxford University Press.

Shepard, R. N. 1994. Perceptual-cognitive universals as reflections of the world. *Psychonomic Bulletin and Review* 1:2–28.

Shinomori, K., Schefrin, B. E., and Werner, J. S. 1997. Spectral mechanisms of spatially-induced blackness: Data and quantitative model. *Journal of the Optical Society of America* A14:372–387.

Silberstein, L. 1942. A fundamental criterion of uniform representability of equiluminous colors on a geometrical surface. *Journal of the Optical Society of America* 32:552–556.

Smith, V. C. 1999. Private communication.

Smith, V. C., and Pokorny, J. 1975. Spectral sensitivity of the foveal cone photopigments between 400 and 500 nm. *Vision Research* 15:161–171.

Smith, V. C., Pokorny, J., and Sun, H. 2000. Chromatic contrast discrimination: Data and prediction for stimuli varying in *L* and *M* cone excitation. *Color Research and Application* 25:105–115.

Sowerby, J. 1809. *A New Elucidation of Colours, Original, Prismatic, and Material.* London: Taylor.

Speranskaya, N. I. 1959. Determination of spectrum color co-ordinates for twenty-seven normal observers. *Optics and Spectroscopy* 7:424–428.

Stevens, S. S. 1946. On the theory of scales of measurement. *Science* 103:677–680.

Stevens, S. S. 1953. On the brightness of lights and the loudness of sounds. *Science* 118: 576 (Abstract).

Stevens, S. S. 1975. *Psychophysics.* New York: Wiley.

Stevens, S. S., and Galanter, E. H. 1957. Ratio scales and category scales for a dozen perceptual continua. *Journal of Experimental Psychology* 54:377–411.

Stiles, W. S. 1946. A modified Helmholtz line element in brightness-colour space. *Proceedings of the Physical Society (London)* 58:41–47.

Stiles, W. S., and Burch, J. M. 1955. Interim report to the Commission International de L'Eclairage, Zurich 1955, on the National Physical Laboratory's investigation of colour-matching. *Optica Acta* 2:168–181.

Stockman, A., MacLeod, D. I. A., and Johnson, N. E. 1993. Spectral sensitivities of the human cones. *Journal of the Optical Society of America* A10:2491–2521.

Stockman, A., and Sharpe, L. T. 1998. Human cone spectral sensitivities: a progress report. *Vision Research* 38:3193–3206.

Stockman, A., and Sharpe, L. T. 1999. Cone spectral sensitivities and color matching. In K. R. Gegenfurtner and L. T. Sharpe, eds., *Color Vision*. Cambridge: Cambridge University Press.

Strocka, D. 1971. Color difference formulas and visual acceptability. *Applied Optics* 10: 1308–1313.

Strohmeyer, C. F., Chaparro, A., Rodriguez, C., Chen, D., Hu, E., and Kronauer, R. E. 1998. Short-wave cone signal in the red-green detection mechanism. *Vision Research* 38:813–826.

Stumpf, C. 1917. Die Attribute der Gesichtsempfindungen. *Abhandlungen der königlich preussischen Akademie der Wissenschaften. Philosophisch-historische Klasse* 8. Berlin: Verlag der Königlichen Akademie der Wissenschaften.

Sugiyama, Y., and Fukuda, T. 1959. Comparison of different U.C.S. by using MacAdam ellipses and Munsell scales. *Journal of Applied Physics (Japan)* 28:757–766.

Svaetichin, G. 1956. Spectral response curves from single cones. *Acta Physiologica Scandinavica* 134:17–46.

Swedish Standard SS 01 91 03. 1982. *CIE tristimulus values and chromaticity coordinates for the colour samples in SS 01 91 02.* Stockholm: Swedish Standards Institution.

Takasaki, H. 1966. Lightness change of grays induced by change in reflectance of gray background. *Journal of the Optical Society of America* 56:504–509.

Takasaki, H. 1967. Chromatic changes induced by changes in chromaticity of background of constant lightness. *Journal of the Optical Society of America* 57:93–96.

Teller, D. A., and Pugh, E. N. 1983. Linking propositions in color vision. In J. D. Mollon and L. T. Sharpe, eds., *Colour Vision*: *Physiology and Psychophysics*, London: Academic Press, pp. 577–589.

Telesio, A. 1529. *Antonii Thylesii Cosentini libellus de coloribus.* Venice.

Teufel, H. J., and Wehrhahn, C. 2000. Evidence for the contribution of *S* cones to the detection of flicker brightness and red-green. *Journal of the Optical Society of America* A17:994–1006.

Theophilus, *The Various Arts*, ed. and transl. C. R. Dodwell. Oxford: Clarendon Press, 1986.

Thomsen, K. 2000. A euclidean color space in high agreement with the CIE94 color difference formula. *Color Research and Application* 25:64–65.

Thurner, K., and Walther, V. 1970. Untersuchungen zur Korrelation von Farbabstandsbewertungen auf visuellen Wegen und über Farbabstandsformeln. *Proceedings of the International Color Meeting* "*Color 69*," Vol. 2, pp. 671–687. Göttingen: Musterschmidt.

Thurstone, L. L. 1927. Psychophysical analysis. *American Journal of Psychology* 38:368–389.

Titchener, E. B. 1896. *Outline of Psychology.* New York: Macmillan.

Tonnquist, G. 1966. A comparison between symmetrical and equi-spaced hue circles. *Die Farbe* 15:376–388.

Torgerson, W. S. 1958. *Theory and Methods of Scaling.* New York: Wiley.

Treviranus, G. R. 1828. *Beiträge zur Anatomie und Physiologie der Sinneswerkzeuge des Menschen und der Thiere.* Bremen: Heyse.

Trezona, P. W., and Parkins, R. P. 1998. Derivation of the 1964 colorimetric standards. *Color Research and Application* 23:221–225.

Turner, R. S. 1994. *In the Eye's Mind.* Princeton: Princeton University Press.

Unger, F. W. 1854. *Disque chromharmonique pour servir a expliquer les règles de l'harmonie des couleurs.* Göttingen.

Urso von Salerno. *De comixtionibus elementorum libellus*, ed. W. Stürner. Stuttgart: Stuttgart University Press, 1976.

Usui, S., Nakauchi, S., and Nakano, M. 1992. Reconstruction of Munsell color space by a five-layer neural network. *Journal of the Optical Society of America* A9:516–520.

Valberg, A. 2001. Unique hues: An old problem for a new generation. *Vision Research* 41:1645–1657.

Veckenstedt, E. 1888. Geschichte der griechischen Farbenlehre. Paderborn: Schöningh.

Villalobos-Dominguez, C., and Villalobos, J. 1947. *Atlas de los colores.* Buenos Aires: *Libreria El Ateneo editorial.*

Volbrecht, V. J., and Kliegl, R. 1998. The perception of blackness. In W. G. K. Backhaus, R. Kliegl and J. S. Werner, eds., *Color Vision*. Berlin: De Gruyter.

Völz, H. G. 1998a. Die Berechnung grosser Farbabstände in nichteuklidischen Farbräumen. *Die Farbe* 44:1–45.

Völz, H. G. 1998b. Transformation der CIE94-Formel in einen euklidischen Farbraum. *Die Farbe* 44:97–105.

Völz, H. G. 1999. Die Euklidisierung des CMC-Raumes zur Berechnung grosser Farbabstände. *Die Farbe* 45:1–23.

Vos, J. J. 1978. Colorimetric and photometric properties of a 2° fundamental observer. *Color Research and Application* 3:125–128.

Vos, J. J. 1979. Line elements and physiological models of color vision. *Color Research and Application* 4:208–216.

Vos, J. J., and Walraven, P. J. 1972. An analytical description of the line element in the zone-fluctuation model of colour vision. *Vision Research* 12:1327–1344, 1345–1366.

Vos, J. J., and Walraven, P. J. 1991. Back to Helmholtz. *Color Research and Application* 16:355–359.

Wachtler, T., Lee, T., and Sejnowski, T. J. 2001. Chromatic structure of natural scenes. *Journal of the Optical Society of America* A18:65–77.

Wallach, H. 1948. Brightness constancy and the nature of achromatic colors. *Journal of Experimental Psychology* 38:310–324.

Waller, R. 1686. A catalogue of simple and mixt colours, with a specimen of each colour prefixt to its proper name. *Philosophical Transactions of the Royal Society* 26:24:32.

Walls, G. 1956. The G. Palmer story. *Journal of the History of Medicine* 11:66–96.

Walraven, P. L., and Bouman, M. A. 1966. Fluctuation theory of colour discrimination of normal trichromats. *Vision Research* 6:567–586.

Walsh, J. T. W. 1958. *Photometry*, 3rd ed. London: Constable. Reprinted by Dover, New York, 1965.

Wässle, H., Grünert, U., Martin, P. R., and Boycott, B. B. 1994. Immunocytochemical characterization and spatial distribution of midget bipolar cells in the macaque monkey retina. *Vision Research* 34:561–579.

Weber, E. H. 1834. *De pulsu, resorptione, auditu et tactu.* Leipzig: Koehler.

Webster, M. A., Miyahara, E., Malkoc, G., and Raker, V. E. 2000. Variations in normal color vision. II. Unique hues. *Journal of the Optical Society of America* A17:1545–1555.

White, M. 1981. The effect of the nature of the surround on the perceived lightness of gray bars within square-wave test gratings. *Perception* 10:215–230.

Whittle, P. 1992. Whiteness, discriminability and the "crispening" effect. *Vision Research* 32:1493–1507.

Wiesel, T. N., and Hubel, D. H. 1966. Spatial and chromatic interactions in the lateral geniculate body of the rhesus monkey. *Journal of Neurophysiology* 29:1115–1156.

Witt, K. 1981. Der Farbenraum nach DIN6164 in neuer Sicht. *Die Farbe* 29:17–52.

Witt, K. 1987. Three-dimensional threshold of color-difference perceptibility in painted samples: variability of observers in four CIE color regions. *Color Research and Application* 12:128–134.

Witt, K. 1990. Parametric effects on surface color-difference evaluation at threshold. *Color Research and Application* 15:189–199.

Witt, K. 1999. Geometric relations between scales of small colour differences. *Color Research and Application* 24:78–92.

Wright, W. D. 1928–29. A re-determination of the mixture curves of the spectrum. *Transactions of the Optical Society London* 30:141–164.

Wright, W. D., and Pitt, F. H. G. 1934. Hue discrimination on normal colour-vision. *Proceedings of the Physical Society (London)* 46:459–454.

Wright, W. D. 1941. The sensitivity of the eye to small colour differences. *Proceedings of the Physical Society (London)* 53:93–112.

Wright, W. D. 1969. *The Measurement of Colour*, 4th ed. New York: Van Nostrand Reinhold.

Wright, W. D. 1996. The origins of the 1939 CIE system. In P. K. Kaiser and R. M. Boynton, *Color Vision*, second ed., Washington, DC: Optical Society of America.

Wuerger, S. M., Maloney, L. T., and Krauskopf, J. 1995. Proximity judgments in color space: Test of a euclidean color geometry. *Vision Research* 35:827–835.

Wuerschmidt, J. 1914. Dietrich von Freiberg, Ueber den Regenbogen. In C. Bauemker, ed., *Beiträge zur Geschichte der Philosophie des Mittelalters*, Vol. 12. Münster: Aschendorff.

Wundt, W. 1874. Grundzüge der physiologischen Psychologie. Leipzig: Engelmann.

Wundt, W. M. 1880. *Grundzüge der physiologischen Psychologie.* Leipzig: Engelmann.

Wundt, W. 1892. *Vorlesungen ueber die Menschen- und Thierseele*, zweite Auflage. Leipzig: Voss.

Wundt, W. 1896. Grundriss der Psychologie. Leipzig: Alfred Körner.

Wyszecki, G. 1953. Valenzmetrische Untersuchung des Zusammenhanges zwischen normaler und anomaler Trichromasie. *Die Farbe* 2:39–52.

Wyszecki, G. 1954. A regular rhombohedral lattice sampling of Munsell renotation space. *Journal of the Optical Society of America* 44:725–734.

Wyszecki, G. 1960. *Farbsysteme.* Göttingen: Musterschmidt-Verlag.

Wyszecki, G. 1963. Proposal for a new color-difference formula. *Journal of the Optical Society of America* 53:1318–1319.

Wyszecki, G. 1967. Correlate for brightness in terms of CIE chromaticity coordinates and luminous reflectance. *Journal of the Optical Society of America* 57:254–257.

Wyszecki, G. 1972. Recent developments on color-difference evaluation. In J. J. Vos, L. F. C. Friele and P. L. Walraven, eds., *Color Metrics*. Soesterberg, Netherlands: Institute for Perception.

Wyszecki, G. 1981. Uniform color spaces. In *Golden Jubilee of Colour in the CIE.* Bradford: Society of Dyers and Colourists.

Wyszecki, G., and Sanders, C. L. 1964. Correlate for lightness in terms of CIE-tristimulus values: Part II. *Journal of the Optical Society of America* 47:840–842.

Wyszecki, G., and Wright, H. 1965. Field trial of the 1964 CIE color-difference formula. *Journal of the Optical Society of America.* 55:1166–1174.

Wyszecki, G., and Fielder, G. H. 1971a. New color matching ellipses. *Journal of the Optical Society of America* 61:1135–1152.

Wyszecki, G., and Fielder, G. H. 1971b. Color-difference matches. *Journal of the Optical Society of America* 61:1501–1513.

Wyszecki, G., and Stiles, W. S. 1982. *Color Science*, 2nd ed. New York: Wileya

Xenophanes of Colophon. In K. Freeman, *Ancilla to the Pre-Socratic Philosophers*, Cambridge: Harvard University Press, 1958.

Yamauchi, Y., Williams, D. R., Brainard, D. H., Roorda, A., Carroll, J., Neitz, M., Neitz, J., Calderone, J. B., and Jacobs, G. H. 2002. What determines unique yellow, *L*/*M* cone ratio or experience? *Proceedings AIC Color 01.* Bellingham, WA: SPIE.

Young, T. 1824. Chromatics. In supplement to the fourth, fifth, and sixth editions of the *Encyclopedia Brittanica*. Edinburgh: A. Constable.

Zeki, S., and Bartels A. 1999. Toward a theory of visual consciousness. *Consciousness and Cognition* 8:225–259.

Figure 6-28 reprinted from Journal of the Optical Society of America A 13 (1996) p. 1317. R. Lenz, M. Osterberg, J. Hiltunen, T. Jaaskelainen, and J. Parkkinen, Unsupervised filtering of color spectra.

Figure 7-21 reprinted from Journal of the Optical Society of America 64 (1974), p. 1696, D. L. MacAdam, Uniform color scales.

Figure 7-23 reprinted from Journal of the Optical Society of America 68 (1978), p. 1616, C. E. Foss, Space lattice used to sample the color space of the Committee on Uniform Color Scales. All materials used with permission of the Optical Society of America.

Princeton University Press, Princeton, NJ:

Quotations of Aristotle in chapter 2 from *The complete works of Aristotle, Volume One*, copyright 1984 by Jowett Copyright Trustees, reprinted with permission of Princeton University Press.

Psychonomic Bulletin and Review, Austin, TX:

Figure 3-6: reprinted with permission from R. N. Shepard, Perceptual-cognitive universals as reflections of the world, Psychonomic Bulletin and Review 1 (1994) p. 24.

Springer-Verlag, Heidelberg, Germany:

Figures 6-1, 6-7, 6-8, 6-9 reprinted from D. L. Mac Adam, *Color Measurement*, 1981, pp. 131, 132, 133, 153.

Figure 7-14 reprinted from G. A. Agoston, *Color Theory and Its Application in Art and Design*, 1987, p. 223, with permission of Springer-Verlag.

John Wiley & Sons, Inc., New York, NY:

Figures 2-46, 2-47, 5-2, 5-6, 5-7, 5-18, 5-20, 6-17, 6-18, 7-9 reprinted from G. Wyszecki and W. S. Stiles, *Color Science, second edition*, 1982, pp. 184, 257, 137, 499, 414, 166, 167, 510 respectively.

Figure 3-5 reprinted from S. S. Stevens, *Psychophysics*, 1975, p. 185.

Figure 4-33 reprinted from R. M. Evans, *The Perception of Color*, 1974, p. 104.

Figure 4-9 reprinted from Color Research and Application 24 (1999) p. 270. T. Indow, Principal hue curves and color difference.

Figure 5-27 reprinted from Color Research and Application 22 (1997) p. 155, M. Melgosa, E. Hita, A. J. Poza, and R. S. Berns, Suprathreshold color-difference ellipsoids for surface colors.

Figures 6-5, 6-30, 6-31 reprinted from Color Research and Application 19 (1994) p. 113, M. Mahy, L. Van Eycken, and A. Oosterlinck, Evaluation of uniform color spaces developed after the adoption of CIELAB and CIELUV.

Figure 6-11 reprinted from Color Research and Application 11 (1986) p. 30, M. R. Luo, and B. Rigg, Chromaticity discrimination ellipses for surface colors.

Figure 6-12 reprinted from Color Research and Application 26 (2001) p. 346, M. R. Luo, G. Cui, and B. Rigg, The development of the CIE 2000 colour-difference formula.

Figures 6-19 and 6-20 reprinted from Color Research and Application 15 (1990) p. 33, S. A. Burns, J. B. Cohen, and E. N. Kuznetsov, The Munsell color system in fundamental color space.

Figures 7-26 and 7-27 reprinted from Color Research and Application 21 (1996) pp. 189 and 194 respectively, A. Hård, L. Sivik, and G. Tonnquist, NCS Natural Color System, Part I.

Figure 7-28 reprinted from Color Research and Application 11 (1986) p. 147. G. Derefeldt and C. Sahlin, Transformation of NCS data into CIELAB colour space. All materials used with permission of John Wiley & Sons, Inc.

Index

Abney, W. deW., 161
Abney effect, 284
Acceptability, 228, 366
Adams, E. Q., 170, 214, 250
  chromance diagram, 214
Adams-Cobb lightness scale, 177
Adams-Nickerson (ANLAB) formula, 215, 226
Adaptation, 4, 366
Adobe Illustrator, Photoshop, 100
d'Aguilon, François (Aguilonius), 37, 159
Alberti, Leon Baptista, 32, 124
Albertus Magnus, 30, 32
Anchoring problem, 153
Aristotle, 22ff, 25
Aubert, H., 76, 78
Averroës, 27
Avicenna, 23, 32

Bacon, Roger, 28, 30–32
Bartholomaeus Anglicus, 31
Benary effect, 154
Benson, William, 78
Berlin & Kay, 26, 109
Bezold, Wilhelm von, 78
BFD formula, 239–240, 268
Blackness, 40, 76, 89, 97, 109, 129–130, 304
Boethius, 36–37
Boring, E. G., 91
Bouguer, Pierre, 63, 152, 159
Boyle, Robert, 51
Breckenridge & Schaub diagram, 208–209
Brenner, Elias, 42
Brewster, David, 72
Brightness, 111, 131–132, 340
  heterochromatic, 183, 341
Brücke, E. W., 59, 126
Burch, J. M., 163

Cardanus, Hieronimus, 34
Castel, L.-B., 47
Categorization, 108
Cattell, J. M., 83
C. B., 46–47, 50
"Celtic" cross, 197–198
Cennini, Cennino, 32, 124
Chalcidius, 27, 31, 124
Chalmers, D. J., 105
Chevreul, M.-E., 59, 66–69
Chroma, 21, 86, 128, 132, 147, 186–191, 331, 351, 356
  circles, constant, 186-189
Chroma Cosmos 5000, 86
Chromaticness, 9, 97

Color Space and Its Divisions: Color Order from Antiquity to the Present, by Rolf G. Kuehni
ISBN 0-471-32670-4

Chromaton 707, 86
CIE, 91–92
  chromatic system, 93, 367
  chromaticity diagram, 164
  standard observers, 161
  U*W*W* system, 211
CIE94 formula, 241–242
  optimization, 244–245
CIEDE2000 formula, 245–347, 270
CIELAB, 14, 101, 199, 230–231, 247, 268
  weights, 242–243
Cleavage planes, 296
CMC formula, 235–236, 268
CMYK space, 100
Cohen fundamental color space, 256
Color appearance:
  models, 5
  systems, 20–21, 358
Color attributes, 6, 131ff, 134, 138ff, 342
Color circle, 46, 49ff, 55ff, 368
Color difference:
  formula performance, 264ff, 347–348
  global, 332
  just noticeable (JND), 11, 64–65, 83, 109, 202
  large, 238–239, 243, 266
  suprathreshold, 118, 225, 238–239, 266
  threshold, 63–65, 83, 105, 112, 116, 216, 266
  unit contours, 322–325, 328–330
Color fundamentals, 161, 163
Color harmony, 45
Color Harmony Manual, 9, 89
Color matching error, 216, 266
  data, 312–313
Color matching space, 351, 359
Color mixing space, 100
Color, object, 2, 7, 91–93
Color order systems, 19–21
Color, primary, 59, 69, 72, 368
Color room, 47
Color solid, 1
  psychological, 6, 121
  psychophysical, 121
  uniform, 352–353
Color space, 1
  cone response, 164ff, 311, 337–338
  cube root, 224
  ideal, 13, 332
  opponent, 169–174
  personal, 3, 4
  regular, 8–9, 101, 264, 336–337
  uniform, 8ff, 14, 357–358
Color specification, 40, 90–91, 307
Colorimeter, 161, 183, 216, 224, 334
Colorimetric purity, 131, 318
Colorimetric system, 161
Cone contrast, 261, 312, 350, 369
Cone functions, 166–168
  variation in, 168
Cone response increments, 320–321
Cones, 4, 16, 160, 164ff, 193–194
Conflation, 189–190
Contrast, 137, 331
Count of Rumford, 137, 159
Crispening, 345
  chromatic, 229, 313ff, 318–319, 335
  lightness, 180, 313ff, 335, 345
Cubo octahedron, 95, 295, 297

Delboeuf, J. R. L., 66, 94
Democritus, 22–22
Descartes, René, 15, 45
De Valois model, 258–261
Dietrich von Freiberg, 31
DIN 6164 system, 93–95
DIN 99 formula, 244
DKL space, 174–175, 256, 258
Donders, F., 78, 169
Doppler, C., 69

Ebbinghaus, H., 66, 81, 177
Elementaristic approach, 2
Ellipse fitting, 226–228
Empedocles, 21
Eraclius, 28
Euclidean geometry, 121, 190, 348–349
Evans, R. M., 148

Fechner, G. T., 64, 83, 105
Ficino, Marsilio, 33
Field, George, 59
Fludd, Robert, 37, 49
Fluorence, 131
Forsius, Sigfridus Aronius, 34–36, 49
Friele FCM color difference formula, 232–234

Friele-MacAdam-Chickering formulas, 219–222
Frisch, J. C., 58

Ganzfeld, 137, 340
Gelb, A., 130
Geodesic, 205, 370
Gestalt psychology, 153–154, 370
Gerritsen, F., 91
Gilchrist, A. L., 138, 153–154
GLAB formula, 343
Glaukos (glaucus), 26, 31, 33, 34
Glisson, Francis, 40–42
Godlove formula, 11–12
Goethe, J. W. von, 53, 58, 63
Grassmann, H. G., 72, 125, 161
Gray scale, 40–42, 68, 118, 151–152, 176ff, 277, 370
Greek color use, 25ff
Grossteste, Robert, 30
Guild, J., 162
Guilford, J. P., 111
Guth ATD model, 253–255

Hardin, C. L., 102
Harris, Moses, 55–58
Hayter, Charles, 71
Hefner lamp, 160
Helmholtz, H. L. F. von, 72–73, 123, 125–126, 161, 205
Helmholtz-Kohlrausch effect, 96, 183–186, 292–293
Henry, Charles, 59
Herbart, J. F., 64
Hering, K. E. K., 75–78, 96, 112, 127, 301–303
  space, 9
Hesselgren, S., 91, 97, 303–304
Hickethier, E. A., 78, 91
Höfler, Alois, 78
HSB color space, 100–101
Hue, 351, 356
  angle, 11–12, 100, 140–141, 145–146, 150, 192, 195, 231, 242–247, 326–332
  coefficients, 141–142, 250
  difference, 325–328
  unique, 4, 132, 138–140, 144–147, 194–195, 340–342, 350
  scaling, psychophysical, 191–193
  superimportance, 13, 151, 310
Hunt, R. W. G., 133–134
  color appearance model, 269
Hunter color difference formula, 224
Hurvich & Jameson, 171–172, 179, 250–251

Image framework, 154
Indow, T., 120, 134, 143, 155, 203, 299
Intrinsic image model, 153
Isomorphism, 121, 371

Jastrow, J., 83
Jameson & Hurvich, 171–172, 179, 250–251
Johannson, T., 91, 97, 303–304
JPC color difference formula, 234–235
Judd, D. B., 11–13, 98, 149–151, 202, 208–212, 248–249, 278, 286–287, 332
Judd's crinkled fan, 286
Judd's value function, 178

Kaneko, T., 179
Katz, D., 128, 153
Kelly, K., 98
Kircher, Athanasius, 39–40
Kirschmann, A., 80, 126
Klotz, Matthias, 58, 63
König, A., 73, 160–161
Kries, J. von, 78, 83, 105
Küppers, H., 91

LABHNU formula, 234, 269
Lambert, J. H., 53–55, 124–125
Land E., 19
Lateral geniculate nucleus 138, 371
Le Blon, J. C., 51
Leonardo da Vinci, 32–33, 124
Leonardo 2000, 277
Lichtenberg, G. C., 53, 363
Lightness, 34, 76, 78, 84, 107, 111, 124–125, 131–132, 151–154, 176, 243, 355–356
  heterochromatic 183, 341
  relative, 94
Limen, 64

Line element, 204ff
  empirical, 216–218
  visual space, 206
Linking proposition, 131
Lucretius, 27
Luminance, 161
Luo & Rigg data, 236, 312
Luther-Nyberg color solid, 93, 169

MacAdam, D. L., 91–92, 95, 117, 202, 216–218, 222–223, 226, 287ff, 298–299
Macula, 169, 193–194, 371
Magnitude, 109
Masking, 181, 372
Maxwell, J. C., 72–74, 161
  triangle, 208, 211
Mayer, Tobias, 51–53, 124
Measurement, 104
Metamers, 256, 264, 372
Metaphorical imperative, 107
Middle Ages, 27
Müller, A., 90
Müller, E. G., 128, 169, 176
Müller-Judd model, 248–249
Munsell, A. H., 9, 84–86, 128
  1915 *Atlas*, 147, 177, 274
  1929 *Book of Color*, 147, 177, 275–277
  "color tree", 9
  Renotations, 9, 86, 277, 281–283
  Re-renotations, 189, 278
  system development, 272–274
  unit difference contour, 285
Musschenbroek, P. van, 152, 364

Natural color system:
  Hering, 75–76, 127, 301
  Swedish, 10, 96–98, 140, 182, 301ff
    atlas, 307–308
    scale fitting, 304
    terminology, 307–308
Neural correlate, 137
Neural network, 134
Newton, Isaac, 19, 43–45, 50, 124, 363
Nickerson-Newhall color solid, 10
Nickerson index of fading, 10, 149–150
Norwich's law, 106

Optical Society of America
  Committee on Uniform Color Scales
  Subcommittee on Spacing of Munsell Colors, 86
  Uniform color scales (OSA-UCS), 7, 13, 95–96, 255
    atlas, 295–298
    formula optimization, 292–295
    system development, 287–292
    revised formula, 298–299
    uniformity, 299–300
Opponent color system, 261–263, 350–351
Opponent color theory, 78
Oresme, Nicole, 36
Ostwald, W., 9, 89–90, 96–97, 129

Paired comparison, 118
Palmer, George, 59, 363
Photometry, 159
  flicker, 160
Perception, 2, 3, 15, 64, 113, 123–124
  empirically determined, 2, 102
Perceptibility, 228
Plateau, J. A. F., 66
Plato, 22, 25
Pliny, 25
Pope, A., 91
Porphyry, 36
Poussin, Nicholas, 51
Power law, 110, 372
Pre-Platonists, 21
Principal component analysis, 101, 264, 342
Principal hue components, 155
Psychometric 133
  function, 119, 372
Psychophysics, 6, 64ff, 104ff
  inner and outer, 65, 107
Psychoquantitative, 133
Ptolemy, 24–25
Pythagoras, 21

Reddish green, 263
Reflectance, 5, 7, 16, 101–102, 134, 163, 359–360
  luminous, 153, 161, 176

Regression:
  linear, 226, 229
  nonlinear, 222
Retina, 4, 59, 76, 123, 160, 164, 373
RGB space, 100
Rhombohedral, regular, 290, 292, 295, 298
Ridgway, R., 86
  color atlas, 86
Richter data, 216, 312
Riemann, B., 121
  geometry, 121, 148, 204, 288, 341, 346, 348, 373
  plane, 328
RIT-Du Pont data, 238, 268–269, 312
Rods, 4, 160, 164
Rood, O. N., 84
Rösch-MacAdam limits, 89, 91, 121, 129, 164, 359
Rubens, Peter Paul, 37, 159
Runge, Phillip Otto, 59–62, 124–125
Russell, B., 19

Saturation, 50, 94–95, 100, 125–126, 128, 132, 373
Saunderson-Milner Zeta space, 186, 215
Scales:
  absolute, 116
  category, 112, 118
  chroma, 186–190
  hue, 191–193
  interval, 115
  lightness, 176ff
  minimally distinct border, 118
  multidimensional, 119–121, 134
  nominal, 114
  ordinal, 114
  ratio, 115
  tonal, 9, 27–31, 33, 34, 37, 39, 50, 57–58, 128
Schiffermüller, I., 152, 179
Schönfelder, S., 152, 179
Schrödinger, E., 92, 205–206
Semmelroth. C. C., 189, 293
Sensation, 15, 64–66, 84, 105–107
Shepard, R. N., 119, 138, 341
Signal detection theory, 106
Silberstein, L., 288, 290
Similitude, 137
Smith-Pokorny functions, 166–167, 197, 314
Sowerby, James, 59
Spectral space, 101–102, 264, 359–360, 373
Speranskaya, N. I., 163
Stevens, S. S., 84, 111–113
Stiles, W. S., 163, 206
Svaetichin, G., 171
Surround, 2, 19–20, 180–181, 236, 243, 245, 309
SVF formula, 240–241

Takasaki, H., 180
Telesio, Antonio, 33
Tetractys, 36, 373
Theophilus, 28ff, 124
Theophrastus, 22, 24
Threshold:
  brightness, 152
  chromatic, 148–149
  data, 237–238
Titchener, E. B., 66, 81–82, 202
Torgerson, W. S., 119
Transformation:
  Linear, 162, 169, 194, 208ff, 230
  nonlinear, 222–223
  projective, 208ff
Trichromatic, 4, 161, 164, 169, 373
Tristimulus, 92, 163–164, 373

Unger, F. W., 59
Universal color language, 98–100, 136
Urfarben (fundamental colors), 76, 302
Urso de Salerno, 30

Value, 86, 128
Veckenstedt, F., 26
Vilialobos system, 91
Vision:
  theory of, 123–124
Visual purple, 160
Vollfarben, 10, 302, 368
Vos-Wallraven line element, 207–208

Wailer, Robert, 42–43
Wavelength, dominant, 95, 131, 194–195, 305, 369

Weber, E. H., 64
Weber-Fechner law, 78, 89, 109, 111–112, 127, 205
Weber fraction, 110, 374
Weight integration, 270
Whiteness, 9, 10, 44, 76, 89, 109, 129–130
Witt data, 237, 239
Wright, W. D., 162, 216–217
Wundt, W. M., 82–83
Wyszecki, G., 14, 132, 211–212
Wyszecki-Fielder data, 216, 312ff, 333–334
Wyszecki-Sanders data, 183, 255–256

Xenophanes, 21

Yellowish blue, 263
Young, Thomas, 59

Zone theory, 169–170, 369